

**REPORT OF THE 2004
INTERNATIONAL NUTRITIONAL
ANEMIA CONSULTATIVE GROUP
SYMPOSIUM**



**IRON DEFICIENCY
IN EARLY LIFE:
CHALLENGES AND
PROGRESS**

**LIMA, PERU
18 NOVEMBER 2004**

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MS. HILARY CREED-KANASHIRO
MS. BOITSEPO GIYOSE**

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Front cover and title page:

The majestic flight of an Andean Condor, Colca Canyon, Arequipa. Heinz Plenge/PromPeru

Flamingoes in Paracas Natural Reserve, a paradise for wildlife, Ica. Heinz Plenge/PromPeru

Llanganuco Lake at 3,800 masl is part of the Northern White Range, where mountaineering is practiced. Carlos Sala/PromPeru

Cheerful looms ancestrally used by women of the community of Llachon, Puno. Domingo Giribaldi/PromPeru

There are around 3,000 popular festivities in Peru the whole year round, each one with its own characteristics. Alejandro Balaguer/PromPeru

Back cover:

Offering to the Apus or mountain spirits, Cusco. Mylene D'Auriol/PromPeru

Marinera is danced all over Peru, albeit with variations. Domingo Giribaldi/PromPeru

The llamas, Andean camelids domesticated around 7,000 A.D., can be found on the whole Andean range. Alejandro Balaguer/PromPeru

Colonial church of La Compañía, built by the Jesuits in 1576, Cusco. Carlos Sala/PromPeru

Religious festivity in Paucartambo, Cusco. Mylene D'Auriol/PromPeru

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Contents

Symposium Organizers _____	1
About INACG _____	2
Publications List _____	2
Acknowledgments _____	3
Program _____	4
Report on Presentations _____	13
Welcome _____	13
Keynote Address: Maternal Nutritional Status, Fetal Growth, and Iron Status during Infancy _____	13
Advances in Assessment _____	16
Supplementation Trials _____	19
Child Development _____	27
Program Implementation _____	35
Closing Remarks _____	45
References _____	46
Abstracts _____	49

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The INACG Symposium was co-hosted by INACG and the Local Organizing Committee of the Peruvian Ministry of Health and representatives of United Nations technical agencies, the private sector, multilateral agencies, and nongovernmental organizations in Peru, with funding from the Government of Peru. The Office of Health, Infectious Diseases and Nutrition, Global Health Bureau, U.S. Agency for International Development, and the Peruvian Ministry of Health assumed major responsibility for organizing the symposium. Special thanks are given to Task Force SIGHT AND LIFE for their contributions to the publishing of this report.



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The Micronutrient Initiative

Unilever Health Institute

Nestlé S.A.

H.J. Heinz Company

About INACG

INACG is dedicated to reducing the prevalence of iron deficiency anemia and other nutritionally preventable anemias worldwide. It sponsors international meetings and scientific reviews and convenes task forces to analyze issues related to etiology, treatment, and prevention of nutritional anemias. Examination of these issues is important to the establishment of public policy and action programs.



INACG Publications

Efficacy and Effectiveness of Interventions to Control Iron Deficiency and Iron Deficiency Anemia (2004) (Available in English and French)

The Role of Communication in Comprehensive Anemia Control: A Framework for Planning and Implementing a Strategic Communication Plan (2003)

Adjusting Hemoglobin Values in Program Surveys (2002)

Technical Brief on Iron Compounds for Fortification of Staple Foods (2002)

Anemia, Iron Deficiency, and Iron Deficiency Anemia (2002) (Available in English, French, Spanish, and Portuguese)

Iron Deficiency Anemia: Reexamining the Nature and Magnitude of the Public Health Problem (J Nutr Suppl 2001)

The Effects of Iron Deficiency and Anemia on Mental and Motor Performance, Educational Achievement, and Behavior in Children - An Annotated Bibliography (1998)

Iron/Multi-Micronutrient Supplements for Young Children (1997)

The Oxford Brief - Child Development and Iron Deficiency (1997)

Iron EDTA for Food Fortification (Fact Sheet) (1997)

Iron EDTA for Food Fortification (1993)

Combating Iron Deficiency Anemia through Food Fortification Technology: An Action Plan (1992) (Available in English, French, and Spanish)

Guidelines for the Control of Maternal Nutritional Anemia (1989) (Available in English, French, and Spanish)

La Lutte Contre la Carence en Fer: Etude de Cas Réalisé au Chili (1987)

Prevenición de la Deficiencia de Hierro: La Experiencia de Chile (1987)

Measurements of Iron Status (1985)

Design and Analysis of Iron Supplementation Trials (1984)

Iron Deficiency in Women (1981) (Available in English, French, and Spanish)

Iron Deficiency and Work Performance (1981)

Iron Deficiency in Infancy and Childhood (1979) (Available in English, French, and Spanish)

Guidelines for the Eradication of Iron Deficiency Anemia (1977)

Acknowledgments

The success of the INACG Symposium is due to the efforts of many individuals and the sponsoring organizations. The primary support for the INACG Symposium was provided by the U.S. Agency for International Development through the Micronutrient Global Leadership cooperative agreement. The Peruvian Ministry of Health, through the Local Organizing Committee, collaborated in the organization of the symposium and helped to generate active participation from Peru.

The INACG Secretariat gratefully acknowledges additional contributions from The Micronutrient Initiative, Unilever Health Institute, Nestlé S.A., and H.J. Heinz Company. Special thanks are given to Task Force SIGHT AND LIFE for their contributions to the symposium through travel grants, simultaneous translation at the symposium, and the publication of this report.

The INACG Steering Committee, composed of Mrs. Rosanna Agble; Dr. Frances R. Davidson, INACG Secretary; Dr. Lena Davidsson, INACG Steering Committee Chair; Dr. Sean Lynch; Dr. H.P.S. Sachdev; and Dr. Rebecca Stoltzfus, gave generously of their time and expertise in planning the symposium program.

The speakers contributed immeasurably to the symposium's success. The INACG Secretariat is grateful to them for the presentations and summary papers they contributed to this report. The individuals who presented scientific and program posters during the INACG Symposium contributed greatly to breadth and depth of the meeting discussions and facilitated the expansion of networks devoted to reducing iron deficiency anemia.

Ms. Hilary Creed-Kanashiro and Ms. Boitshepo ("Bibi") Giyose served ably as the rapporteurs for the meeting, generously offering their skills to provide a comprehensive summary of the symposium for this publication.

Finally, the meeting attendees were the true success of this event. Hopefully, they gained new insights and information that will help foster vital iron deficiency and anemia control programs in their own countries.

The Micronutrient Global Leadership project is a cooperative agreement of the Office of Health, Infectious Diseases and Nutrition, Global Health Bureau, U.S. Agency for International Development with the International Life Sciences Institute (ILSI) Research Foundation. The ILSI Research Foundation's Human Nutrition Institute serves as the INACG Secretariat.



2004 INACG Symposium

Thursday, 18 November 2004

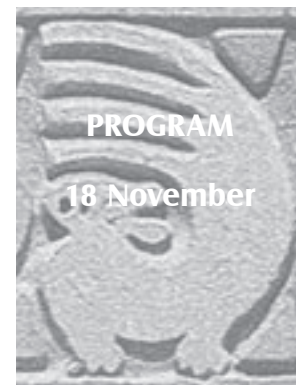


0815		Welcome Dr. Frances R. Davidson
0830		Keynote Address: Maternal Nutritional Status, Fetal Growth and Iron Status During Infancy Dr. Caroline Fall
0900		Open Discussion
0910		Advances in Assessment Chair: Dr. Lena Davidsson
0910		Iron Requirements and Iron Status During Infancy Dr. Magnus Domellöf
0930		Report on the WHO/CDC Consultation on Iron Status Indicators Dr. Bruno de Benoist
0940		Open Discussion
1010		Poster Session 1 and Break
1110		Supplementation Trials Chair: Dr. Sean Lynch
1110		Overview Dr. Olivier Fontaine
1120	Th82*	Mortality Risk Is Not Affected by Iron-Folate Supplementation among Preschool Children in Nepal Dr. Subarna Khattry
1130		Effect of Iron-Folate Supplementation on Hospitalization and Mortality in a High Malaria Transmission Setting Dr. Sunil Sazawal
		Commentary
1140		Dr. Kenneth Brown
1150		Dr. Sean Lynch
1200		Open Discussion
1230		Lunch
1430		Child Development Chair: Dr. Rebecca Stoltzfus
1430	Th83	Effect of Iron Supplementation on Mental and Motor Development in Children: Evidence from Randomized Controlled Trials Dr. Tarun Gera
1445	Th84	Different Effects of Iron and Zinc Supplementation on Growth in Anemic and Non-Anemic Infants Dr. Marjoleine Dijkhuizen
1455	Th85	A Low-Cost Fortified Baby Porridge Improved Iron Status and Motor Development of 6- to 12-Month-Old Infants Dr. Mieke Faber

* Readers can use the codes next to presentation titles to locate abstracts of the presentations beginning on page 49.

Thursday, 18 November 2004 (continued)

- 1505 **Th86** Positive Effects of Zinc and Iron-Folic Acid Supplementation on Time to Walking and Infant Behavior among 5- to 18-Month-Old Zanzibari Infants
Dr. Patricia Kariger
- 1515 Open Discussion
- 1530 **Program Implementation**
Chair: Mrs. Rosanna Agble
- 1530 **Th87** Implementing Strategic Communication Plan to Reduce Anemia in Pregnant Women in Ghana
Mrs. Kate Quarshie
- 1545 **Th88** Anemia Rates Significantly Reduced in Nicaragua
Dr. Josefina Bonilla
- 1555 **Th89** Effectiveness of Soy Sauce Fortified with NaFeEDTA for Reducing Anemia in West Java, Indonesia
Dr. Saskia de Pee
- 1605 **Th90** Baobab Fruit Pulp (*Adansonia digitata* L.) Improves Iron Status in Nigerian Children
Dr. Ngozika Nnam
- 1615 **Th91** Integrated Programming, Including Home-based Fortification Using “Sprinkles,” Is an Effective Strategy for Addressing Anemia in Mongolian Children
Dr. Solongo Altangerel
- 1625 **Th92** Reduced Anemia through Biannual Deworming Brings Brighter Future for Preschool Children in Nepal: Deworming Impact Evaluation Study
Mr. Pragya Mathema
- 1635 Open Discussion
- 1655 Closing Remarks
Dr. Lena Davidsson
-
- 1710 **Poster Session 2**
-
- 1800 End of INACG’s formal sessions
- 1900–2000 Evening Session 1: Fortifying the Fight Against Poverty: GAIN’s Way of Working with Countries
Global Alliance for Improved Nutrition (GAIN)
- 2030–2130 Evening Session 2: Examination of Venous and Capillary Blood Specimens for Assessment of Vitamin A Deficiency in Thailand
Program for Appropriate Technology in Health (PATH)



Thursday Posters

Posters on Assessment



- Th1** Ferritin Concentrations in Dried Serum Spots Prepared by Field-Friendly Approaches: A Validation Study in Guatemala
Dr. Namanjeet Ahluwalia
- Th2** Simple Dietary Tool Predicts Hemoglobin Concentrations in Ugandan Children
Dr. Phil Harvey
- Th3** Relationship of Iron Reserves and Anemia in Pregnant Women
Dr. Senarath Mahamithawa
- Th4** Comparison of Indicators of Iron Status in Children and Women in the United States
Dr. Zuguo Mei

Posters on Supplementation

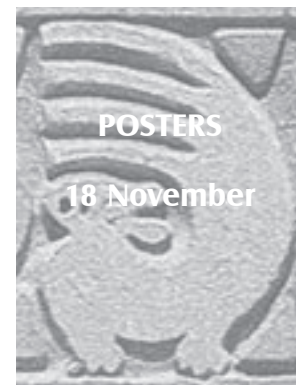
- Th5** Weekly Iron-Folate Supplementation for More Than 6 Weeks Improves Iron Status of Reproductive-Age Women: An Evaluation Study
Dr. Imelda Angeles-Agdeppa
- Th6** Effectiveness of Biweekly Versus Daily IFA Administration on Anemia Status in Preschool Children in India
Dr. Shally Awasthi
- Th7** Dietary Iron Intake and a Food-Based Approach in Prevention of Anemia in Tanzania
Dr. Simon Tatala
- Th8** Cost-Effectiveness of Combined Deworming and Weekly Iron Supplementation in the Reduction of Anemia among Preschoolers
Mrs. Lorena Wambangco-Tengco
- Th9** Effectiveness of a Redesigned Iron Supplementation Delivery System for Pregnant Women
Mrs. Lorena Wambangco-Tengco
- Th10** Patterns of Compliance to Maternal Iron Supplementation
Dr. Nelly Zavaleta

Posters on Child Development

- Th11** The Effects of Iron-Deficiency Anemia on Caregiver Infant Interaction: A Coding System
Dr. Jane Kvalsvig
- Th12** Effects of Iron and Zinc Treatment on Cognitive Function of Lead-Exposed Mexican Schoolchildren
Dr. Katarzyna Kordas

Thursday Posters (continued)

- Th13** The Effects of Iron Supplementation and Anthelmintic Treatment on the Social and Emotional Behavior and Development of Preschoolers on Pemba Island, Zanzibar
Dr. Jane Kvalsvig
- Th14** Iron Status Affects Cognition in Young Adult Women
Dr. Laura Murray-Kolb
- Th15** Associations between Iron and Zinc Status and Cognitive Performance in School-Aged Children in Indonesia and Australia
Dr. Saskia Osendarp
- Th16** Effect of Zinc and/or Iron-Folate Supplementation on Fagan Test Score in 39- and 52-Week-Old Children Living in South-Central Nepal
Ms. Emily Siegel
- Th17** The Effect of Multiple-Fortified Salt on the Hemoglobin and Cognition of School-Aged Children
Mrs. Malavika Vinod Kumar



Posters on Program Implementation

- Th18** Barriers to Maternal Anemia Control in Rural Mali
Dr. Víctor M. Aguayo
- Th19** Resorting to Radio Clubs to Enhance Nutritional Status in Two Health Districts in Niger
Mr. Issa Baguirbi
- Th20** The Efficacy of Iron Pots and Steel Pots in Reducing Prevalence of Anemia in Vietnam: Report of Midline Findings
Dr. Peter Berti
- Th21** Community-Based Distribution of Iron+Folic Acid in Niger: Success and Challenges
Ms. Aissa Mamadoultai bou
- Th22** Reduction of Iron Deficiency Anemia and Improvement of Nutritional Status of Children in Conflict Situation: Implementation, Challenges and Success in Yatta Town, West Bank
Mr. Mohammad Jaber
- Th23** Positive Deviance Approach to Improve the Impact of Iron-Folate Supplementation in Senegalese Pregnant Women
Mr. Mamadou Ndiaye
- Th24** Communication Strategy to Prevent Iron Deficiency Anemia in Women and Children
Ms. Irma Yolanda Núñez

Thursday Posters (continued)



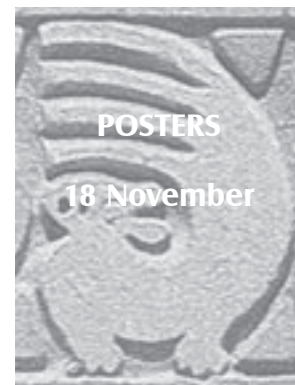
- Th25** Weekly Iron Supplementation among Primary School Children in Burkina Faso: Improving Coverage
Dr. C. Ouédraogo
- Th26** Community-Based Iron+Folic Acid Supplementation and Nutrition Education for Pregnant Women: Findings from Manica Province, Mozambique
Mr. Maurício Pene
- Th27** Effectiveness of School-Based Iron and Folic Acid Supplementation for Adolescent Girls: Findings from Manica Province, West-Central Mozambique
Mr. Maurício Pene
- Th28** Reducing Iron Deficiency Anemia among Pregnant Mothers and Children in Gaza and the West Bank (GWB): Innovative Approaches for an Emergency Situation
Ms. Heba Al Qedwa
- Th29** Improving Nutritional Status of Palestinian Schoolchildren
Dr. Mohammed Rimawi
- Th30** Foods Naturally Rich in Iron Increase Hemoglobin Concentration among Anemic Indonesian Adolescents
Mrs. Mayang Sari
- Th31** Management of Anemia in Pregnant Women: Health Agents' Practices and Opinions
Mrs. Ann Tarini
- Th32** Iron Deficiency Anemia Prevention and Control Program in Kazakhstan
Prof. Shamil Tazhibayev
- Th33** Designing a Program for Large-Scale Delivery of 'Sprinkles'
Mr. Joris van Hees
- Th34** Small Animal Revolving Fund Addresses Iron Deficiency Anemia in Malawi
Mrs. Miriam Yiannakis
- Th35** Rehabilitative Assistance, Educational Program in Rural Gaza-Strip: The Prevalence of Anemia in Palestinian Territories is Critical
Ms. Hegazi Yusur

Posters on Bioavailability

- Th36** Human Milk as a Source of Ascorbic Acid: No Enhancing Effect on Iron Bioavailability from a Complementary Food
Dr. Lena Davidsson

Thursday Posters (continued)

- Th37** Enzymatic Treatment of High-Tannin Sorghum Increases the Bioaccessibility of Iron
Mrs. Erika Matuschek
- Th38** The Effect of Particle Size Reduction and Encapsulation of Ferric Pyrophosphate on Bioavailability in Rats
Ms. Rita Wegmüller



Posters on Biofortification

- Th39** Towards Absorption and Enhanced Iron Accumulation in Rice Endosperm
Dr. Karabi Datta
- Th40** Biofortified Rice Improves the Iron Status of Iron-Deficient Women
Dr. Laura Murray-Kolb

Posters on Fortification

- Th41** Regular Consumption of Complementary Foods Fortified with Micronutrients Improves Iron Status of Vietnamese Infants
Dr. Jacques Berger
- Th42** Iron and Vitamin A Content of Fortified Flour in Selected Flour Mills in the Philippines
Ms. Aegina Bolima
- Th43** Effect of Packaging Materials on the Retention of Vitamin A, Iron and Iodine in Fortified Soy Sauce
Dr. Mario Capanzana
- Th44** Retention of Vitamin A, Iron, and Iodine in Fortified 'Bihon' Noodle
Dr. Mario Capanzana
- Th45** Scale-up of Production of Salt Double-Fortified with Iodine and Iron
Prof. Levente Diosady
- Th46** Effect of Folic Acid Fortification of Wheat Flour on Anemia Prevalence in Women
Dr. Eva Hertrampf
- Th47** Increased Prevalence of Iron Deficiency Due to Withdrawal of Iron Fortification of Flour in Sweden
Prof. Lena Hulthén
- Th48** Efficacy of Daily vs Weekly Home Fortification of Weaning Foods with 'Sprinkles' among Infants and Young Children in Bangladesh
Dr. Ziauddin Hyder
- Th49** Efficacy of 'Sprinkles' Home Fortification to Reduce Anemia and Micronutrient Deficiencies in Young Children in Indonesia
Ms. Elviyanti Martini

Thursday Posters (continued)



- Th50** Effectiveness of NaFeEDTA-Fortified Fish Sauce in Controlling Iron Deficiency in Vietnam
Dr. Pham Van Thuy
- Th51** Consumer Acceptance of a Home Food Iron Fortificant
Dr. David Yeung
- Th52** Village-Level Micronutrient Fortification in Malawi
Mrs. Miriam Yiannakis
- Th53** Stability of Iron-Fortified, Roller-Milled Wheat Flour in Pakistani Storage Conditions
Dr. Aurang Zeb
- Th54** Iron-Fortified Extruded Rice
Dr. Michael Zimmermann
- Th55** Dual Fortification of Salt With Iodine and Micronized Ferric Pyrophosphate: A Randomized, Double-Blind, Controlled Trial
Dr. Michael Zimmermann
- Th56** Home Fortification Using 'Sprinkles' Containing 12.5 mg of Iron Successfully Treats Anemia in Ghanaian Infants and Young Children
Dr. Stanley Zlotkin

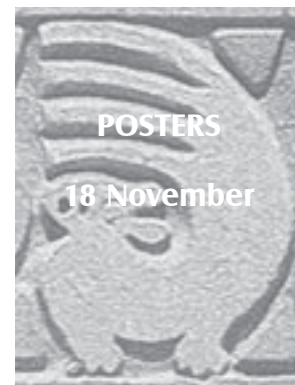
Posters on Multiple Micronutrients

- Th57** Efficacy of Multiple Micronutrient Supplementation on Hemoglobin and Micronutrient Status among Anemic Adolescent Girls in Bangladesh
Dr. Faruk Ahmed
- Th58** Can Megadose of Vitamin A Enhance the Impact of IFA and Vitamin C Supplementation on Improving Hb Levels?
Dr. Umesh Kapil
- Th59** Daily Multi-Micronutrient Supplementation for Addressing Micronutrient Deficiency and Growth Faltering in Infants: The Four-Country Iris Trial Pooled Data Analysis
Dr. Marius Smuts
- Th60** Interactive Effects of Iron, Zinc and Calcium on Availability from a Rice-Based Meal: An In Vitro Assessment
Ms. Leah Perlas
- Th61** Daily Iron and Daily Multiple-Micronutrient Foodlets Are Efficacious in Improving Body Iron Stores of Indonesian Infants Aged 6-12 Months
Mrs. Maria Wijaya-Erhardt
- Th62** Changes in Iron Deficiency Anemia and Zinc Status in Children Supplemented with Iron and/or Zinc in the Amazon Region
Dr. Nelly Zavaleta

Thursday Posters (continued)

Posters on Determinants of Anemia

- Th63** Anemia in Mongolian Children 0–5 Years: A Study of the Role of Iron, Folic Acid and Vitamin B12
Dr. Solongo Altangerel
- Th64** Determinants of Anemia and Associated Factors among Children 0–59 Months of Age in Rural Tanzania
Ms. Elizabeth Macha
- Th65** Determinants of Iron Deficiency Anemia in the Philippines
Dr. Corazon Barba
- Th66** Determinants of Micronutrient Status of 0–5-Year-Old Children
Mrs. Wilma Molano
- Th67** Predictors of Anemia in Rural Kenyan Children: Malaria, Infection, Vitamin B12 and A, and Meat Intake
Dr. Charlotte Neumann
- Th68** Prevalence and Risk Factors of Anemia among Women and Children in Benin
Mr. Ismael Ngnie Teta
- Th69** Impact of Maternal Iron Status on Child Care Practices of Nursing Mothers from the Lower Socioeconomic Groups of Delhi
Dr. Santosh Jain Passi
- Th70** Anemia and Body Mass Index of Sri Lankan Adolescents
Dr. Sanarath Mahamithawa
- Th71** Seasonality, Maternal Iron Intake and Hemoglobin Status Compared with Pregnancy Outcome in Women from Poorer Strata
Dr. Bani Tamber Aeri
- Th72** Role of Iron Deficiency in the Etiology of Anemia in Schoolchildren in Northeast Thailand Is Overestimated
Dr. Pattanee Winichagoon



Posters on Recent Surveys

- Th73** Iron Deficiency Anemia in Preschool Children and Women of Eritrea
Dr. Zemui Alemu
- Th74** Iron Deficiency: A Problem among Urban Adolescent Girls and Women of Childbearing Age in Sri Lanka
Prof. Sunethra Atukorala
- Th75** Weaning Practices in Rural and Urban Côte d'Ivoire and Implications for Iron Bioavailability
Dr. Fatoumata Camara

Thursday Posters (continued)



- Th76** Variation in Iron Deficiency Anemia Prevalence in Schoolchildren from Neighboring Villages in Northern Morocco
Dr. Sonja Hess
- Th77** Concomitant Prevalence of Iron and Zinc Deficiency in Pregnant and Non-Pregnant Women in Rural India
Dr. Umesh Kapil
- Th78** Iron Deficiency Anemia among Children under Five in Indonesia: An Alarming Call for Action
Ms. Elviyanti Martini
- Th79** Iron Status of Children under Five in Nigeria: Results of the Nigeria Food Consumption and Nutrition Survey
Dr. Busie Maziya-Dixon
- Th80** Prevalence of Hematinics Deficiency among Female Students and Its Correction
Dr. Bhupatrai Mehta
- Th81** National Prevalence of Anemia in Children Between 12 and 35 Months Old and Childbearing Women
Prof. Carlos Rojas Dávila

Report of the 2004 International Nutritional Anemia Consultative Group Symposium: Iron Deficiency in Early Life: Challenges and Progress

18 November 2004, Lima, Peru

The International Nutritional Anemia Consultative Group (INACG) held its fourth international symposium, "Iron Deficiency in Early Life: Challenges and Progress," in Lima, Peru, on 18 November 2004. The symposium was attended by approximately 800 policy makers, program managers, and scientists from 71 countries.

Welcome

Dr. Frances Davidson, of the US Agency for International Development (USAID), in Washington, DC, USA, and who also serves as Secretary of INACG, opened the symposium. In her welcome remarks and opening statement, Dr. Davidson noted with emphasis the lack of adequate attention to micronutrient malnutrition, especially that of iron. This is unfortunate given the very high prevalence of iron deficiency and anemia worldwide. The debilitating effects and developmental consequences brought about by the deficiency of this important nutrient, particularly in early life, are tragic. She

went on to highlight the issues at hand by noting that infectious diseases such as malaria contribute to this situation. Given this scenario, Dr. Davidson emphasized the need for strong and successful policies worldwide.

Given that micronutrient deficiencies usually overlap, and do not appear as isolated problems, it is critical for scientists, policy makers, and program managers to work together toward the prevention and eradication of micronutrient malnutrition. She added that there have been recent positive highlights in research and program efforts internationally, and that lessons from these must be learned and applied.

In conclusion, Dr. Davidson recognized that there is significant progress overall in iron deficiency/iron deficiency anemia prevention and control, but was quick to impress upon the participants that more work still needs to be done in order to reach the public health goals set by nations.

All contents presented in this report are the work of the authors and do not necessarily reflect those of INACG, USAID, or the International Life Sciences Institute.

Keynote Address: Maternal Nutritional Status, Fetal Growth, and Iron Status during Infancy

Dr. Caroline Fall, of the University of Southampton, in Southampton, UK, at the outset noted that the amount of literature on iron is enormous and can also be confusing. She acknowledged that there is agreement on a few points. One of these is that there is an increased requirement for iron during pregnancy, both to achieve an increase in maternal red cell mass and to satisfy fetal requirements. Despite increased iron absorption, it is difficult for the mother to meet these requirements from dietary sources alone. Iron supplements are therefore often prescribed in an attempt to maintain or improve maternal iron status.

The rationale for prescribing iron to pregnant women is also based on the belief that this improves functional outcomes for both the mother and fetus. Iron deficiency is thought to impair maternal well-being and survival; it may also impair fetal growth and increase the risk of preterm delivery, and is thought to impair fetal iron status, resulting in iron deficiency in infancy and adverse effects on postnatal physical growth, neurodevelopment, and immune function. However, the evidence for these effects is somewhat poor, necessitating further research.

While it is undisputed that there are associations between maternal anemia and/or iron deficiency and adverse pregnancy outcomes, these may not be causal. Iron deficiency is often one element in a cluster of nutritional and social deprivations resulting from poverty, which may underlie these associations, rather than iron deficiency itself.

One of the difficulties in assessing the effects of iron deficiency on fetal growth is that of measuring iron status during pregnancy. A normal maternal adaptation to pregnancy is plasma volume expansion, a phenomenon that is detectable within 5 to 6 weeks of conception, and increases up to about 20 to 25 weeks of gestation. Although red cell mass increases, it does not keep pace with plasma volume expansion, leading to a normal drop in hemoglobin even in iron-replete women. In many normal pregnancies, hemoglobin dips to below the level that defines anemia. Greater plasma volume expansion is thought to increase blood flow to the fetoplacental unit, and is associated with better pregnancy outcome. Failure to expand plasma volume, for example, in pathological conditions such as preeclampsia, is associated with an increased risk of low birth weight, prematurity, and fetal loss. As a result, the relationship between maternal hemoglobin and adverse outcomes such as intrauterine growth restriction or preterm delivery tends to be positive. There is an increased risk of adverse outcome at both extremes of the hemoglobin distribution, most markedly at higher hemoglobin concentrations. Poor outcomes at high hemoglobin levels probably have nothing to do with iron status; they are more likely a reflection of whatever pathology leads to poor plasma volume expansion. Adverse outcomes at very low hemoglobin levels may reflect an association with iron deficiency.

Thus, there are two factors lowering hemoglobin in pregnancy: one of these, plasma volume expansion, is associated with better pregnancy outcomes, while the other, iron deficiency, may be associated with poor pregnancy outcomes. This phenomenon would tend to mask any

effects of iron deficiency or anemia on fetal growth.

Serum ferritin concentration, often used to assess iron status, is correlated with maternal iron stores as measured by bone marrow iron. However, plasma volume expansion also affects this measure, and the relationship between maternal ferritin concentration and birth weight also tends to be inverse. This appears to be true even in populations with high rates of maternal iron deficiency. For example, data from an observational study conducted by Dr. Fall and her colleagues in Pune, India¹ showed that mean birth weight is lower and rates of intrauterine growth restriction are higher at higher maternal ferritin concentrations. Another problem with ferritin is that it is an acute-phase reactant and increases in the presence of infection, which is another possibility with poor fetal growth. While the drop in hemoglobin in early gestation may mask any effects of iron deficiency, the upturn in hemoglobin toward the end of gestation could have the opposite effect, leading to spurious associations between anemia recorded in late gestation and preterm delivery.

Dr. Fall emphasized the need for better measurements of iron status during pregnancy. Most methods that are commonly used have disadvantages, but transferrin receptors have a number of theoretical advantages. These receptors are shed into the blood in increased amounts because of increased expression on the surface of iron-deficient cells. Transferrin receptors are therefore thought to reflect "tissue need" and to be a functional measure of iron deficiency. They are not influenced by plasma volume expansion, are not acute-phase reactants, and are relatively easy to measure. However, so far, transferrin receptors have not been extensively studied in pregnant women.

One solution to the problem of assessing iron status during pregnancy is to measure it before conception. However for obvious reasons, few studies have done this. Randomized, controlled trials provide the best evidence of causal effects, and a large number of supplementation trials have been

performed. The main conclusions were that iron supplements clearly improve indices of iron status, but the evidence that they improve other maternal outcomes and outcomes for the baby are inconclusive.

Two recent trials suggest that iron supplementation may improve fetal growth. The first was in non-anemic and iron-replete US women, who were randomized to receive iron (30 mg/d) or placebo.² Mean gestational age at the start of supplementation was 11 weeks, and supplementation continued until 28 weeks, when all subjects were given iron. There were no differences in maternal hemoglobin or ferritin concentration at 28 weeks, but birth weight was increased by 206 g and gestational length by 0.6 weeks in the iron group. There were significant reductions in the incidence of smallness for gestational age and preterm low birth weight as well. The other trial was a cluster-randomized study in an undernourished population at high risk of iron deficiency in Nepal.³ The control group received folate alone, and the other groups received folate and additional iron, folate and iron plus zinc, or folate and multiple micronutrients (including iron and zinc). The results showed an increase in mean birth weight and a reduction in small for gestational age births in the folate plus iron group. Interestingly, there was no increase in birth weight in the folate plus iron and zinc group (possibly attributable to interference with iron absorption), and no additional effect in the multiple micronutrient group.

On assessing the benefits of iron supplementation, Dr. Fall noted that there are possible adverse effects. Three that relate to fetal growth are increased blood viscosity, oxidative damage, and an increased risk of maternal infection. There is a theoretical risk that iron may cause an excessive increase in hemoglobin, hyperviscosity, and reduced placental blood flow; however, this seems unlikely given that viscosity tends to increase only at very high hemoglobin concentrations. A study in Finland found no evidence of a harmful effect of supplementation on birth weight or other outcomes.⁴

Several studies^{5,6} have shown an increase in rates of malaria in women on iron supplementation, especially first-time mothers. Clearly, untreated iron deficiency is not the ideal way to control malaria, but on the other hand, an increased risk of malaria from iron supplements does have to be taken account in endemic areas. However, a study in the Gambia⁷ (a country with a high prevalence of malaria), which was limited to women who had had multiple pregnancies, showed an increase in hemoglobin and birth weight in iron-supplemented mothers, but no increase in malaria. There is no other convincing evidence that other infections are increased in women on iron supplements, but there are few data.

Iron plays a role in reactions that lead to the production of reactive oxygen species, which are thought to cause tissue damage, especially to DNA and lipid constituents of cell membranes. Theoretically, the placenta is at risk of free radical damage because of a high density of mitochondria, and iron could enhance this risk, leading to membrane damage and impaired nutrient exchange. There are several studies^{8,9} on free radical damage as a result of iron deficiency and as a result of iron treatment.

Dr. Fall explained that the majority of fetal iron accretion takes place in the third trimester as a result of active transport by specific iron transporters. Increased fetal demand leads to up-regulation of transferrin receptors on the maternal apical surface of the syncytiotrophoblast. There is good evidence that iron transfer to the fetus increases in mothers with lower iron status; however, there is also evidence that once the mother becomes anemic, iron transfer to the fetus diminishes and there is a risk of fetal iron deficiency. Measurement of iron status is unreliable in the newborn, and maternal iron status frequently shows no correlation with neonatal iron status. However, in later infancy, infants of iron-deficient women have been shown to have poorer iron status.

Some interesting studies^{10,11} in infants of mothers with gestational diabetes have shown markedly low levels of iron in

tissues such as the brain, heart, and liver. Gestational diabetes is characterized by polycythemia (a condition marked by abnormal increases in the number of circulating blood cells) in the fetus, and it is thought that fetal iron is prioritized to erythropoiesis at the expense of other tissues. In the nervous system, iron is required for energy metabolism, neurotransmitter production, and myelination. Animal studies show functional neurological deficits in low-iron conditions, and suggest that the hippocampus in the brain is particularly vulnerable. This phenomenon has not been studied extensively in humans.

Follow-up of infants from randomized trials of iron supplementation during pregnancy show significantly increased iron status in those whose mothers received iron. A study done in Niger¹² showed that iron supplementation during pregnancy improved iron status of infants born to the supplemented mothers. A study from New Delhi¹³ examining the effect of delayed cord clamping on infant iron status showed improved iron status at 3 months. Iron deficiency in infancy has been associated with impaired cognitive ability and immune dysfunction, and trials of iron supplementation during infancy have shown evidence of improved neurodevelopment. However, the role of maternal iron status in determining these functional outcomes in infancy and the effect of maternal iron supplementation are not clear. There is therefore a need for continuing follow-up of the infants born in these trials.

The main conclusions of Dr. Fall's keynote address were:

- Standard methods of assessing iron status during pregnancy may underestimate the adverse effects of iron deficiency on fetal growth seen in observational studies.
- Trial evidence suggests possible benefits of maternal iron supplementation on newborn size (fetal growth has not been examined), but more evidence is required.

- Infants of iron-deficient mothers are at increased risk of iron deficiency, but the benefits of maternal iron supplementation have not been well studied.
- There is no evidence that iron supplementation has harmful effects on the fetus.

Open Discussion

To start off the discussion, a member of the audience from the University of the Western Cape in South Africa suggested that a broader view of micronutrients should be taken—studies should include more than just iron, and the mothers and infants should be followed for a longer duration and assessed for functional effects as well.

Dr. Fernando Viteri, of the University of California, in Berkeley, California, USA, commented that the times when iron status is critical for fetal development are the first and second trimesters. The risk of low birth weight and preterm weight appear to be detected at week 28 of pregnancy but not at birth. Therefore, many of the effects seen at birth are probably misleading. Thus, it is supplementation in the first trimester that has an effect. Dr. Viteri also mentioned that pre-conception supplementation and continued supplementation during pregnancy have shown an increase in infant birth weight in women entering pregnancy with a better iron status.

Advances in Assessment

Iron Requirements and Iron Status during Infancy

Dr. Magnus Domellöf, of Umea University, in Umea, Sweden, presented and discussed iron requirements and iron status during infancy. He opened the discussion by noting that measuring iron in infants is problematic, so several indicators are used simultaneously. Dr. Domellöf said that there are basically four factors that make it difficult to measure iron in infants: 1) there are inherent difficulties with the six known measures of iron status (hemoglobin, mean

cell volume, transferrin saturation, serum ferritin, transferrin receptor, and zinc protoporphyrin), 2) there are large changes in iron status in infants, 3) there is poor correlation between iron status variables in early infancy, and 4) there are clear sex differences.

A healthy, term, newborn infant has about 260 mg of total body iron, corresponding to 75 mg/kg. Most of this iron is bound to hemoglobin but iron stores are also generous. After birth, the hemoglobin concentration decreases as the iron is released to stores. In the following months, the iron is shifted from stores to hemoglobin as the baby grows and the total blood volume increases. Thus, the baby is virtually self sufficient during the first 6 months, but after that time the total body iron needs to be increased by about 200 mg, and so iron requirements increase.

In explaining the poor correlation between iron status variables in early infancy, Dr. Domellöf noted that the correlation coefficients between hemoglobin and several other iron status variables in healthy infants are very low at 4 to 6 months of age, and improve at 9 months, suggesting that these indicators may be poor markers of iron status in early infancy.

As far as sex differences are concerned, there is a 10-fold increased risk of boys being diagnosed with iron deficiency anemia at 9 months. This is partly due to a more rapid growth rate in boys compared with girls, but there may also be physiological differences between boys and girls for mean cell volume, zinc protoporphyrin, and ferritin.

Dr. Domellöf reported that serum ferritin has been validated as a marker of iron stores in adults but not in infants. Hemoglobin response to iron therapy is the gold standard for the diagnosis of iron deficiency anemia in adults and children, but has not been tested in infants. Hemoglobin response to iron was investigated in Honduran and Swedish children, and the conclusion was that iron metabolism is different in early infancy, so response to iron is not a useful marker of

iron deficiency anemia in infants, at least not before 6 months of age.¹⁴

Another way of validating iron status indicators during infancy is to compare changes in iron status indicators with the theoretical changes in iron compartments (iron bound to hemoglobin and iron in stores) in a typical infant expressed per kilogram body weight and normalized as a percentage of the normal adult level. The few studies done suggest that both zinc protoporphyrin and transferrin receptors are higher in neonates than in older infants, despite the fact that they are inversely related to iron status.^{15,16}

In regard to cutoffs for anemia and iron deficiency in infants, Dr. Domellöf said that the most commonly used value of 110 g/L for hemoglobin is extrapolated from older children and of 12 µg/L for serum ferritin is extrapolated from adults. To determine these cutoffs, normative population methods were used, including breastfed, iron-supplemented, and iron-replete infants.¹⁷ Using this technique, two standard deviations of reference limits for several iron status variables were calculated. However, a larger study is needed to verify these limits.

The four known strategies to prevent iron deficiency anemia are consumption of iron-rich complementary foods, supplementation with iron, commercial fortification of foods, and home fortification of foods. However, care must be taken as iron supplements can be toxic at high doses. There are several adverse effects of iron supplementation, including diarrhea and other abdominal symptoms. The most serious effect has been observed with iron drops, not with iron-fortified foods. Therefore, it is important to study not only the efficacy but also the safety of new forms of supplements.

In conclusion, Dr. Domellöf emphasized three key points:

1. Definitions of anemia and iron deficiency in infants need to be re-evaluated using new techniques. Some mechanisms that have been studied

in adults (e.g., transport proteins and other factors such as hepcidin) need to be studied in infants as well.

2. It is important to continue performing randomized, clinical trials of iron supplementation, including “Sprinkles,” spreads, and multinutrient supplements. These studies should focus on safety and on long-term outcomes, not just on changes in iron status, since we currently do not know the relationship between iron status in infants and their health later in life.
3. Until we know more, iron supplementation should be targeted to those with the highest iron requirements. Studies are needed to evaluate practical methods to identify these groups and individuals.

Open Discussion

A participant asked whether there should be different recommended daily allowances for iron for boys and girls. Dr. Domellöf replied that there may be physiological differences and not necessarily deficiency, and therefore we should look at health outcomes. It is possible that boys are less sensitive to iron deficiency in infancy.

Dr. Rebecca Stoltzfus, of Cornell University, in Ithaca, New York, USA, asked about the basis for the calculations of total body iron in newborns. Dr. Domellöf responded that they were based on the body composition analyses performed by Widdowson in the 1950s.¹⁸ A member of the audience asked whether young infants have any control in iron absorption. It was clarified that infants are able to regulate iron absorption and respond to iron deficiency with a significant increase in the absorption of iron. However, down-regulation of iron absorption in iron-replete infants does not seem to occur in early infancy.

Report on the WHO/CDC Consultation on Iron Status Indicators

Dr. Bruno de Benoist, of the World Health Organization (WHO), in Geneva, Switzerland, presented a summary of the

report of the joint WHO and US Centers for Disease Control and Prevention (CDC) technical consultation on assessment of iron status in populations. The consultation was held on 6–8 April 2004 in Geneva, Switzerland.

Dr. de Benoist underscored that iron deficiency is an important public health problem with consequences for cognitive and physical development of children and work productivity in adults. The objectives of the consultation were to:

- Review the indicators currently available to assess iron status;
- Select the best indicators to assess iron status at the population level and to evaluate the impact of iron interventions to control iron deficiency; and
- Identify priorities for research.

A WHO/CDC working group was set up, which undertook literature reviews on iron status indicators currently available and analysis of 10 double-blind, randomized, controlled iron intervention studies to evaluate the performance of five indicators (hemoglobin, zinc protoporphyrin, mean cell volume, transferrin receptors, and serum ferritin) in predicting changes in and assessing iron status.

Of the five indicators of iron status, three were recommended: hemoglobin, serum ferritin, and transferrin receptors. If possible, the acute-phase protein C-reactive protein and/or α -1 acid glycoprotein should also be measured. The thresholds to interpret data on serum ferritin and transferrin receptors still need to be validated. Serum ferritin and hemoglobin were recommended for the evaluation of the impact of interventions to control iron deficiency. Again, if possible, C-reactive protein and/or α -1 acid glycoprotein and transferrin receptors should be measured.

The following six priorities for research were identified: 1) produce an international reference manual to standardize transferrin receptor assays, 2) review existing data to validate proposed thresholds for serum

ferritin and transferrin receptors, 3) examine performance of indicators used to assess outcomes in iron interventions, 4) review existing data to select the best amyloid precursor protein, 5) develop field methods, and 6) continue to look at alternative indicators such as zinc protoporphyrin, hepcidin, etc.

In conclusion, Dr. de Benoist highlighted two key points: the assessment and monitoring of iron status should be encouraged, and the performance of the proposed indicators and their interpretation need to be further documented and validated.

There were several posters highlighting the pros and cons of using certain methods to assess iron levels in pregnant women and infants, as well as the benefits of supplementation. For example, a study from Sri Lanka on the relationship between iron reserves and anemia in pregnant women concluded that iron status is not adequately detected by hemoglobin estimations, and that the prevalence of storage iron deficiency is 2.7 times higher than that of anemia (Th3*).

Open Discussion

Dr. Lindsay Allen, of the University of California, in Davis, California, USA, asked for a consensus on the use of indicators such as transferrin receptors in areas where malaria is endemic. These indicators are specifically recommended in these areas because they are not affected by infection. Dr. Allen expressed concern that there is a lack of standardization on how these indicators and their cutoff points are used. Dr. James Cook, of the University of Kansas, in Kansas City, Kansas, USA, commented that there is not enough information on transferrin receptors in malarial infections and that transferrin receptor levels may be affected by other factors related to the stage of the infection.

Dr. Sean Lynch, of the Eastern Virginia Medical School, in Norfolk, Virginia, USA, said that hemoglobin rather than hematocrit is the best indicator for anemia,

and that serum ferritin in combination if possible with serum transferrin receptor levels is the best indicator for measuring iron status in older children and adults in population surveys. Serum ferritin alone has performed well in demonstrating improvements in iron status and can be used to determine whether interventions are likely to be effective. It is however difficult to know what the best indicator is for children 6 to 12 months of age, and more research is needed. It is also necessary to stimulate research to find less expensive indicators and methods that are appropriate for developing countries.

Dr. Nelly Zavaleta, of the Instituto de Investigación Nutricional, in Lima, Peru, commented on the use of serum ferritin and the need to exclude subjects with high ferritin as a result of infection, thus raising the question of how useful this indicator is in developing countries with high levels of infection. Dr. de Benoist answered that the confounding effect of infection has been acknowledged as a problem. C-reactive protein does not work well as a method for correcting for the effect of infection, especially in the presence of malaria. Because of these limitations, transferrin receptors may be more helpful. Clearly, other indicators need to be explored.

Supplementation Trials

Overview

Dr. Olivier Fontaine, of the WHO, in Geneva, Switzerland, presented an overview of three supplementation trials to evaluate the effects of zinc and/or iron on childhood mortality. In many countries, iron-folic acid supplements are recommended after 2 months of age, and a system of procurement and distribution of iron-folic acid supplements is often already in place. Therefore, if adding zinc to the iron-folic acid supplement was demonstrated to have a substantial impact on mortality and severe morbidity, zinc could be added in public health interventions to the iron-folic acid formulation with marginal additional costs.

** Readers can use the codes next to presentation descriptions to locate the abstracts of the presentations beginning on page 49.*

The studies discussed by Dr. Fontaine were conducted in Delhi, India, Sarlahi, Nepal, and Pemba Island, Zanzibar, Tanzania. Children enrolled in the studies were between 1 and 35 months of age, and the population sizes ranged from 25,000 in Nepal to 35,000 in Zanzibar and 65,000 in India. The four treatment groups in Nepal and Zanzibar were: 1) placebo, 2) zinc supplementation, 3) iron-folic acid supplementation, and 4) zinc plus iron-folic acid supplementation. In India, because the recommendation to supplement children with iron and folic acid was already partly implemented, the inclusion of a placebo group was not feasible, and the trial included only two treatment groups (groups 3 and 4). The levels of supplementation were: 10 mg zinc as zinc sulfate (5 mg for infants under 12 months); 12.5 mg of iron as iron sulfate (6.25 mg for infants under 12 months); and 50 µg of folic acid (25 µg for infants under 12 months). The primary outcomes were all-cause mortality in all three sites; in India and Zanzibar overall hospital admissions and diarrhea- and pneumonia-specific hospital admissions were also considered. The study design was a household randomized, controlled trial in India and Zanzibar and a cluster randomized, controlled trial in Nepal. Hospital admissions were recorded by passive surveillance in a subset of hospitals in India and in all hospital facilities of Pemba Island, Zanzibar, whereas in Nepal there was no recording of hospital admissions.

The supplement was highly acceptable even by very young infants, presented as tablets that dissolved in 5 mL of water or breast milk in less than 30 seconds. The metallic aftertaste of zinc and iron was eliminated to make the taste similar to that of the placebo. This supplement is stable in tropical conditions for at least 2 years and is inexpensive. The process of developing the supplement to achieve this acceptable product took 18 months. Adherence to taking the supplement during the study was high at all three sites, ranging from about 70% in India to between 85% and 88% in Nepal and Zanzibar.

Dr. Fontaine explained that the studies were carefully monitored. Monthly reports were sent to WHO and to the data safety monitoring board (DSMB) for each site, the latter of which met every 6 months and made site visits. An independent audit was made of the Pemba site. This audit concluded that the trial was conducted according to the highest international standards of good clinical practice, that due attention was paid to all ethics requirements, and that the data presented for analysis were highly unlikely to contain any significant bias or errors in supplementation allocation or data acquisition that might lead to false-positive or false-negative results.

Impact of Iron-Folic Acid Supplementation on Preschool Child Morbidity and Mortality in Nepal

Following the overview of the three studies, Dr. Subarna Khattri, of the Nepal Nutrition Intervention Project, in Kathmandu, Nepal, presented the trial from the Sarlahi district, which is located in southern Nepal (Th82). Dr. Khattri began by noting that iron deficiency and anemia are common in young children in Nepal. National data show that 75% of preschool children are anemic, and data from prior research in the study area in the southern plains show that more than 50% of newborns are anemic by 12 weeks of age. Dr. Khattri suggested that, based on the success of iron supplementation in reducing the incidence of severe anemia, it would be reasonable to expect an overall reduction in mortality with universal iron supplementation in populations with high rates of iron deficiency anemia. However, he noted that few data are available on the impact of iron supplementation on morbidity and mortality, especially in areas with a high burden of non-malarial infectious disease, such as the study area in Nepal. Prior to policy decisions regarding universal supplementation, it is critical to understand the risks and benefits of such programs.

In order to determine the efficacy of daily iron-folic acid supplementation on mortality among preschool-age children, a population-

based, randomized community trial among children 1 to 35 months of age in 30 village development committees of the Sarlahi district was conducted. Specific aims were: 1) to assess the impact of daily zinc and/or iron-folic acid supplementation on mortality among children ages 1 to 35 months, and 2) to assess the impact of these interventions on morbidity, growth, and motor and cognitive development.

The study population was composed mostly of peasant farmers or laborers and their families. Sarlahi is considered a poor area even for Nepal, with almost three-quarters of the population below the poverty line. The study area was divided into 426 sectors, which were randomized to receive one of the four treatments mentioned in the preceding overview. In this study, all children received high-dose vitamin A supplementation (200,000 IU for those 12 months or older, 100,000 IU for those 6–12 months of age, and none for children under 6 months) twice per year as part of the national vitamin A program.

All enrolled children received their sector's assigned treatment. Children were enrolled at baseline or as they turned 1 month of age. Children were followed until 35 months of age. At approximately 12 months after supplementation was begun, a sample of children 24 months or older was selected for assessment of serum zinc status, hemoglobin, and serum ferritin. Two independent samples of approximately 1200 children each who were enrolled in the main trial and who were younger than 24 months of age were selected for participation in the morbidity sub-study. The first sample was followed for a full 12 months; the second sample was followed from enrollment in February 2003 through the time the iron-folic acid arms of the study were suspended in mid-November 2003.

The primary outcome in the study was all-cause mortality. Child deaths were ascertained during the vital status and supplementation visits conducted every week at the home. For any child found to have died, the process of death verification and cause of death determination was

initiated. A verbal autopsy conducted with members of the immediate family after an appropriate mourning period was used to assess cause of death. Secondary outcomes included cause-specific mortality, the incidence and severity of diarrhea, dysentery, and acute respiratory illness in the sub-samples.

The independent DSMB for the study met five times to review the protocol and data for safety and efficacy. At their July 2003 meeting, the DSMB suggested that the iron-folic acid-containing arms of the trial be stopped because of lack of impact on mortality. This was done in mid-November of 2003. Dr. Khatri's presentation reported on the comparisons of the primary and secondary outcomes between the placebo, iron-folic acid, and iron-folic acid plus zinc groups.

A total of 25,718 children were enrolled, resulting in a total of 30,218 child-years of follow-up. Baseline characteristics of the families and children were well balanced across treatment groups. Twelve months following the start of supplementation, both hemoglobin and serum ferritin values were significantly higher in the arms with iron-folic acid than in the placebo group. While over 6% of children in the placebo group had severe anemia (hemoglobin < 7 g/dL), less than 2% of children in the iron-folic acid arms of the trial were severely anemic. Similar differences were apparent for moderate anemia (hemoglobin = 7–9 g/dL) as well. Overall rates of anemia in the placebo group were approximately 60% compared with approximately 40% in the two iron-folic acid arms.

There was no difference in total mortality by treatment group, with relative risks of 1.00 for the iron-folic acid group and 0.98 for the iron-folic acid plus zinc group compared with placebo. The similarity of the mortality experience was also apparent when examining the Kaplan-Meier survival curves. There was no evidence of interaction of treatment group on mortality with sex, ethnic group, age, history of prior child death in the family, or baseline nutritional status.

There were no significant differences in the incidence of diarrhea, dysentery, or acute respiratory illness between the iron-folic acid-only or the iron-folic acid plus zinc and the placebo groups.

Providing daily supplementation with iron-folic acid or iron-folic acid plus zinc had no effect on mortality risk in this population of young Nepali children. It is unlikely that this lack of impact can be explained by the lack of iron and zinc deficiency in this population, as there were significant differences in hemoglobin and serum ferritin levels between the active treatment groups compared with the placebo group after approximately 12 months of supplementation. It is also unlikely that selection bias in recruitment into the study played a role in these findings, as participation rates exceeded 99% at enrollment for all three treatment groups. All three treatment groups had similar characteristics at baseline. Therefore, random imbalance in predictors of child mortality is an implausible explanation for our results. Despite this dramatic effect of treatment on the distribution of hemoglobin values in the population, the rates of morbidity and mortality were unchanged relative to placebo. Dr. Khattry suggested that it may be that limitations in iron status are not a rate-limiting response to infectious morbidity and mortality in this setting.

Dr. Khattry concluded that this trial found no effect of iron-folic acid supplementation on young child morbidity or mortality. While other outcomes may be positively affected by iron supplementation, he suggested that better evidence is needed to justify universal iron-folic acid supplementation in this setting.

Effects of Iron-Folic Acid Supplementation on Hospitalization and Mortality in a High Malaria Transmission Setting

Dr. Sunil Sazawal, of the Johns Hopkins Bloomberg School of Public Health, in Baltimore, Maryland, USA, presented the results of a trial conducted in a high

malaria transmission setting in Pemba Island, Zanzibar. This study had the same factorial design as the other two studies introduced by Dr. Fontaine, however, for this study, there was a preparatory phase during which a baseline survey was conducted and eligible children were selected. The children were randomized into one of the four treatment groups mentioned in the preceding overview. The intervention doses were the same as with the other studies, and all children received vitamin A. Follow-up included weekly home visits, hospital surveillance, and verbal autopsy. Dedicated laboratory technicians conducted the malaria counts. Five hospitals were included in the study, which were all maintained under surveillance with a study team in each hospital covering two shifts. Follow-up continued until 19 August 2003.

Based on the recommendations of the DSMB, the iron-folic acid arms were discontinued as of August 2003 and the study was converted to a two-arm trial of zinc versus placebo, which is still ongoing. In this session, Dr. Sazawal presented the results of the interim analysis of the iron-folic acid supplementation effect.

In this study, adverse events were considered to be the death of a child or a child requiring admission to a hospital (which included overall admissions and cause-specific admissions). A total of 14,000 children participated in the study. Adverse events increased by 10% and 14% in the iron-folic acid and iron-folic acid plus zinc groups, respectively, compared with the control group, with an overall combined significant increase in adverse events of 12% in the iron-supplemented groups. This negative effect was not modified by the age of the child or the duration of supplementation.

There was a similar trend for mortality: an increase of 17% and 13% in the iron-folic and iron-folic acid plus zinc groups, respectively, in comparison with the control group, was observed. There was an overall combined increase in mortality of 15% in the iron-supplemented groups. As

a consequence, the study was stopped for safety reasons.

Dr. Sazawal went on to present the results of the cause-specific effects in the outcomes. Adverse events increased significantly by 16% for malaria-related causes in the iron-folic acid-supplemented groups, showing both higher rates and more severe disease. The effect was higher in cerebral malaria and lower in non-cerebral malaria. There was a significant increase in adverse events by 32% across infection-related causes of hospitalization; this was especially high in the case of pneumonia, with a 33% increase observed.

Dr. Sazawal summarized the effects of iron supplementation on total adverse events as including:

- A 12% higher adverse event rate;
- A 15% increase in mortality rate that did not reach statistical significance;
- Most of the effect being attributable to children over 12 months of age; and
- The mortality trend being higher in the iron-supplemented groups, with more hospitalizations in the iron-and-zinc-supplemented groups.

In his summary on the cause-specific effects of the outcomes, Dr. Sazawal stated that the higher morbidity and mortality was mainly attributed to malaria and infection, and that there is a trend toward a greater effect with more severe disease, in this case suspected cerebral malaria.

Dr. Sazawal went on to present the results of a second study carried out concurrently and at the same research site. In this sub-study, the design was the same as the first, with the same four treatment groups, but with the exception that malaria treatment was also provided. At baseline, blood samples were collected and there was a visit to the study clinic, where a clinical examination was done. Two cross-sectional surveys were conducted at 6 months and 1 year post enrollment. At each of these, a blood sample was taken, there was a clinic visit and clinical examination, and treatment for malaria was given for positive

cases. There was ongoing treatment for malaria for diagnosed cases during the study.

In this study, Dr. Sazawal showed that there was a significant reduction (24%) in adverse events with supplementation of iron-folic acid when given with malaria treatment. When analyzed by iron status and anemia, the greatest reduction (49%) in adverse events was with the anemic and iron-deficient group. Children in the iron-replete/anemic group and those in the iron-replete/non-anemic group experienced a substantial increase in adverse events with iron supplementation.

When the effect of iron supplementation on adverse effects by baseline zinc protoporphyrin was examined in this sub-study, there was a significant decrease in adverse events when the zinc protoporphyrin was over 80 $\mu\text{mol/mol}$ heme and an increase when it was ≤ 80 $\mu\text{mol/mol}$ heme.

Dr. Sazawal presented several conclusions and implications from this important study. First, he noted that if iron-folic acid supplementation is coupled with appropriate treatment for malaria, it is associated with an overall reduction in adverse events. Second, it is only iron-deficient children who benefit from the supplementation; children who are not iron deficient may have an increase in infectious morbidity. The results of this study indicate that recommendations for the prevention of anemia among children in areas with high malaria transmission need to include a package for control and/or treatment of malaria. Finally, Dr. Sazawal warned that, even with these approaches, iron-replete children may have adverse effects with iron-folic acid supplementation.

Commentary

Dr. Kenneth Brown, of the University of California, in Davis, California, USA, began his commentary on the supplementation trials carried out in Nepal and Pemba, Tanzania by reviewing the study methods and noting that iron supplementation apparently increased

the occurrence of severe adverse events (hospitalizations and death) in Pemban children. He posed the question of whether these latter results should be a matter of concern or just considered as possibly spurious findings. He proceeded to list the following strengths of these studies, all of which lend credence to the results:

- Randomized, controlled design;
- Large sample sizes powered to detect relatively uncommon adverse effects;
- Controlled supplement delivery;
- Active surveillance for disease outcomes;
- Nested, “intensive” sub-study; and
- Careful statistical analysis with examination of possible modifying effects.

Dr. Brown complimented the investigators for carrying out these well-designed trials and honestly reporting the results. He then proceeded to evaluate the strength of the evidence. Although the magnitude of the observed adverse effect is small, the absolute number of deaths means that these outcomes have to be taken seriously. Moreover, the findings across the different sites are consistent; the level of adherence to treatment was quite high, eliminating possible participation bias; the temporality of the responses occurred in logical relation to the initiation and duration of the supplementation; and the results are consistent with known pathophysiologic mechanisms and with prior research. In particular, animal models have shown a U-shaped relationship between hepatic iron reserves, hepatic mitochondrial function, and markers of oxidative stress; in other words, both iron deficiency and elevated hepatic iron levels lead to increased oxidative stress and cellular dysfunction.¹⁹ Adverse effects of excess of intake have also been reported from prior studies in young children. For example, studies in infants in Chile found increased rates of diarrhea in younger, but not older, infants receiving iron-fortified milk,²⁰ and in Bangladesh, children 2 to 11 months of age (but not older children) receiving iron supplements (15 mg/d) had a 49% increase in dysentery.²¹

Data from Dewey have shown an increased risk of diarrhea among iron-supplemented infants with normal preexisting hemoglobin levels, but no such effect among infants with low preexisting hemoglobin levels.²²

Dr. Brown went on to discuss some of the possible modifying effects of the impact of iron supplementation on infectious morbidity, including the following:

- Age;
- Underlying iron, protein, antioxidant status, other micronutrients; and
- Concomitant infection (malaria, other), other pro-oxidant stress.

He noted that the observed increase in age-related mortality rates in Nepal in infants 1 to 5 months of age in the iron- and folic acid-supplemented group, decreasing thereafter, and the relative risk of adverse events in the Pemba study according to iron status, were both consistent with the possibility that underlying iron status may be an important modifying effect of the outcome of iron supplementation. Dr. Brown presented a hypothetical relationship of the increase in the relative risk of adverse effects of iron supplementation as iron status increases from deficient through adequate to excess.

Dr. Brown then discussed some of the possible implications that these results have for public health programs, including the need for screening of individuals or populations for preexisting iron status, which indicator might be useful, and whether proxy indicators such as age or birth weight might be used. He also explored other factors, such as dosing regimens (amount, frequency, and duration), that might modify the effects of iron supplementation. He concluded by listing the implications of these results for future human research: namely, we need to look at both the benefits and the risks of supplementation, and trials need to have sufficient power to understand the factors that may modify the effects of supplementation.

Dr. Lynch introduced his comments by saying that the new results from the trials in Nepal and Pemba should not be considered in isolation, but rather in conjunction with data from earlier trials and careful consideration of both the deleterious consequences of iron deficiency and the benefits of iron supplementation. Young children suffering from iron deficiency anemia experience motor and cognitive developmental delays with effects on emotional behavior and later academic achievement at school. Physical performance is impaired and there is a sub-optimal response to iodine in populations with endemic goiter. Severe anemia is associated with increased mortality in malaria. The risk of severe anemia is reduced by maintaining higher baseline hemoglobin levels by giving intermittent anti-malarial treatment together with iron supplementation.

The relationship between iron and infection has often been characterized as a double-edged sword. Iron is an essential nutrient for both the host and the pathogen. Iron deficiency may limit the access of pathogen to iron, but it also impairs the host's immune function. Earlier systematic analyses of published and unpublished data concluded that clinically important risk elevations related to iron supplementation of children in regions with high malarial transmission rates could not be ruled out. Parenteral iron administration and high oral iron doses may have increased the risk. On the other hand, clinically important positive effects on hemoglobin levels were observed in all of these studies. These findings were the basis for the 1999 INACG consensus statement: "The available data from malaria-endemic regions indicate that the known benefits of iron supplementation are likely to outweigh the risks of adverse effects caused by malaria." It was, however, recognized that there was an urgent need for an adequately powered trial that might provide more definitive information on which to base future recommendations for iron supplementation. The Nepal and Pemba trials address this need.

Dr. Lynch drew the following conclusions from the data presented at this meeting:

- There is a significant risk of increased morbidity and possibly mortality for young children receiving an iron-folic acid supplement in a region with intense malarial transmission.
- The adverse effects appear to be limited to some children. Others may experience a significant benefit from the supplementation.
- It may well be possible to identify both those who will benefit and those who will be at risk for adverse effects by measuring zinc protoporphyrin and hemoglobin.
- The Nepal and Pemba trials do not demonstrate a protective effect of iron deficiency against malaria-related morbidity and mortality, suggesting that the risks may be related to the mode of delivery (formulation, dose, time, etc.) of the supplemental iron (perhaps in conjunction with iron status) rather than iron status alone.

Dr. Lynch also listed several unanswered questions:

- Is the risk of iron supplementation related to interactions with other nutrients, particularly folic acid?
- Is the risk related to the mode of delivery (formulation/dose/time) of the iron?
- Is the risk related to iron status?
- Is the risk increased or reduced by other factors such as genetic disorders and protein energy malnutrition?

Dr. Lynch summarized his comments with the following concluding remarks:

- The results from Nepal indicate that iron-folic acid supplementation is not associated with increased risk for morbidity or mortality in a region of the world where malaria is not prevalent.
- The results from Pemba indicate that iron supplementation is associated with an increased risk of severe malaria-related morbidity and perhaps mortality in certain children living in

a region where malarial transmission is intense.

- Additional research is needed to evaluate the biological basis for the increased risk and to determine whether such risk is related to the mode of delivery of the iron and/or co-morbidities such as protein energy malnutrition in the children. The development of methods for identifying children who may be at risk is also an urgent priority.
- The INACG/UNICEF/WHO guidelines published in 2000 should be revised in light of both the Nepal and Pemba findings and other information that has been gathered in the last 5 years. These revisions should be guided first by a careful analysis of the biological implications of the Nepal and Pemba findings and then by a careful consideration of the benefits of iron supplementation, the need for integration with other strategies for improving overall health, and the programmatic realities and practical problems related to implementing possible approaches to iron supplementation. Programs may have to be tailored to the local conditions and the specific needs and resources of different countries or regions.

Three posters reported on studies of iron supplementation in women of reproductive age and/or pregnant women. One study in the Philippines showed a benefit of weekly iron-folic acid supplementation for at least 6 weeks on the iron stores of both pregnant and non-pregnant women, although there were only mild effects on hemoglobin (Th5). An effectiveness study with an improved delivery system, also in the Philippines, showed a reduced prevalence of anemia in pregnant women in the study group (Th9). A study in Peru demonstrated high compliance of taking prenatal iron supplements in both anemic and non-anemic pregnant women by using strategies to motivate both health workers and the women (Th10). An interesting study in Tanzania (Th7) showed a reduction in the prevalence of anemia in schoolchildren

through the use of a daily dietary supplement for 6 months in the form of a multiple-micronutrient beverage.

Open Discussion

Dr. Allen asked about the value of including a non-iron placebo group and about whether iron in food may cause adverse effects, and noted that it is important to not lose track of whether other infections increased, not just malaria. Finally, she asked whether there was better care and monitoring for malaria in the sub-study. In response, Dr. Sazawal indicated that all who tested positive for malaria were treated. In the second study, any sick child who entered the clinic was tested for malaria. There was no active surveillance to test for malaria.

There was a question regarding whether boys were more protected than girls in terms of malaria and iron supplementation. In the Pemba study, there were no statistically significant gender differences in either hospital admissions or deaths.

Dr. Noel Solomons, of the Center for Studies of Sensory Impairment, Aging & Metabolism (CeSSIAM), in Guatemala City, Guatemala, emphasized that screening should be addressed. Another participant said that there is a need to be clear about the take-home message as far as supplementation during illness, given that there have been conflicting views on the topic. Malaria areas are different from other areas of the world, and guidelines should be adapted regarding differences in dosing.

Dr. Cook noted that animal laboratory studies looking at the effects of supplementation had not been addressed in this discussion. These studies have shown that if iron is withheld in animals, infection incidence and severity are rapidly reduced. The process was found to be through a chelator mechanism. Withholding iron with the administration of a chelator could reduce the infection rate. Dr. Sazawal responded that the data taken during an infection and the fact that iron deficiency affects immunity must both be considered.

Dr. Stoltzfus stressed that, prior to this study, the body of evidence supporting iron deficiency anemia-prevention in young children was based on the purported benefits to child development. The Pemba study has shown a large and important reduction of severe morbidity when children with iron deficiency anemia were given iron supplements. This is very important for policy and advocacy. Although screening for iron deficiency is a challenge, results based on this recent study indicate that iron-deficient children can apparently be identified with a simple indicator, zinc protoporphyrin. The question emerges whether zinc protoporphyrin measurement can be made user-friendly in the field, at low cost. Finally, based on theoretical grounds, iron supplementation and malaria prevention have been recommended to be implemented together. The Pemba trial provides empirical evidence to support this recommendation, in as much as the iron-supplemented children have better morbidity/mortality outcomes overall in the sub-study areas where malaria treatments were provided. Therefore, iron supplementation should be delivered in concert with malaria control programs where malaria is prevalent. Integrated interventions that are better for children should be delivered.

Dr. Jane Crawley, of Roll Back Malaria, WHO, in Geneva, Switzerland, congratulated the investigators on these important studies. She commented that one of the arms contained zinc and zinc must be looked at as an important element in infection prevention and treatment because we do not yet know whether there is interaction. She mentioned that malaria is reduced in young children by 50% to 60% with the use of treated mosquito bed nets, and the two interventions should be delivered together. She commented that current guidelines for iron supplementation are often impractical and iron supplementation is not happening in many places.

A question was raised regarding weight gain of infants and the birth weight in the study and whether this was related to risk for iron deficiency. Dr. Sazawal responded that the

main study did not include body weight, but that this was included in the sub-study and will be looked at.

A doctor from Peru asked whether one could assume that iron supplementation would affect the pathology of tuberculosis and HIV/AIDS. The answer was that there are ongoing studies to address the issue.

Finally, Dr. Zavaleta asked a question on a possible protective effect of adding zinc to iron supplementation in children under 5 in malaria areas, especially with regard to supplementing children at 1 month of age, and whether this is a good idea given the fact that the gut of a 1-month-old baby may not be developed enough to handle the iron. Dr. Sazawal responded that it is routine to start from 6 months.

Child Development

The Effect of Iron Supplementation on Mental and Motor Development in Children: Evidence from Randomized, Controlled Trials

Dr. Tarun Gera, of the Sunder Lal Jain Hospital, in New Delhi, India, presented a systematic review designed to evaluate the effect of iron supplementation on mental and motor development in children (Th83). Dr. Gera noted that animal studies have indicated an effect of iron deficiency on macro- and microstructure of the brain and enzyme activity, especially in those regions involved with cognitive, auditory, and motor functions. Observational human data give conflicting results, but a substantial association with IQ (between 10 and 15 points) has been shown. However, these study designs have been relatively weak and the role of confounding factors unclear, so interpretation is difficult. Randomized, controlled trials are the strongest study design to give intelligible conclusions, and thus the systematic review was planned limited to only include this type of study.

The predefined criteria for inclusion of trials in this review were: 1) randomized, placebo-controlled trials (excluding those that used a parenteral route of iron

administration); 2) iron supplementation through the oral or parenteral route or in the form of iron-fortified formulas or cereals in the intervention group; 3) one of the development indices was an evaluated outcome measure. Studies in which other micronutrients and drugs were simultaneously administered were included if the only difference between the study and the control groups was the administration of iron.

The trials were identified from simultaneous searches of the various medical databases, reference lists of identified articles, hand searches of reviews, bibliographies of books and abstracts, and proceedings of international conferences or meetings, with help from donor agencies, experts, and authors of recent iron supplementation trials. To avoid publication bias, both published and unpublished trials were included.

A total of 32 studies were identified as potentially eligible for inclusion in the systematic review. After thorough scrutiny, 15 of these trials were excluded and 17 (16 published, one unpublished) were included. The pooled sample consisted of 2827 children, 1412 receiving iron and 1415 receiving placebo. Analyses showed that there was no publication bias.

The initial analysis evaluated the improvement in "mental development score," a logical combination of different tests assessing the same aspect of mental development (Bayley Mental Development Index, Stanford Binet Test, Peabody Picture Vocabulary Test, and Intelligence Quotient and Cognition Scores). The pooled sample standardized mean estimate of the change (pre- to post-test difference) in mental development score following iron supplementation was 0.30 (95% CI = 0.15, 0.46; $p < 0.001$; test for heterogeneity = 72.05, $p < 0.001$). The parameters assessing the quality of the studies did not show any consistently significant association with the results. Sensitivity analysis showed that the benefits of iron supplementation were associated with oral route of supplementation, longer duration of iron therapy (>1 month), older age (>2 years),

lower baseline hemoglobin, and presence of iron deficiency in the supplemented children. Meta-regression did not show any consistent association between the effect on mental development score and duration of supplementation or the age of the child; however, lower baseline hemoglobin and the presence of iron deficiency were significant predictors of a positive effect of iron supplementation.

For the Bayley Mental Development Index (eight studies), the pooled estimates of the weighted mean difference of the change in the test scores between the iron and control groups was 0.95 (95 % CI = -0.56, 2.46) and was not statistically significant ($p = 0.217$). On meta-regression, when controlled for all other variables, the iron-deficient anemic children were significant predictors of a beneficial response. Using both the Bayley Mental Development Index and the Stanford Binet test with these eight studies, the results were similar.

The pooled, standardized, weighted mean difference of the change in the IQ scores in older children between the supplemented and the control groups was 0.41 (95% CI = 0.20, 0.62), which was significant ($p < 0.001$). Children with anemia (hemoglobin < 11 g/dL) and iron deficiency had a greater improvement with iron supplementation, but it was not a significant explanatory variable on meta-regression.

The pooled estimates did not show any significant difference in the motor scores of the iron and placebo groups (10 studies, 1246 children; 630 received iron, 616 received placebo). Similarly, there was no benefit of iron supplementation on the psychomotor development (nine studies) or, more specifically, on the Bayley Psychomotor Development Index scores (eight studies).

Dr. Gera stressed that in the interpretation of these results the following caveats need to be considered: 1) whether the different indices were combinable, 2) the results were not controlled for socioeconomic status, 3) there was no differentiation between therapeutic and preventive effects, 4) anemia is not the same as iron deficiency,

and 5) specific components of development were not addressed.

Dr. Gera concluded that iron supplementation improves the global mental development score, but the effect is modest (pooled standardized mean difference of 0.3, equivalent to 1.5 to 2 points on scale of 100). This effect is particularly apparent for intelligence tests in initially anemic or iron-deficient children, in whom the results support a causal role for iron in mental development. There is a greater improvement in older children (above 5 years of age). Dr. Gera stated that there is no convincing evidence that iron treatment has an effect on mental or motor development in children below 2 years of age.

Dr. Gera suggested that future research should be directed to preventive supplementation, especially in younger subjects, and on specific components of development. Emphasis should be placed on the sample size, iron status of the child, and the duration of the intervention.

Different Effects of Iron and Zinc Supplementation on Growth in Anemic and Non-Anemic Infants

Dr. Marjoleine Dijkhuizen, of the University of Nijmegen, in Nijmegen, Netherlands, who is also an investigator in the South East Asia Multicountry Trial on Iron and Zinc Supplementation in Infants (SEAMTIZI) study group, presented the results of several studies using a similar protocol and conducted in the southeast Asia region between 1996 and 2000 (Th84). She introduced her presentation by noting that deficiencies of iron and zinc often occur concurrently and listed the consequences of these deficiencies. Impaired growth is one of the consequences of zinc deficiency, yet the effect of iron deficiency on growth has not been defined.

Children and infants are especially at risk for iron deficiency, as rapid growth increases iron requirements. Iron supplementation has been shown to improve growth in infants and children in populations with

a high prevalence of anemia. No effect on growth has been shown in mixed populations or in populations in which the initial iron status is not known. Given the fact that in many developing countries over half of the infants are anemic at the age of 1 year, and the possible detrimental effects of iron deficiency on psychomotor development, it is not surprising that blanket iron supplementation to prevent and/or treat iron deficiency in infants is being considered.

Dr. Dijkhuizen mentioned, however, that there is growing concern about possible negative effects. Some evidence suggests that iron supplementation may increase morbidity of infectious diseases, and may reduce linear growth in iron-replete infants. Moreover, iron supplementation has been shown to negatively affect zinc status.

Zinc supplementation has been shown to improve growth of stunted children over 1 year of age with low zinc status. Reasons for a lack of an effect of zinc on growth in other circumstances may be related to underlying factors such as initial zinc status, other constraints on growth such as lack of other nutrients, and different responses according to the different phases of growth—and another reason may be that plasma zinc is not an adequate indicator for zinc deficiency.

Combined supplementation of iron and zinc may be an effective tool for the prevention of both iron and zinc deficiency and the question is: can iron and zinc supplementation affect growth, the functional end point of many metabolic pathways? Dr. Dijkhuizen posed the questions: should infants be routinely supplemented with iron and/or zinc, and should iron and zinc supplementation be combined? Aspects to be considered include the risk of concurrent deficiency, interactions at different levels (absorption, functional, molecular, or metabolic), and whether the supplementation is beneficial and effective. Current evidence on the interactions between iron and zinc is confusing, and a better understanding of and more specific information on the efficacy and effectiveness of combined

supplementation are needed before recommendations can be made.

In a collaborative, multi-country trial framework, parallel studies on iron and zinc supplementation in infants were conducted in three countries of southeast Asia (Thailand, Vietnam, and Indonesia) between 1996 and 2000. On the initiative of UNICEF, researchers from several countries in southeast Asia met in February 1996 to decide on a core protocol for the supplementation studies so that they would be able to combine the data of the separate sites after completion for a pooled analysis. The different study sites represent a range of conditions encountered in southeast Asia. However, throughout the region, cultural habits and dietary patterns are shared to a large extent, leading to similar infant breastfeeding and weaning practices and similar nutritional risk profiles.

Infants were enrolled between 4 and 6 months of age and received supplements for 6 months. The study was a 2 x 2 factorial design and was placebo controlled. The supplements consisted of 10 mg of iron and/or zinc. Basic measurements included growth (length, weight, z scores), recalculated per site for actual age at measurement and for increments for actual time intervals; hemoglobin concentrations at baseline in three sites and at end point in four sites; plasma ferritin concentrations at baseline in two sites and at end point in three sites; and plasma zinc concentrations, again, at baseline in two sites and at end point in three sites.

The pooled data base included a total of 2458 infants, of which 628 received placebo; 627 received iron; 619 received zinc; and 594 received iron plus zinc. Factorial analysis was conducted to examine the effects of iron, zinc, and two-way interactions. Significant gender differences were found among sites, therefore the analysis controlled for this factor.

Dr. Dijkhuizen showed that there were no effects of supplementation on growth in any of the study groups when all infants were included. The percent of infants stunted

was 23%, 22%, 21%, and 22% at the end of the study for the placebo, iron, zinc, and iron plus zinc groups, respectively. Thus, the results of this multi-country study show that neither iron nor zinc supplementation prevent the progressive decrease in anthropometrical z scores during the first months of life in southeast Asia.

There was a clear effect on anemia in the iron and iron plus zinc-supplemented groups after 6 months. At baseline, there was a 50% prevalence of anemia, and this was significantly reduced to 26% and 33% in the iron-supplemented and iron plus zinc-supplemented groups, respectively.

This study also identified subgroups in which supplementation of iron or zinc had important effects on growth. Supplementation of zinc in anemic infants for 6 months improved linear growth by a z score of 0.22. However, at the same time, zinc supplementation of infants who were not anemic prior to supplementation negatively affected linear growth by a z score of 0.18 (with a maximum possible negative effect of -0.35).

Evidence of a differential effect of micronutrient supplementation in different sub-groups is emerging, especially for iron supplementation in iron-deficient and iron-replete infants. While in the study described by Dr. Dijkhuizen a differential effect of iron supplementation was present, the differential effect of zinc supplementation on anemic and non-anemic infants was much stronger.

Furthermore, there is concern that the WHO cutoff value presently used for anemia in infants (i.e., 110 g/L) might be too high. While this definition of anemia identified a subgroup of infants clearly benefiting from zinc supplementation, and a group for whom zinc supplementation is not beneficial, it is not known whether this definition of anemia reflects iron status with enough precision. Moreover, using a stricter cutoff for anemia at hemoglobin concentrations under 105 g/L made the differential effect of zinc supplementation only stronger.

In the study Dr. Dijkhuizen described, there was no evidence that infants stunted prior to supplementation benefited more from zinc supplementation than non-stunted infants. However, subjects were all under 1 year of age, and all commenced supplementation at the age of 4 to 7 months, perhaps prior to the development of stunting. There was no significant effect of zinc supplementation on growth in infants who were zinc deficient prior to supplementation, whereas there was a positive effect of iron supplementation in these infants. However, baseline zinc concentrations were only measured in two sites, and zinc deficiency was much less prevalent than anemia. Furthermore, low plasma zinc does not necessarily identify subjects who benefit from zinc supplementation.

Some studies report a differential effect of zinc supplementation in boys and girls. In the study described here, gender had a significant main effect only on height-for-age z scores and weight increments, but did not modify the effect of either zinc or iron supplementation on anthropometrical indicators.

Except for a small positive effect of iron supplementation on weight-for-height z score, there was no overall effect of supplementation on anthropometry. However, for many of the anthropometrical indicators, there were differences among the sites and interactions of the sites with supplementation, indicating that differences in growth pattern and in the effect of supplementation can be expected in different populations. Differences in the prevalence of deficiency for other micronutrients and in the general nutritional status of the population and morbidity patterns might give rise to differential effects of supplementation.

Dr. Dijkhuizen concluded that although this study shows that in southeast Asia iron and zinc supplementation are not sufficient to prevent the overall progressive growth faltering that occurs during the first year of life, both can improve growth in specific groups. Anemic infants significantly benefited from supplementation, especially

with zinc and to a lesser extent with iron. However, zinc supplementation reduced growth in non-anemic infants. Although the mechanisms underlying these effects are not clear, the implications are very important, as blanket zinc supplementation might be counter-effective and perhaps even harmful for a large proportion of the population. Dr. Dijkhuizen noted that the fact that similar effects were recently reported for iron supplementation in infants indicates that the effect of micronutrient supplementation on growth needs to be reexamined taking baseline characteristics such as anemia into account before recommendations for populations can be made. An important question still to be answered is whether these negative effects are still present to the same extent when a fortification approach is used rather than supplementation.

A Low-Cost, Fortified Baby Food Porridge Improved Iron Status and Motor Development of 6- to 12-Month-Old Infants

Dr. Mieke Faber, of the Medical Research Council, in Tygerberg, South Africa, presented the results of a study on the effects of consumption of a fortified porridge on iron status and motor development in infants (Th85).

Dr. Faber initiated her presentation by emphasizing that the critical period for developing childhood malnutrition is in the first two years of life, as complementary foods are often nutritionally inadequate in most developing countries. Maize meal, a bulky food of low nutrient density, is used as complementary food in many African countries, including South Africa. It is unlikely that mandatory fortification of staple foods such as maize meal will have a major impact on infant nutrition, because the levels of fortification are set to be safe and efficacious for adults, but are low relative to the high nutrient requirements of infants and the small quantities of food that they consume. A low intake of commercially available fortified infant cereals was observed for South African infants, and it was argued that

the high cost of these products prohibited an adequate intake. Availability of and access to fortified complementary foods that are affordable by the majority of the population could potentially contribute to a long-term solution to micronutrient deficiencies in infants. The aim of this study was to determine the effect of a low-cost maize meal porridge specifically fortified at levels to meet the nutritional needs for development of 6- to 12-month-old infants—specifically iron, zinc, and vitamin A status and motor and language development.

A newly developed baby porridge made with maize meal, which cooks in 3 minutes (versus 20–30 minutes for standard maize meal) and with a retail price of 25% to 50% of other baby cereals, was fortified to supply 27.5 mg of iron as ferrous fumarate, 7.5 mg of zinc as zinc sulfate, and 7.5 mg of beta-carotene per 100 g of dry product. A daily ration of 40 g of dry product per day supplied 11 mg of iron, 3 mg of zinc, and 3 mg of beta-carotene. Ascorbic acid (sodium ascorbate) was added (140 mg/100 g dry product) to enhance iron absorption. Other micronutrients added included copper, selenium, riboflavin, vitamins B6 and B12, and vitamin E.

The study area was the Valley of a Thousand Hills, a rural area of low socioeconomic status in KwaZulu-Natal, South Africa. All mothers of 6- to 12-month-old infants in the catchment area of eight community health posts were recruited. Infants were excluded from the study if their birth weight was below 2500 g or if their hemoglobin concentration was below 8 g/dL. The latter were referred to the clinic for appropriate treatment.

Infants aged 6 to 12 months were randomized to either the fortified or control group. Infants in the control group received the same porridge but without the added micronutrients. Daily consumption of 40 g of dry product mixed with 250 mL of liquid and consumed as either one or two meals was recommended. Daily rations of the dry product were packed in individual packets. To avoid spillage of the product to other children in the home, all children aged 5

years and younger in the household received 1.5 kg of the dry product (according to the treatment group of the participating child) per month. The intervention period was 6 months. Measurements were taken at baseline and post intervention. The main outcomes were: hemoglobin, serum retinol, zinc, ferritin concentrations, and motor development.

Of the 361 infants who were enrolled, 292 (81%) completed the study. A blood sample could not be obtained for three infants during the post-intervention survey. The final data set therefore consisted of 289 children (fortified group: $n = 144$; control group: $n = 145$). Compliance was measured weekly by observation, monthly by a short questionnaire, and, during the fourth month of the study, through focus group discussions. It is estimated that 95% to 99% of infants across the two groups ate the porridge every day, with good acceptability.

No intervention effect was observed for serum zinc and retinol concentrations. Median serum ferritin concentrations increased significantly for infants receiving the fortified porridge, from 8.7 to 15.8 $\mu\text{g/L}$ ($p = 0.001$); the levels of the control group remained the same. At baseline, the mean hemoglobin concentrations were similar for the two groups; at post intervention, the mean value for hemoglobin was significantly higher for the fortified group than for the control group. The proportion of infants with a hemoglobin concentration below 11 g/dL decreased from 45% at baseline to 17% at 6 months in the fortified group, whereas it remained above 40% in the control group.

Motor development of the study infants was assessed by parental rating, a method known to have considerable accuracy and sensitivity for identifying developmental delays and to correlate well with Bayley II scores. Mothers were asked if their child could do each of 25 tasks related to motor development, and 1 point was scored for each item that the mother reported the child could do. At baseline, the mean motor score was 7.6 for both groups. After 6 months, the infants who received the fortified porridge achieved, on average,

15.5 of the 25 motor development skills, compared with 14.4 in the infants who received the unfortified porridge ($p = 0.03$). Of course, motor development had also increased in both groups due to the children being 6 months older.

Dr. Faber concluded that daily consumption of the fortified porridge for a period of 6 months resulted in improved hemoglobin and serum ferritin concentrations as well as motor development of infants. Considering that this low-cost, fortified maize meal porridge was well accepted, it can potentially have a significant impact on reducing iron deficiency and improving development in infants. However, Dr. Faber stressed that fortified complementary foods must be used in the context of a broad strategy to improve childhood malnutrition.

Positive Effects of Zinc and Iron-Folic Acid Supplementation on Time to Walking and Infant Behavior among 5- to 18-Month-Old Zanzibari Infants

Dr. Patricia Kariger, of Cornell University, in Ithaca, New York, USA, opened her presentation by saying that there is some evidence that iron deficiency anemia and zinc deficiency are related to slower motor development and clingy, "fussy" behavior in young children (Th86). She also pointed out that the data are not conclusive regarding whether giving zinc and/or iron supplementation to deficient infants is beneficial to their development. She highlighted two studies carried out in Asia. A supplementation trial carried out in Bangladesh²³ demonstrated that zinc and iron together improved motor scores and improved positive behavior among the children. A supplementation trial in Indonesia²⁴ examined the effects of 12 months of daily supplementation with zinc and/or iron-folic acid on the motor and behavioral development of poorly nourished infants, but the results indicated an increase only in motor scores for the iron-only group; there were no effects on behavior.

Pemba, one of the Zanzibar islands, is a malaria endemic zone, and there is a high prevalence of anemia. The present study was a sub-study of the mortality trial reported by Dr. Sazawal in the morning session. Thirty-five thousand children 1 to 35 months of age were enrolled in the 2×2 factorial design randomized study. The children received 10 mg/dL zinc and/or 12.5 mg/dL iron with 50 μ g of folic acid and placebo; infants under 12 months of age received half the dose. The study also looked at growth, hemoglobin, and malaria morbidity in relation to iron and/or zinc supplementation. Of the 35,000 children, 864 children of those 5 to 19 months of age were included in a child development sub-study for motor milestone assessment and observations of activity and behavior. The developmental assessments were made in the home. Motor milestones were assessed every 2 weeks, during which time trained field workers encouraged children to demonstrate the most advanced milestone they could perform and recorded the results.

The first analysis conducted was to answer the question of whether treatment with iron-folic acid and/or zinc is related to faster attainment of walking. Inclusion criteria for this study were that the child was not yet walking and that he or she was under 12 months of age. Survival analysis using the Cox regression was applied, where the dependent variable was walking alone or not and the independent variable was the treatment group. There was no interaction between iron-folic acid plus zinc on walking, so a main effects model was used for iron-folic acid (with or without zinc) compared with no iron plus folic acid and zinc (with or without iron-folic acid) compared with no zinc. Covariates were age, sex, socioeconomic status, hemoglobin, height-for-age z score, and baseline milestone score. For the walking analysis, 319 infants were included. Of these, 50% were boys, the mean (SD) age was 8.9 (1.8) months, hemoglobin (g/L) was 92.0 (16.0), and height-for-age z score was -1.4 (1.1). The results indicated a positive and significant effect of iron-folic acid on attainment of

** "Fussy" was defined as including crying, irritability, whining, and other behaviors that characterize an unhappy child.

walking. Children who received iron-folic acid with or without zinc walked about 20 days earlier than those who did not; zinc had no significant effect on attainment of walking.

The second analysis was to answer the question of whether iron-folic acid and/or zinc is related to how much babies want to be carried or fuss. Infants were observed for 3 to 4 hours at home, and their behavior was coded in 15-second intervals. From these, estimates of percent time spent in each behavior were made. For this analysis, the inclusion criteria were at least 2.5 hours of observation at baseline and at 12 months ($n = 617$). General linear models were applied, where the dependent variables were the percent of time spent fussing at 12 months post treatment and the independent variable was the treatment group. Again, there was no interaction found between iron-folic acid plus zinc on these behaviors, so a main effects model was used. The two comparison groups were those receiving zinc (with or without iron-folic acid) and those receiving placebo or iron-folic acid alone. Covariates were age and the baseline percent of time being carried or fussing.

The results showed that children who received a zinc supplement were carried significantly less than those who did not receive it ($p = 0.009$; $\beta = -0.717$, 95% CI = 0.180–1.255). This indicates that there is a positive effect in that the children are more independent. Children who received zinc also fussed less than those who did not receive it ($p = 0.043$, $\beta = -0.302$, 95% CI = 0.009–0.596).

Dr. Kariger listed the following conclusions from these results:

- Iron-folic acid and zinc were associated with positive child development outcomes, but these effects differed.
- Children supplemented with iron-folic acid (with or without zinc) walked about 20 days earlier than those not receiving it.
- Children supplemented with zinc (with or without folic acid) were carried less and fussed less than those

not receiving zinc. These are the first results from a comprehensive study that includes language development and other social behaviors not yet analyzed. Further longitudinal research is needed to assess the long-term significance of these results.

Several posters addressed the effects of iron and/or zinc supplementation on the cognitive and social development of young children. In Zanzibar, both iron supplementation and de-worming in preschoolers after a period of 1 year, had significant although independent effects on aspects of social and emotional function (Th13). A study exploring associations between iron and zinc status and cognitive performance in school-aged children in Indonesia and Australia found that indicators of iron status were associated with a number of cognitive abilities (Th15). However, serum zinc status was not associated with any of the measured areas of cognition in Indonesia, whereas some associations were observed in the Australian population. An interesting study in Nepal showed an effect of zinc and iron-folic acid supplementation on the information processing of children 39 and 52 weeks of age (Th16). The use of a multiple micronutrient-fortified salt in school-aged children in India showed both improved hemoglobin levels and improved cognition (Th17).

Open Discussion

Dr. Stoltzfus, who was one of the investigators in the Pemba, Zanzibar study, asked Dr. Faber how the cost of the fortified porridge was kept low. Dr. Faber answered that it had simple packaging and was not an instant porridge. An instant product would be too expensive because it would have to be drum dried.

Dr. Darnton-Hill said that these were all good studies, and even though the last three were not included in the meta-analysis presented by Dr. Gera, asked whether the results of a meta-analysis would be any different. Dr. Gera responded that these studies were relatively large and used strong designs, and therefore would be likely to

influence the results of the meta-analysis, yielding a more favorable conclusion for the benefits of iron on motor development.

Dr. Saskia de Pee, of Helen Keller International, in Singapore, asked what type of iron was used in the porridge study. The answer was that ferrous fumarate was used to fortify the baby cereal. Regarding the Zanzibar study, she noted that the time being carried (1%) is very small and wondered whether mothers would recognize and appreciate such a difference. The response was that there are no data specifically on this, but that rates of carrying dropped substantially for all children as they grew older.

Dr. Maureen Black, of the University of Maryland, in College Park, Maryland, USA, commented that child development and behavior are important outcomes but are difficult to measure. In a 10-month zinc and copper supplementation trial with small-for-gestational-age infants in India, mothers were asked about their children's temperament: how fussy or difficult did mothers think their children were. The response was the same whether at home or in the clinic. However, the results were opposite to those found here: mothers reported zinc-supplemented children as being more irritable. The interpretation was that these were small-for-gestational-age children and perhaps those supplemented were more energetic, but when mothers' perceptions were examined against the child's development, those children considered by the mothers to be more fussy and difficult did worse developmentally. Dr. Black asked whether they had looked at developmental skills in this study. The investigators replied that they are planning on looking at this along with the activity levels, language levels, and developmental scores. Dr. Black added that it would make sense that the carrying behavior, which is essentially initiated by the child, could be related to other developmental skills.

Ms. Michelle Lozada Urbano, of the Instituto de Investigación Nutricional, in Lima, Peru, asked Dr. Faber how much porridge was given to the mother and consumed by the babies in her study. Dr.

Faber responded that the recommended amount was 40 g of the dry product, which equals one cup of the cooked porridge. Infants 6 to 9 months old consumed this amount in two meals during the day, while the older infants consumed this amount mostly in one meal. Dr. Oscar Rosas Zarate, of the Ministry of Health, in Lima Peru, asked if the researchers gave any nutrition education to the study beneficiaries in the study presented on South Africa. Dr. Faber replied that they had not because this would have affected their diet and skewed the results, although they did promote breastfeeding.

Dr. Solomons asked if, in terms of the safety context in the Zanzibar study, whether the investigators looked at treatment on retarded development. Dr. Kariger replied that it was not done, but there is still work to do to look at behaviors. Even though the cutoffs are unclear in this study, they could still help with policy recommendations. Dr. Black also responded to Dr. Solomons' question by saying that the context in which children are raised is very important and outcomes are influenced by caregiving behaviors. Furthermore, she cautioned against looking at single behaviors rather than a constellation of behaviors.

A participant from the CDC in Atlanta, Georgia, USA, commented that he was still trying to understand the Pemba study and asked if there were any identified pathways of how iron affects motor development. In the sub-study, iron had a positive effect on development, but not all the pathways are understood yet. It is possible that iron supplementation has a positive effect on some aspects of development and not on others.

Program Implementation

Implementing Strategic Communication Plan to Reduce Anemia in Pregnant Women in Ghana

Mrs. Kate Quarshie, of the Ghana Health Service, in Accra, Ghana, described how

the high prevalence of anemia in Ghana, coupled with the absence of a policy on anemia control and poor coordination of existing programs, led to the development of an integrated and comprehensive anemia control strategy by a multisectorial committee (Th87). A comprehensive communication plan was drawn up as part of the strategy.

Initially, a situational analysis was carried out by reviewing all existing literature and assessing existing policies and programs. A 1995 survey indicated that anemia prevalence was 83.5%, 71.3%, 64.5%, and 59% for preschool children, school-aged children, pregnant, and lactating women, respectively, using the WHO cutoff points. Several causes of these high anemia prevalences were presented:

- Low consumption of foods high in bioavailable iron;
- Coexistence of other micronutrient deficiencies;
- High prevalence of malaria, schistosomiasis, and intestinal helminth infection, notably hookworm;
- Low level of awareness and knowledge about anemia;
- Poor environmental hygiene and sanitation;
- Lack of political commitment; and
- Weaknesses in existing service delivery programs regarding iron and folic acid supplementation, malaria prophylaxis, and nutrition education.

Formative research led to understanding the problems of existing programs, which included delayed and infrequent prenatal care visits; inadequate distribution of iron-folic acid supplements; non-uniform dosing for iron supplements and malaria prophylaxis/treatment; inadequate counseling on the need for use of iron supplements; inadequate training, supervision, and monitoring of health staff at all levels; weak communication support; and lack of integration among programs.

The national 5-year integrated anemia control strategy targets three groups: pregnant women, preschool children less than 5 years of age, and schoolchildren 5 to 14 years of age. The aim of the strategy was to reduce the anemia prevalence by 25% in each of the groups within 5 years (by 2007).

Mrs. Quarshie presented the main components of the strategy:

- Strengthening iron and folic acid supplementation for pregnant women and weekly supplementation of school-aged children with iron and vitamin C;
- Food-based approaches, including increasing production and consumption of iron and vitamin A- and C-rich foods and fortification of selected foods with iron, vitamin A, and some B vitamins;
- Malaria control;
- Twice annual de-worming of school-aged children in Roll Back Malaria (RBM)/Integrated Management of Childhood Illness (IMCI) districts and treatment for worm infestation in pregnant women; and
- Promoting good hygiene and environmental sanitation.

In addition, because all components require changes in knowledge, attitudes, and behavior, the interventions are supported with the strategic communication plan.

To effectively implement these components, the anemia control strategy is being integrated into other programs. The communication plan was developed by a multisectorial core group whose members include representatives of the nutrition community, the Pharmaceutical Society of Ghana, reproductive health, RBM, IMCI, a pediatrician, a health journalist, the School Health Education Program of the Ghana Education Service, and the Ministry of Local Government. The objectives of the strategic communication plan are short-, medium-, and long-term. The short-term objectives focus primarily on improving political and public awareness. The

medium-term objectives are to improve knowledge, attitudes, and skills of health providers and to improve knowledge for the target group and the general public. The long-term objective is to improve knowledge of other extension workers and change agents.

The initial focus of the strategy was on anemia control in pregnancy, applying the short- and medium-term objectives, and promoting five key messages for this theme. A central objective was to improve public awareness. To this end, three encounters with media representatives resulted in newspaper articles and radio discussions about anemia control throughout the country. The following key messages were developed:

- Visit the clinic as soon as you know you are pregnant and attend regularly;
- Take iron and folic acid supplements daily;
- Eat fruit with your meals;
- Sleep under insecticide-treated bed nets; and
- Seek treatment for malaria.

An advertising agency organized the campaign. Materials developed included a jingle, radio spots in six local languages, leaflets, cue cards, counseling tapes, and a wall chart indicating dosages of supplements and drugs routinely prescribed.

The campaign was launched by the director general of the Ghana Health Service at an antenatal facility, and brought together pregnant women, schoolchildren, chiefs and opinion leaders, health workers of the district, market women, journalists, and the general public. The radio spots were aired on both national and private FM stations with wide audiences in all 10 regions. The radio time was carefully selected to include peak listening time.

Mrs. Quarshie described the successful experience of sensitizing organizers of the national beauty pageant, which culminated in the acceptance of anemia control as the campaign theme for Miss Ghana 2003.

The campaign took her to eight regions of Ghana; in each region she gave talks to students and pupils of first- and second-cycle institutions, as well as associations of beauticians, hairdressers, and dress makers (including men). She distributed leaflets and implored her audience to share the messages received with friends, family, and clients. The campaign was given wide coverage in both the electronic and print media in all regions visited.

The medium-term activities centered mostly on training to improve the knowledge, attitudes, and skills of health providers. The multisectorial committee developed a training manual to address the issues identified in the formative research, specifically the late start and irregular attendance at antenatal clinics, non-uniformity in dosages of iron-folic acid supplements and malaria prophylaxis prescribed, poor counseling on the use of supplements, non-adherence to dosage regimen, and lack of uniformity in educational messages given. At the national level, training was provided to regional teams comprised of regional officers in charge of nutrition, reproductive health, health promotion, and disease control. The regional teams were then supervised to train members of district health management teams, who in turn supervised the training of sub-district teams and antenatal care providers in both governmental and nongovernmental health facilities. Training was integrated into ongoing training activities at all levels. To date, 50% of targeted health providers have been trained.

Training key extension workers and agents of change are long-term aims of the program. Members of faith-based and other community-based organizations are trained in anemia control and are provided with copies of materials and a simplified version of the messages for promotion through frequent meetings with members of their organizations.

Mrs. Quarshie discussed some of the constraints and challenges in the implementation of the communications strategy. Abrupt changes in organizational

policies and difficulties in accessing funds from development partners posed major constraints. Difficulties were experienced in the selection and performance of the advertising agency. Other major challenges included ensuring the availability of resources, supportive monitoring and supervision at all levels, sustaining the campaign, and ensuring that knowledge acquired translates into behavior changed.

There are several lessons learned from this program. Mrs. Quarshie stressed the importance of obtaining relevant data initially that can be translated into language that is understood by the decision makers at all levels. Other elements found to be necessary for adequate implementation include perseverance and obtaining the cooperation of other program areas within the same organization, as well as from other sectors, and finding others to champion the program. An essential component to success was integration. In this case, the anemia training activities were well integrated into the ongoing relevant training of related programs, including that of Safe Motherhood, RBM, and IMCI.

Finally, Mrs. Quarshie stated that through these communication strategies it is hoped that adequate knowledge will be acquired to motivate all of those involved to bring about positive behavior change, leading to a reduction of the high anemia prevalence in Ghana.

A poster of a review conducted in El Salvador by The Manoff Group emphasized the importance of tailoring and delivering the right messages to the target audience—families and health workers—through the right medium (Th24). This supports the Ghana communications approach as a feasible strategy to reduce iron deficiency in women and children.

Anemia Rates Significantly Reduced in Nicaragua

Dr. Josefina Bonilla of the Federación Red Nicasalud, in Managua, Nicaragua, introduced her presentation with a

description of the anemia situation in Nicaragua (Th88). National data from 1993 indicated that 34% of women of reproductive age and 29% of children 12 to 59 months of age were anemic. Iron intake was estimated to be 10.4 mg/d for the general population and 6.4 mg/d for children.

In 1994, a national micronutrient plan was developed. The strategies included iron supplementation of pregnant women and children under 5 years of age, fortification of wheat flour with iron and B vitamins, a communication strategy, and other public health interventions. Between 1994 and 2000, iron supplementation policies were formulated for weekly and daily supplementation, and were implemented mainly through prenatal and child health services. Guidelines for health personnel were prepared, and extensive training of health professionals was completed. At the same time, wheat flour fortification was implemented.

The national micronutrient survey conducted in 2000 showed that the anemia prevalence rates in women of reproductive age had decreased from 34% to 24%, but for children 12 to 59 months of age had remained the same (29%). This raised the question of why anemia rates in children had not improved and what needed to be done. As a result, an anemia control program with new strategies was implemented between 2000 and 2004.

The new program, PROCOSAN (which stands for Community Program of Health and Nutrition, in Spanish), is a community-based nutrition program led by the Ministry of Health. It involves the active participation of health professionals from the Ministry of Health and nongovernmental organizations, and community health workers (“brigadistas”). PROCOSAN includes growth monitoring, counseling, and the distribution of vaccines, oral rehydration solution, and iron supplements to children under 5 years of age. A few communities were first selected to validate the program, which is now included in the national health plan and is being expanded. Dr. Bonilla showed the

wide extension of the program, covering more than half of the area of Nicaragua. Iron supplementation is included in semiannual national health campaigns. Supplement distribution through these campaigns include pregnant women, and less frequently, women of reproductive age and children.

Dr. Bonilla presented results of the evaluation. Iron supplementation coverage as reported in the 12 months prior to each of the surveys increased between 2000 and 2003 from 70% to 88% in pregnant women, and from 37% to 62% in children 6 to 59 months of age.

There were also achievements in other public health interventions. The use of contraceptive methods increased from 49% in 1993, to 60% in 1998, to 69% in 2001. In 2001, 14% of women were using injections, 15% the contraceptive pill with iron, and women's sterilization was also commonly employed among married women or women in a monogamous relationship. Anti-parasite drug treatment in children 2 to 4 years of age increased from medium coverage in the 1990s, to 100% coverage for both first and second doses in 1999 through 2002 in the national health rallies.

The prevalence of anemia in women of reproductive age diminished from 34% in 1993, to 24% in 2000, to 16% in 2003. The prevalence in children 12 to 59 months of age also diminished in the recent evaluation: from 29% in 1993 and 2000, to 23% in 2003.

Dr. Bonilla concluded her presentation by listing the next steps to be taken in the program to control anemia. With respect to iron supplementation, the logistical management system for distribution of iron supplements needs to be improved, and emphasis must be placed on the supplementation of children under 24 months. Health services and community-based activities need to be strengthened and extended, counseling and follow-up skills need to be improved, and the high rates of coverage and quality maintained. Other interventions include improving access to iron-rich foods (including fortified

foods) and integrating other public health interventions in anemia control. These include vitamin A supplementation, sugar fortification, breastfeeding promotion, anti-malarial strategies, and de-worming programs.

Effectiveness of Soy Sauce Fortified with NaFeEDTA for Reducing Anemia in West Java, Indonesia

Dr. de Pee presented preliminary results of a study on fortifying soy sauce with iron conducted in Bandung, West Java (Th89). She started her presentation by saying that iron deficiency anemia is a major problem in many developing countries, with severe health and economic consequences, and that the fortification of condiments is one way to address this problem. Sodium-iron-ethylenediaminetetraacetic acid (NaFeEDTA) is an iron fortificant with high bioavailability. Promising results have been obtained with NaFeEDTA-fortified fish sauce and soy sauce in Vietnam and China, respectively.

Soy sauce was the condiment selected in Indonesia because it is widely consumed and very suitable for fortification with NaFeEDTA. The brand most used is ABC, which is sold in three different packages (glass bottles, plastic bottles, and sachets) that are used by different socioeconomic groups. The sachets contain 16 mL of soy sauce, enough for one meal for a family. Data from the Government of Indonesia and Helen Keller International's Health and Nutrition Surveillance System (GOI/HKI-NSS) show that between 70% and 95% of households in West Java consume soy sauce, the vast majority of these consume the ABC brand, and intake of soy sauce from sachets is estimated at 1.6 to 2.1 mL/d among adults and 0.8 to 1.1 mL/d among children under 5 years of age.

For this study, 2.7 mg of Fe (as NaFeEDTA) was added to each 16-mL packet. The fortified sachets were indistinguishable from the non-fortified sachets. Market saturation was assessed by observing the stamp on packaging slips. Distribution to warehouses in the Bandung district started

in May 2003. A baseline evaluation was conducted from April to June 2003 as part of the GOI/HKI-NSS Nutrition and Health Surveillance System, and the final evaluation was conducted in the same households June to July 2004. The total sample size at baseline was 600 households, of which approximately 75% could be revisited one year later. Distribution to warehouses started in May 2003, and from the surveys among the neighborhood stores it appears that full market saturation was reached in October 2004. Households thus consumed fortified sauce for 6 to 9 months before the end of the survey.

The consumption of soy sauce was found to be related to maternal education level, which is a good indicator of socioeconomic status. Those of higher socioeconomic status consumed more soy sauce from bottles. Even among the sachet users, it appears that those of lower socioeconomic status consumed less soy sauce than those from higher strata.

Comparison of anemia levels at baseline and at follow-up showed that among mothers who consumed 1.5 mL or more of soy sauce from sachets per day, anemia prevalence dropped from 36% to 20% ($p < 0.05$). Among the other groups that consumed less or no soy sauce from sachets, anemia prevalence remained stable at 10% to 25%. It was also found that the mothers who consumed at least 1.5 mL of soy sauce from sachets per day had the highest prevalence of anemia at baseline and were therefore most in need of fortification. It was found that the sachets were preferred by the poorer segments of the population who are most in need of iron fortification because of the higher anemia prevalence.

While an impact was found among mothers, no impact was found among children aged 12 to 59 months at baseline, which may be for two reasons. First of all, anemia prevalence among children decreased considerably over the follow-up period, which makes it less likely that a small additional effect of the fortified soy sauce could be detected. In addition, the consumption of soy sauce among children is lower than among adults because it is

added to the family meal, of which they consume a smaller share.

Note that an intake of 1.5 mL per adult per day is equivalent to one 16-mL sachet per household every other day (assuming 5 to 6 household members). The fact that EDTA enhances the absorption of other iron in a meal may be responsible for part of the observed effect.

Recommendations formulated by Dr. de Pee and her colleagues as a result of this study are:

- For young children, other strategies to reduce anemia, such as in-home fortification, need to be explored;
- Another iron-fortified soy sauce intervention study using different dosage levels of NaFeEDTA should be done to better understand the observed impact of this low dosage;
- Where the prevalence or risk of anemia among older children and adults is high, there should be a carefully controlled and rigorously monitored expansion of the fortification of soy sauce with NaFeEDTA.

Baobab Fruit Pulp (*Adansonia digitata L.*) Improves Iron Status in Nigerian Children

Dr. Ngozika Nnam, of the University of Nigeria, in Nsukka, Nigeria presented a study to show how the baobab fruit can be used to improve iron status in Nigerian children (Th90). In some regions of Nigeria, iron deficiency anemia rates in children are as high as 50%. About 90% of the total dietary supply of iron in Nigeria comes from plants, which contain non-heme iron that is poorly absorbed. There is a need for an intervention program in Nigeria promoting locally available foods within the reach of the communities to enhance bioavailability of dietary iron.

Baobab (*Adansonia digitata L.*) is a tree plant belonging to the family bombacaceae. The tree produces numerous fruits varying from ovoid to oblong and irregular in length

(up to 40 cm long in West Africa). The fruit is composed of a woody, very hard outer part (epicarp) and an inner part (endocarp), which constitutes the pulp of the fruit. When ripe, the inside of the fruit is dry and floury with numerous seeds embedded in the pulp, which has a whitish, powdery appearance. The fruit pulp is rich in ascorbate, containing 337 mg of vitamin C per 100 g of pulp (about six times the level in citrus fruit). The pulp is used to prepare a drink that is consumed either cold or hot or added to cereal porridges. The fruit is locally available in rural communities in Nigeria.

The objective of the study was to determine the effect of baobab leaf pulp on iron status in children using hemoglobin concentration and serum ferritin level as indicators. Three hundred schoolchildren 6 to 8 years of age were drawn by sampling from a rural community primary school and screened for the study; 142 children with hemoglobin levels less than 11 g/dL were selected. The children stayed in a metabolic unit at the University of Nigeria's Department of Home Science and Nutrition for the duration of the study. The 142 children were de-wormed and divided into equal groups of 71 children each. One group served as the control. The hemoglobin levels of each group were comparable. The test group was fed 250 mL of baobab fruit pulp drink (BFPD), which provided 60 mg ascorbate per day after a cereal/legume/vegetable-based meal for 3 months. The other group was fed the meal only. The hemoglobin and serum ferritin levels of both groups were estimated before and after the intervention period.

In reporting the results of the study, Dr. Nnam indicated that the intervention group had a mean hemoglobin of 10.85 g/dL (control group mean = 10.86 g/dL) at baseline and 65% had serum ferritin below 12 µg/L (control group = 68%). After 3 months of intervention with BFPD, the mean hemoglobin of the test group increased to 12.92 g/dL and 23% had serum ferritin below 12 µg/L. The control group had only a slight increase in hemoglobin (10.86 to 11.01 g/dL) and no change in serum ferritin.

The significant increase in hemoglobin of the children from 10.85 to 12.92 g/dL was indicative of improved iron status due most likely to the added BFPD in the diet. BFPD is high in ascorbate, which promotes absorption of iron, possibly by chelation or by reducing the iron to the ferrous state. The slight increase in mean hemoglobin of the control group was probably due to improved dietary habits during the experimental period.

The decrease in the prevalence of children with serum ferritin below 12 µg/L (65% to 23%) showed that there was a significant improvement in the iron status of the children during the intervention with BFPD.

In conclusion, Dr. Nnam stated that baobab fruit is an inexpensive, natural, and nutritious source of vitamin C, which could be used to improve the iron status of children. The fruit pulp is locally available in rural communities and could be incorporated into many dishes to diversify and improve the bioavailability of iron.

A study conducted in Indonesia to investigate the effectiveness of consuming acceptable and affordable locally available meals rich in iron, especially heme-iron, from natural foods in improving the iron status of adolescent girls had a similar outcome as that of Dr. Nnam (Th30). The conclusion was that foods naturally rich in iron can contribute to reducing the prevalence of anemia among adolescent girls. It increased hemoglobin concentration and reduced the prevalence of anemia significantly.

Integrated Programming, Including Home-Based Fortification Using "Sprinkles" is an Effective Strategy for Addressing Anemia in Mongolian Children

Dr. Solongo Altangerel, of World Vision International, in Ulaanbaatar, Mongolia, opened her presentation by introducing the geographical and population landscape of Mongolia (Th91). In this landlocked country of 2.5 million inhabitants, the

nutrition and health realities for children under 5 years of age are bleak. The traditional complementary foods consist mainly of flour- or rice-based porridge made with water and occasionally milk, sugar, and butter.

The goal of the nutrition program was to improve the intake of iron and vitamin D and the overall health status of children under 5 years of age and pregnant and lactating women in the World Vision program areas in Mongolia. The program was implemented between October 2000 and November 2003 in four provinces: Ulaanbaatar, Bulgan, Dundgobi, and Erdenet. The program used an integrated approach, combining both short- and long-term strategies. There were 13,321 children 6 to 35 months of age enrolled in the program. Prevention and treatment of anemia in this group was achieved through the use of "Sprinkles," commercially available, single-serving packets of tasteless dry powder containing 400 IU vitamin D, 600 IU vitamin A, 50 mg vitamin C, 150 µg folic acid, 40 mg iron, and 10 mg zinc. Sprinkles were distributed by community nutrition workers on a monthly/bimonthly basis to the homes of participants. Nutrition workers compiled distribution and consumption records into monthly reports.

There were 10,195 children 3 to 5 years of age, and this group received iron syrup containing 3 mg/kg for 3 months daily for prevention and treatment of anemia. The syrup was distributed by family doctors at medical clinics and by community nutrition workers through home visits. The third group consisted of 1558 pregnant women and 5460 lactating women, who were supplemented with iron-folic acid; 60 mg of iron and 400 µg of folic acid were administered per day during the second and third trimester and 6 months post delivery. A 1-month supply was provided through medical clinics and home visits.

Medical personnel were trained on the prevention and treatment of anemia and other micronutrient deficiencies. Nutrition education at the community

level was provided by nutrition workers through workshops and home visits. Key topics included infant nutrition, exclusive breastfeeding, and dietary diversification, with a focus on iron-rich foods and nutrition requirements during pregnancy and lactation. Raising awareness of key nutrition and health issues was accomplished through multimedia approaches, including radio announcements and billboards in buses, health clinics, and businesses. Nutrition education videos were also produced. The program sought to influence national nutrition policy by providing guidance for the national plan of action on nutrition.

Baseline and final surveys were multi-cluster and pre- and post-comparison designs. The key indicators measured included anemia as defined by hemoglobin levels below 11.5 g/dL (altitude adjusted), exclusive breastfeeding rate (based on mothers self-report), coverage of home-based fortification (Sprinkles), and iron supplementation.

The results of the intervention indicated that children 6 to 35 months of age had a significant reduction in anemia: from 55% to 33%. The survey findings indicate a significant relationship between the duration of Sprinkles use and the prevalence of anemia. Children under 3 years of age using Sprinkles fewer than 3 times per week had a prevalence of anemia of 52%, compared with 31% among children who used Sprinkles three or more times per week. Eighty-eight percent of the households with children 6 to 35 months of age reported using Sprinkles for a period of 4 months or more, suggesting good acceptability of the product. In addition to the increased intake of iron through Sprinkles, the decrease in anemia among children under 3 years of age can be attributed to improved breastfeeding practices. Rates of exclusive breastfeeding to 6 months of age increased from 16% to 40% in one region and from 19% to 44% in another region.

Significant reductions in anemia were also observed among children 3 to 5 years of age as prevalence decreased from 29% to 13% in combined program regions. Training of medical personnel on the early detection of anemia, along with ensuring the supply of iron supplements to medical posts and pharmacies, resulted in increased identification and treatment of anemia among these children, as demonstrated by increased coverage rates for supplementation. This, combined with the prevention of anemia through the use of Sprinkles, improved exclusive breastfeeding, and dietary diversification, is believed to have effectively reduced anemia in children 3 to 5 years of age.

In conclusion, Dr. Altangerel reiterated that integrated programming is a successful approach for reducing anemia among children under 5 years of age in Mongolia. Home-based fortification using Sprinkles, which were widely accepted, effectively reduced anemia. A further benefit to the home-based fortification approach was that this strategy did not require the introduction of new foods, but added value to the commonly used complementary foods already consumed.

Dr. Altangerel emphasized that recommendations for future programs in Mongolia are to continue promoting exclusive breastfeeding, and that Sprinkles may be used for the effective treatment and prevention of anemia in children under 3 years of age, starting at 6 months of age. Nutrition education and dietary diversification strategies promoting iron-rich foods should also be included in future programs.

A poster on designing a program for large-scale delivery of Sprinkles, the objective of which was to evaluate the effectiveness of Sprinkles distribution on the nutritional status of children under 5 years of age and to identify appropriate distribution channels, reported some positive outlooks (Th33). The conclusion of this study was that home-based fortification with Sprinkles is an innovative strategy to address the problem of child anemia.

Reduced Anemia Through Biannual De-worming Brings Brighter Future for Preschool Children in Nepal: De-worming Impact Evaluation Study

Mr. Pragma Mathema, of UNICEF, in Kathmandu, Nepal, opened his presentation by giving some background information about Nepal, a country with one of the highest child mortality rates in the world (91/1000 live births) (Th92). Malnutrition is also high in Nepal. According to the 1998 National Micronutrient Survey, 78% of preschool children were found to be anemic and more than 50% of children to be suffering from general malnutrition. Furthermore, worm infection has been a serious health concern, with studies reporting infection rates over 50%, contributing to the high rates of anemia.

In 1993, Nepal launched its national vitamin A supplementation campaign. Starting with eight districts, the program has expanded to cover the whole nation. The program has been very successful in terms of coverage and impact, reaching over 90% of the 3.3 million children between the ages of 6 and 59 months. This program offered an ideal channel to combine de-worming with vitamin A capsule distribution in a cost-effective manner, while ensuring high rates of coverage. In 1999, de-worming was integrated with the vitamin A supplementation campaign. Children ages 2 to 5 years of age were de-wormed with a single dose of albendazole. Female community health volunteers and other health workers delivered both interventions through the village development committees twice a year. The "vitamin A plus" program began in 14 districts. By October 2004, it was expanded to all 75 districts in Nepal.

An evaluation conducted in 2003 to assess the impact of de-worming on anemia and helminth infection sampled and evaluated some 1920 children 2 to 5 years of age. Three rounds of de-worming were done, and in all three rounds, more than 85% of children were de-wormed; in the third round of distribution, de-worming coverage reached 95%. With each round of

de-worming, the prevalence of helminth infection progressively declined. Initially, 40% of children were infected, but after the third round of de-worming, only 19% were infected. More importantly, significant reductions were seen in the intensity of roundworm, hookworm, and *Trichuris trichiura* infection in children. For instance, the mean load decreased from 4330 eggs/g in the baseline to 774 eggs/g after the third round.

The impact of de-worming on anemia was drastic, with a reduction from 47% prevalence at baseline to 29% after the first round, and 11% after the second round of de-worming. After the third round of de-worming, the prevalence remained at 11%. Subsequently, mean hemoglobin increased from 11 to 11.4 to 12.2 g/dL after each respective round of de-worming. An overall reduction in the prevalence of anemia by 77% after two rounds of de-worming was seen.

In conclusion, Mr. Mathema confirmed that the preschool de-worming program in Nepal has been extremely successful both in terms of the coverage and the impact. The post-distribution surveys have consistently indicated coverage rates of over 85%. In 2004, coverage for both rounds of de-worming was over 95%, and over two million children were de-wormed twice. Furthermore, the program has been a very cost-effective intervention. The key costs for integrating de-worming into the national vitamin A supplementation campaign in Nepal are the procurement of the de-worming tablets, training, and social marketing work. Each tablet costs only 1 US cent, and the initial training (including social marketing) 16 US cents, making the total price for integrating biannual de-worming just 17 US cents per child. Given the relatively low cost of de-worming and its considerable benefits, Nepal has decided to continue integrating de-worming into their major ongoing programs.

Open Discussion

A question concerning adherence to iron supplements was posed to the panel by a participant from India. The participant

stated that, in India, health workers provide iron supplements, but that women often take only a few tablets. He asked whether there are models or studies that have been documented to improve adherence to taking supplements. Another participant commented that in Gaza, Palestinians considered supplements as medication, and therefore did not want to take them. Mrs. Yiannakis said that in Malawi, community women volunteers hold an "iron supplement day." On this day, one iron tablet is given to the mother and taken in front of the volunteer; the mother then takes six tablets home to take one each day for the rest of the week. Any mother who does not attend is followed up in her home. One volunteer is responsible for 250 households and this has been found to be quite feasible. The same strategy may be applicable to other population groups, including those under 5 years of age.

Ms. Rossina Pareja Torres, of the Instituto de Investigación Nutricional, in Lima, Peru, mentioned that there is a high prevalence of anemia in Peru, yet there is a reluctance to give supplements because of the risk of infection, and wanted to know how this is managed in the program with health workers in Nicaragua. Dr. Bonilla said that in Nicaragua the decision to have the most influential professionals in the society involved in the program, specifically health professionals, was taken 10 years ago. Consequently, there was a series of workshops and materials developed for health professionals. First, the scientific community needed to be convinced and then other aspects fell into place.

Dr. Crawley asked whether interviews will be conducted to see how well women are being counseled in the program in Ghana presented by Mrs. Quarshie. Mrs. Quarshie commented that indicators will include change in knowledge and awareness levels, change in proportion of pregnant women receiving counseling, as well as some of the malaria program indicators such as pregnant women receiving intermittent preventive treatment and sleeping under insecticide-treated bed nets. The Ghana Demographic Health Survey of 2003 is providing baseline hemoglobin levels and

will be reassessed in 2007 to determine changes.

In response to questions regarding the Ghana program and particularly in relation to how to combat anemia in children, Mrs. Quarshie commented that school-aged children were given weekly iron and folic acid supplements and will be de-wormed twice a year. For pre-school-aged children, there is discussion about whether to give supplements or not, but the program does incorporate the promotion of breastfeeding and appropriate and timely complementary feeding, improving home-based care for malaria treatment, promoting the use of insecticide-treated bed nets, and promoting good sanitation, among other health interventions.

A participant asked if Sprinkles were provided free of charge. Dr. Altangerel responded that a sachet of Sprinkles costs 4 US cents, but the population receives them for free. Mothers have been asked whether they would buy them if they were not free, and a small trial may be conducted to see how this would be accepted.

A participant commented that in India, there was a commitment to pay 100 rupees to community volunteers. De-worming was done every 21 days and the quality of the water supply was addressed. Mr. Mathema commented that in Nepal, the community volunteers were not paid and access to safe water supply improved 60% to 70%.

Mrs. Yiannakis asked about the cost of iron fortification per sachet of soy sauce in Indonesia and who covered this. Dr. David Yeung, of the H.J. Heinz Company, in Toronto, Ontario, Canada, answered that the H.J. Heinz Company together with Akzo Nobel, the producer of Ferrazone (FeNaEDTA), covered the cost of the fortified soy sauce while impact was assessed by Helen Keller International. The actual price of the sachet for the consumer was the same as the non-fortified sachet. He commented that they wish to expand this fortification effort and explore different cost-reducing options, including the possibility of government tax exemptions.

Dr. Omar Dary, of MOST, The USAID Micronutrient Program, in Arlington, Virginia, USA, commented that the soy sauce sachets contained a small amount of iron, and thus would have a limited impact on iron status.

Dr. Darnton-Hill commented that, globally, anemia prevalence has not decreased much and that fortification is one way of addressing this. He suggested focusing on adolescent girls so that they have better iron status when entering pregnancy, and considering home-based fortification of this population with Sprinkles.

Dr. Stoltzfus commented that it is not a single strategy but rather a combination of approaches that strengthen programs to achieve a reduction in anemia levels.

Closing Remarks

Dr. Lena Davidsson, Chair of the INACG Steering Committee, summarized the presentations and highlighted the importance of the symposium. The keynote address by Dr. Fall on maternal nutritional status, fetal growth, and iron status during infancy gave new insights on assessing iron status during pregnancy. The first session continued with recent advances in assessment—how to assess and define requirements in vulnerable groups of the population, especially infants. This was followed by a presentation of the WHO/CDC consultation on indicators to assess iron status of populations. She recognized that the iron community is well aware of the limitations of indicators and has been awaiting ideas to move forward; the discussion of hemoglobin, serum ferritin, transferrin receptors, and acute-phase proteins as indicators was helpful. Dr. Davidsson noted that the WHO/CDC consultation has also been useful in setting research priorities.

Different strategies to combat iron deficiency in different situations were also presented: supplementation, food fortification, and dietary modification and diversification. The risks and benefits of universal iron-folate supplementation to infants and young children were discussed,

clarifying some issues. Supplementation studies in different settings were presented: in Nepal, where there is little malaria but a high burden of infectious disease, and in Zanzibar, where there is high malaria transmission. Dr. Davidsson emphasized that the goal of supplementation is maximum benefit and minimum risk. The discussion highlighted that one size does not fit all with iron supplementation, and there is a need for more specific recommendations, including how to screen children to arrive at the best intervention.

In the area of child development a meta-analysis of 17 randomized, placebo-controlled studies and results from very recent studies were been presented. This is an area that is very difficult to evaluate. Questions remain regarding which is the best method to be used in different settings and what can be inferred from interventions starting at different ages and different duration of intervention.

Dr. Davidsson referred to the wide range of ongoing program interventions for anemia control. The strategic communication plan in Ghana involving celebrities such as a beauty queen demonstrated a creative and novel approach. The sharing of experiences in food fortification, home fortification, increasing the consumption of vitamin C-rich foods, and de-worming, among other approaches, provided important and helpful information for program implementation.

Dr. Davidsson made reference to the wide range of interesting posters presented covering the following topics: assessment, supplementation, child development, program implementation, bioavailability, biofortification, fortification, multiple micronutrients, determinants of anemia, and surveys.

Finally, Dr. Davidsson acknowledged and thanked the hosts of the 2004 INACG Symposium, the Local Organizing Committee, the INACG Steering Committee and Secretariat, the rapporteurs, and the organizations that contributed funding for the symposium.

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ABSTRACTS



Abstracts that appear in this booklet were presented at the INACG Symposium.

Th1 FERRITIN CONCENTRATIONS IN DRIED SERUM SPOTS PREPARED BY FIELD-FRIENDLY APPROACHES: A VALIDATION STUDY IN GUATEMALA. N Ahluwalia, J Bulux, NW Solomons, M-E Romero-Abal, M Mercedes Hernández, and E Boy. Department of Nutritional Sciences, The Pennsylvania State University, University Park, PA; Center for Studies of Sensory Impairment, Aging, and Metabolism (CeSSIAM), Guatemala City, Guatemala; and Micronutrient Initiative, Ottawa, Canada.

Background: Iron deficiency and anemia continue to be public health problems world-wide. Recent development of filter paper-based dried serum spot (DSS) techniques may assist in iron status assessment in population studies. Spot-ferritin assay on DSS samples, prepared from venous or capillary blood, provides reliable and accurate determination. Standard DSS preparation, however, involves precise aliquot of serum and requires some skill and training of field personnel. **Objective:** We evaluated the validity of spot ferritin assay, on DSS prepared by standard and field-friendly simpler approaches, versus serum ferritin by traditional method in a periurban community near Guatemala City. **Design:** Venous blood (5 mL) was obtained from subjects (n=104; age: 24±15 y) and transferred into 2 heparinized and 4 nonheparinized (2 "plain" and 2 "special" SAFECAP® {SAFE-TEC Clinical Products Inc., Ivyland, PA}) capillary tubes and a microtainer®. DSS were prepared, on Whatman No.1 filter paper, using various approaches: A. Standard (precise delivery of 20 µL serum); B. Blot (dropped 25-35 mm serum column); and C. Special dispenser (pushed 20 µL serum directly from special capillary without breaking the capillary tube). Spots were air-dried and placed in airtight plastic bags with a desiccant, until analysis 2 wk later. For DSS A and C entire spot, and for DSS B a circle (d=15.2 mm; ~ 20 µL serum) cut in the center were analysed using spot ferritin assay. An aliquot of serum was also stored frozen until analysis of ferritin by the traditional radioimmunoassay. **Results:** DSS ferritin (A-C) correlated strongly with traditional ferritin (r: 0.71-0.88; P < 0.05). The geometric means (± 1SD) for DSS (A, B, C) and traditional ferritin were 27.5 (12.6-60.2), 32.4 (13.5-77.6), 27.5 (11.7-64.6), and 30.2 (13.8-66.1) µg/L, respectively, and did not differ (P > 0.05). The difference in ferritin values obtained by various DSS approaches versus the traditional ferritin was small (< 4 µg/L, P > 0.05). **Conclusion:** Field-friendly and standard DSS methods provide accurate assessment of iron status for population studies. The simpler DSS approaches for serum ferritin determination need to be evaluated further in populations where iron deficiency is prevalent.

Supported by grants from the Micronutrient Initiative, Canada

Th2 SIMPLE DIETARY TOOL PREDICTS HEMOGLOBIN CONCENTRATIONS IN UGANDAN CHILDREN. PWJ Harvey, TM Taylor, A Kilian, L Sserunjogi, MOST/USAID/JHU, USAID/CDC, Kampala, Makerere University Kampala, Uganda.

Background: Anemia is common in Ugandan children (64%) and nutritionists often argue that child-feeding practices are a major cause of this. We are not aware of any simple dietary assessment tool that has demonstrated this relationship. Ruel and Menon developed an infant and child feeding index (ICFI) based on data collected by Demographic and Health Surveys (DHS) (J. Nutr. 2002 132:11). This index provides a score of dietary quality and feeding practices for children aged 6-36 months. **Aim:** To determine the usefulness of a simple dietary assessment tool in predicting hemoglobin concentrations (Hb) in Ugandan infants and children. **Methods:** We calculated ICFI scores for 2071 children aged 6-36 months in the 2001 Uganda DHS who also had Hb assessed. Scores were grouped into high and low values and included in a linear regression, with Hb (g/L) as the dependent variable. Other covariates included urban/rural residence, wealth quintile, altitude group (a proxy for malaria transmission), age in months, stunting, and wasting. **Results:** Children with better ICFI scores had Hb 3.3 g/L higher than those who scored less well. High malaria transmission was associated with substantially lower Hb (6.5 g/L). Stunting and wasting malnutrition were also significantly associated with low Hb. **Conclusion:** A simple dietary assessment tool demonstrated a relationship between recommended feeding practices and higher Hb. That malaria transmission and general nutritional status are also important determinants of Hb argues for an integrated approach to anemia that addresses the identified preventable causes comprehensively.

Th3 RELATIONSHIP OF IRON RESERVES AND ANAEMIA IN PREGNANT WOMEN. AMASB Mahamithawa, SRHP Gunawardena, CL Piyasena. Medical Research Institute, Colombo, Sri Lanka.

Background: A high prevalence of anaemia in pregnant women and infants emphasizes the need to study the iron reserves at varying stages of pregnancy. Serum ferritin is considered a reliable indicator of iron deficiency than haemoglobin. **Aims:** To describe the iron reserves in women in varying stages of pregnancy in relation to age, parity, duration of pregnancy and anaemic status. **Methods:** A descriptive study was carried out on a sample of pregnant women attending tertiary care ante natal clinics in Castle Street Hospital for women, Colombo, Sri Lanka. Three hundred healthy pregnant women were recruited randomly covering 5 clinic days. Structured questionnaire was administered to all women and samples of blood for haemoglobin and serum ferritin were taken. Indirect cyanmethaemoglobin method using hemocue microcuvettes was employed for the haemoglobin estimation while enzyme linked immunosorbent assay (ELISA) was used to determine the serum ferritin concentration. **Results:** WHO Cut off points was used for determining prevalence of anaemia and iron deficiency. Prevalence of anaemia was 16.6% and 44.3% had low serum ferritin. Highest storage iron deficiency (58.3%) was seen in the first trimester. They were not anaemic as per haemoglobin estimation. Prevalence of anaemia in second trimester was 15.4% while iron deficiency was 42.5% and in the third trimester 19.4% was anaemic and 45.2% were iron deficient. Women less than 18 years of age and over 35 years of age showed higher prevalence of anaemia and iron deficiency. Women in their first and second pregnancy recorded a lower prevalence of anaemia and iron deficiency compared to women of higher parity. **Conclusions:** Iron status is not adequately detected by haemoglobin estimations and the prevalence of storage iron deficiency is 2.7 times higher than that of anaemia. Periodical determination of serum ferritin on sub sample is useful to evaluate the iron status. Poor iron reserve status of women may be the reason behind high prevalence of anaemia in early infancy.

Th4 COMPARISON OF INDICATORS OF IRON STATUS IN CHILDREN AND WOMEN IN THE UNITED STATES. Z Mei, I Parvanta, ME Cogswell, LM Grummer-Strawn. Division of Nutrition and Physical Activity, Centers for Disease Control and Prevention (CDC), Atlanta, USA.

Hemoglobin, mean cell volume (MCV), serum ferritin (SF), transferrin saturation (TS), and erythrocyte protoporphyrin (EP) measurements are commonly used to test for iron deficiency. However, little evaluation has been conducted of these tests' sensitivity and specificity. The objective of this study was to examine the performance of each single indicator above for defining iron deficiency in young preschool children and women of childbearing age. We examined data from the third National Health and Nutrition Examination Survey (N = 1220, children aged 1 to 2; N = 5175, non-pregnant women aged 15-49). We estimated the correlation coefficients matrix among Hb, EP, SF, MCV, and TS. Then we compared the sensitivity and specificity of EP, Hb, SF, MCV, and TS in relation to iron deficiency across the spectrum from iron depletion to anemia. Iron deficiency was defined by low SF or low Hb, or by a four-variable model (at least two of four abnormal values on SF, TS, MCV, and EP).

Using the four-variable model as reference, the sensitivities and specificities of EP and MCV in detecting iron deficiency were statistically better than those of SF, TS, and Hb for 1-2 year old children; TS and EP were statistically better than MCV, SF, and Hb for non-pregnant women aged 15-49 years. The same results were observed using iron depletion (Low SF) as the reference. Using anemia (low Hb) as the reference, however, MCV and TS had better sensitivity and specificity than EP and SF for children 1-2 years and MCV had better sensitivity and specificity than the other three indicators (EP, SF, and TS) for non-pregnant women.

Overall, EP or MCV are a better screening tools for iron deficiency for US children aged 1-2. However, for US non-pregnant women, TS or EP may be the alternative indicators of choice for the detection of iron deficiency.

Th5 WEEKLY IRON-FOLATE SUPPLEMENTATION FOR > 6 WEEKS IMPROVES IRON STATUS OF REPRODUCTIVE AGED-WOMEN: AN EVALUATION STUDY. I Angeles-Adgeppa, LS Paulino, AC Ramos, M Etorma, T Cavalli-Sforza. Food & Nutrition Research Institute, Department of Science and Technology, Taguig, Metro Manila, Department of Health, Manila, WHO-WPR.

Background: IDA remains prevalent in the Philippines. The programmatic issues for ineffective iron supplementation program are: lack of tablet supply and poor compliance due to daily prolonged intake. **Aim:** To determine the effectiveness and duration of supplementation in improving the iron status of women. **Methods:** The study was conducted in three pilot municipalities. A total of 774 pregnant and non-pregnant women had participated. All pregnant women at ≤ 20 weeks had to take weekly free Femina OB until 3 month lactation. After which they have to take weekly Femina caplets which all non-pregnant women had to buy at designated drugstores. Pregnant women at > 20 weeks had to take daily the usual free iron-folate tablets. The project lasted for 12 months. Four surveys were conducted at an average interval of 4 months. Blood samples were taken during each survey period. Hb was analyzed using cyanmethemoglobin method; ferritin was analyzed using Enzyme Immunoassay. **Results:** There was a high rate of loss-to-follow up across survey periods. A total of 2158 blood samples were collected, corresponding to the number of contacts the women had during the 4 surveys. At baseline, the prevalence of anemia among non-pregnant women (33%) was lower than the prevalence among pregnant women (54%). The prevalence of ID was 19% in non-pregnant while 27% in pregnant women. The supplementation period ranged from ≤ 4 weeks to ≥ 9 weeks with a mid-point of 6 weeks. Among pregnant women who took weekly tablets for > 6 weeks, ferritin levels was higher by $13.6 \pm 4.5 \mu\text{g/L}$ compared to those who took these for ≤ 6 weeks; among non - pregnant women it was higher by $15.3 \pm 2.4 \mu\text{g/L}$. No analogous effect was observed in hemoglobin, both among pregnant and non-pregnant women. **Conclusion:** Weekly iron-folate supplementation for > 6 weeks significantly increases iron stores of both pregnant and non - pregnant women but had only mild effects on Hb. Further study is recommended to evaluate the effects of other nutrients in improving the Hb levels of women.

Th7 DIETARY IRON INTAKE AND A FOOD BASED APPROACH IN PREVENTION OF ANAEMIA IN TANZANIA. S Tatala, D Ash, U Svanberg and M Latham. Tanzania Food & Nutr Centre, Dar es Salaam, TZ., Harvard School of Public Health, Boston, MA., Dept Food Science, Chalmers Univ of Tech, Gothenburg, Sweden and Div Nutr Sc Cornell Univ, Ithaca, NY.

Objective: To determine the nutritional relationship between dietary iron intake and prevalence of anaemia among Tanzanian schoolchildren (age 6 to 12 years) and to test the effectiveness of providing a micronutrient beverage to reduce the prevalence of anaemia. **Methods:** Dietary intake was assessed in 101 children using a semi-quantitative food frequency questionnaire. A randomised double blind placebo controlled trial was used to test the efficacy of a multiple micronutrient beverage that provided 5.4 mg iron per school day to 392 schoolchildren for 6 months in the study group. To assess for anaemia and iron status, haemoglobin (Hb), haematocrit (Hct), erythrocyte protoporphyrin (EP) and serum ferritin (SF) were measured. **Results:** A significantly lower intake of iron was seen in schoolchildren with $\text{Hb} < 11.5 \text{ g/dL}$ compared with those who were normal. Total iron intake was 22 ± 7 and $27 \pm 13 \text{ mg/day}$ respectively ($p < 0.05$), and only minor amounts of iron from animal sources were taken. There was also a significant correlation between iron intake and serum ferritin ($r = 0.233$, $p < 0.05$). After six months of supplementation, the study group had a significantly larger increase in haemoglobin than the placebo group (9.2 vs 0.2 g/L respectively). EP decreased significantly in the study group ($p < 0.01$) compared with the placebo group (-18.5 vs $4.9 \mu\text{mol/mol haem}$) and the increase of SF was significantly higher in the study group ($p < 0.001$) than in the placebo group (15.9 vs $2.1 \mu\text{g/L}$). Of those who were anaemic at baseline, 69.4% in the placebo group and 55.1% in the study group remained anaemic at follow up ($\text{RR} = 0.79$), a cure rate of 21%. **Conclusion:** Iron intake was inadequate to maintain normal iron nutrition in schoolchildren most likely due to consumption of foods with low iron bioavailability. Dietary supplement for 6 months containing physiological amounts of iron and vitamins in a multiple micronutrient beverage significantly lowered the prevalence of anaemia and iron deficiency in the schoolchildren.

Th6 EFFECTIVENESS OF BIWEEKLY VERSUS DAILY IFA ADMINISTRATION ON ANEMIA STATUS IN PRESCHOOL CHILDREN IN INDIA. Shally Awasthi, Tuhina Verma, Shiela Vir, Dept. of Pediatrics, King George Medical University, Lucknow (UP) India and Lucknow Field Office, UNICEF, India.

Three-fourth of preschool children in India are anemic. With the aim to identify cost-effective strategy for iron supplementation for them the study objective was to assess the effectiveness of daily versus biweekly Iron folic acid (IFA: 20 mg elemental iron and 0.1 mg folic acid/tablet) on change in haemoglobin (Hb) levels of preschool children (3-6 years). It was a rural community based effectiveness study in Uttar Pradesh, North India. IFA was given in two schedules, biweekly (2 tablets/dose) and daily (1 tablet/dose) for 1 year with fortnightly monitoring for adherence. Enrolled in daily and biweekly regimens were 400 and 403 children, respectively, of which 57.32 % and 50.25 % anemic ($\text{Hb} < 11 \text{ g/dL}$) in each group. Adherence in biweekly and daily regimens was 89.05% versus 63.5% . After 1 year, mean Hb rise in daily and biweekly regimen was 1.063 g/dL ($\text{SD}: 1.6$; $p = 0.000$) and in 1.053 g/dL ($\text{SD}: 1.73$; $p = 0.001$), respectively. Reduction in point prevalence of anaemia was 65.7 % daily versus 56.1 % in biweekly regimen ($p = 0.0047$). We conclude that biweekly as well as daily IFA administration are effective in raising Hb level and decreasing community prevalence of anemia significantly; however since there is better adherence and lower drug costs associated with biweekly IFA administration this can be considered for programmatic purposes.

Key words: preschool children, anemia, nutritional, IFA, biweekly, daily, India

Th8 COST-EFFECTIVENESS OF COMBINED DEWORMING AND WEEKLY IRON SUPPLEMENTATION IN THE REDUCTION OF ANEMIA AMONG PRESCHOOLERS. FS Solon, LB Fajutrao, JAA Solon, JN Sarol Jr, LS Wambangco-Tengco, LS Fermin. Nutrition Center of the Philippines, Metro Manila, Philippines and University of the Philippines, Manila, Philippines.

Background: Iron deficiency anemia (IDA) afflicts 30% of Filipino children aged 1-5 y. The strategy for IDA in hookworm-endemic areas should include addressing hookworm infection concurrently. **Aim:** This study aimed to determine the cost-effectiveness of combined deworming and weekly iron supplementation in the reduction of anemia in preschoolers. **Methods:** This randomized trial was done among 2,082 1-5 y old children in 8 rural villages in Cebu province, Philippines. One group received deworming with albendazole followed by 16 wk of iron supplementation (DIS group). Another group received iron supplementation alone (IS group). Ferrous sulfate was given weekly for 16 wk, at $\sim 3 \text{ mg iron/kg body weight}$. **Results:** At baseline, the prevalence of anemia in the DIS and IS groups was 15.6% and 16.8%, respectively. Hookworm infection was at 3.3% and 3.9%; Trichuris infection at 14.7% and 18.8%; and, Ascaris infection at 50.3% and 54.1%. Except for Trichuris infection, these prevalences were not significantly different. At post-intervention, the mean hemoglobin (Hb), zinc protoporphyrin (ZPP) and serum ferritin (SF) levels improved in both groups, without significant differences between groups. Overall, the prevalence of anemia was reduced by 43%; iron deficiency by 65% (using SF) and 50% (using ZPP); and, IDA by 73% (using Hb and SF) and 70% (using Hb and ZPP). The reductions between groups were not significantly different. The prevalence of infection for all helminths was similar to baseline after 4 months but the prevalence and intensity was significantly lower in the DIS group. Using 2003 as base year, the average cost of administering DIS to a child is \$1.55 and \$0.91 for IS. The cost of drugs comprised 68.2% of total costs for DIS and 62.5% for IS. IS prevented additional mild anemia cases while DIS prevented fewer mild anemia cases and is more costly than IS. DIS caused significant reductions in hookworm and Ascaris infections. **Conclusion:** The combined intervention of DIS did not significantly impact on IDA possibly due to the low prevalence of IDA and hookworm infection. A 16-week regimen with IS was effective in reducing anemia at a lower cost. The relationship between IDA and hookworm infection and the cost-effectiveness of single or combined strategies need to be explored. **Funder:** Early Childhood Development Project-DSWD, Philippines.

Th9 EFFECTIVENESS OF A REDESIGNED IRON SUPPLEMENTATION DELIVERY SYSTEM FOR PREGNANT WOMEN. FS Solon, MGD Risonar, LS Wambangco-Tengco, L Paulino, E Villate. Nutrition Center of the Philippines, Metro Manila, Philippines; Department of Health, Manila, Philippines; and, Helen Keller International, Manila, Philippines.

Background: More than 50% of pregnant women in the Philippines suffer from iron deficiency anemia despite the implementation of a large-scale iron supplementation program. The effectiveness of an iron supplementation program depends to a large extent on the delivery system and compliance of the target recipients. **Objective:** This study aimed to determine the effectiveness of a redesigned iron supplementation delivery system (ISDS) in reducing the prevalence of anemia in pregnant women. **Methods:** This effectiveness trial was conducted among 298 pregnant women in 9 villages in Negros Occidental, Philippines (experimental area) and 284 pregnant women in 9 villages in Negros Oriental, Philippines (control area). Interviews with pregnant women and health workers were conducted and blood samples for hemoglobin level determination (using a HemoCue kit) were collected from the pregnant women at baseline and post-intervention. The pregnant women in the control area were given UNICEF iron tablets (with 60 mg elemental iron and 0.40 mg folic acid) for 6 months using the existing ISDS while those in the experimental area were given the same tablets for 6 months using the new ISDS. The new ISDS was designed based on the results of a preliminary survey on the existing ISDS that was conducted among selected pregnant women and health workers from both areas. The features of the redesigned ISDS included (1) involvement of the indigenous health workers in the identification of pregnant women, distribution of iron supplements and monitoring of compliance; (2) spot mapping and clustering to identify pregnant women early; (3) use of monitoring notebooks to record compliance; and, (4) use of various information, education and communications materials for promoting iron supplementation in the community and for counseling pregnant women. **Results:** After the intervention, the mean hemoglobin level of the pregnant women in both areas increased but the increase was significant only for the experimental group (from 10.8 g/dl to 11.45 g/dl). A significant reduction in the prevalence of anemia (from 50.6% at baseline to 35.5% at post-intervention) was also observed in the experimental group. **Conclusion:** The redesigned ISDS was effective in the reduction of anemia among pregnant women. **Funder:** National Center for Disease Prevention and Control—Department of Health, Philippines.

Th10 PATTERNS OF COMPLIANCE TO MATERNAL IRON SUPPLEMENTATION. N Zavaleta, LE Caulfield, T Garcia, A Figueroa. Instituto de Investigacion Nutricional Lima and, Ctr for Human Nutr, Johns Hopkins School of Public Health, Baltimore.

Routine prenatal iron supplementation has been recommended to control maternal anemia. However low compliance and side effects have usually been claimed as a limiting factor in the response to this intervention. **Objective of the study:** To measure patterns of compliance to prenatal supplements. **Methods:** A double blind supplementation study was carried out in a Hospital located in a peri-urban shantytown in Lima Peru; 1295 pregnant women, 10-24 wk of gestation, were enrolled and supplemented until 4 wk postpartum with either: 60 mg iron and 250 µg folate or 60 mg iron, 250 µg folate and 15 mg zinc. Supplements were provided monthly during prenatal visits. Compliance, side effects and health status was recorded by weekly home visits. **Results:** At entry both groups have similar characteristics in age (mean 24.4 yrs), gestational age (mean 15.9 wks), nutritional and SES status. Mean consumption was 124.6 tablets in group (Fe) and 124 in group (Fe + Zn), there was no difference between groups nor by initial anemia or non-anemia. The anemic women consumed 119.2 tablets in Fe group and, 114.3 in Fe + Zn group. The non-anemic consumed 127.4 (Fe group) and, 128.6 tablets (Fe + Zn group). Mean Compliance was 86 % for all subjects; mean compliance for Fe group was 86.3 %, for Fe and Zn group was 85.8%. Compliance in the anemic mothers was 86.4% and, 85.8% in the non anemic. Most common reported side effects were: epigastric discomfort, constipation, nausea and, headache. Some side effects were reported by at least 50% of subjects and there was no difference by type of supplement. At least 60% of supplemented women referred to feel better, more energetic and increased appetite. **Conclusions:** Compliance to supplementation was high; it could be explained by the following reasons: 1) Health workers were strongly motivated to control anemia. 2) Anemia is recognized as nutritional deficiency in this community. 3) Iron supplementation was very closely bound to prenatal care and it was a good incentive to start and continue with the prenatal visits; 4) Availability of the supplement; 5) Continue monitoring and counseling.

Child Development

Thursday, 18 November

Th11 THE EFFECTS OF IRON-DEFICIENCY ANAEMIA ON CAREGIVER INFANT INTERACTION: A CODING SYSTEM. AM Dellis, JD Kvalsvig, SJ Cowley, IK Addallah, NS Ali, P Kariger, D Olney, RJ Stoltzfus. Department of Psychology, University of KwaZulu-Natal, Durban, South Africa, Public Health Laboratory, Wawwi Pemba, Institute of Nutrition, Cornell University, Ithaca, New York.

The majority of studies concerned with the impact of iron-deficiency anaemia (IDA) on infant cognitive development have relied on global *developmental scales* to assess cognitive outcomes. While it has been shown that infants with IDA score significantly worse than non-anaemic comparisons, the value of this form of assessment is limited. Global developmental scales are not well suited to the assessment of *specific processes* that are thought to be involved in early cognitive development. Recently, researchers have begun to explore putatively affected developmental processes, such as disturbances in IDA infants' interaction with the physical and social world. Findings suggest that IDA infants may become 'functionally isolated', thereby impeding their cognitive development through reduced physical and social interaction. Evidence for this suggestion is based predominately on observer ratings from the Infant Behaviour Record (IBR) of the Bayley Scales II and on a limited number of observational studies. In addition, very little data is available concerning the behaviour of caregivers in relation to infants with IDA.

We suggest more comprehensive investigations are required, particularly with systematic observation as an assessment tool. This poster reports on a coding system developed to assess the impact of IDA on caregiver infant interaction among dyads from Pemba Island, Zanzibar. The rationale behind the coding of infant, caregiver and dyadic activity is explained. We report significant associations between some of the codes and a range of independent measures, namely, anthropometric, infant haemoglobin and caregiver depression. Our findings provide additional support for the view that infants with IDA are 'functionally isolated'

Th12 EFFECTS OF IRON AND ZINC TREATMENT ON COGNITIVE FUNCTION OF LEAD-EXPOSED MEXICAN SCHOOL CHILDREN. K Kordas, P Lopez, JL Rosado, J Alatorre, G Garcia Vargas, ME Cebrian, RJ Stoltzfus. DNS, Cornell University, Ithaca NY; INCMN, Mexico City; UAQ, Queretaro, Mexico; UNAM, Mexico City; UJED, Gomez Palacio, Mexico; CINVESTAV, Mexico City.

Background: Lead exposure in children is adversely associated with cognitive performance. Iron and zinc are thought to counteract the negative effects of lead, and iron is recommended for treatment of mild to moderate lead exposure. **Aim:** Our objective was to measure the effects of iron and/or zinc treatment on blood lead (PbB) and cognition of lead-exposed school children. **Methods:** In a 2x2 factorial, placebo controlled trial we randomized 602 Mexican 1st graders to 6 mo daily treatment with 30 mg Fe, 30 mg Zn, both, or placebo. Three assessments were performed: baseline (T1), immediately after treatment ended (T2) and again, 6 mo later (T3). Lead, nutritional status and cognitive performance were evaluated. 14 tasks were given to measure cognitive domains of learning, visual spatial abilities and memory/attention. **Results:** 527 children completed treatment (average compliance 92%) and testing at T2; 513 were seen again at T3. At T1 mean PbB was 11.5 ± 6.1 µg/dL; 51% of the sample had PbB ≥ 10 µg/dL, 10% was anemic (Hb < 12.4 g/dL), 12% iron deficient (SF < 12 µg/L) and 29% zinc deficient (SZn < 65 µg/dL). Iron but not zinc reduced PbB (-0.5 µg/dL at both times p < .01). At T2 zinc antagonized the benefit of iron on Hb and SF. Benefits of Zn on SZn and of Fe on Hb did not persist until T3; Fe continued to reduce ZPP at T3. Over long term only 4 persistent treatment effects on cognition emerged but all were small: Fe negatively affected math achievement and memory, but improved information processing; zinc had a negative effect on math and attention. **Conclusions:** PbB reduction by Fe was persistent but small, and Fe effects on cognitive outcomes were inconsistent. Zn had no effect on PbB and small negative long-term effect on 2 cognitive tasks. Fe and Zn cannot be recommended as sole treatment of Pb exposed children but may benefit exposed populations with higher prevalence of Fe deficiency.

Th13 THE EFFECTS OF IRON SUPPLEMENTATION AND ANTHELMINTIC TREATMENT ON THE SOCIAL AND EMOTIONAL BEHAVIOUR AND DEVELOPMENT OF PRESCHOOLERS ON PEMBA ISLAND, ZANZIBAR. JD Kvalsvig, R Stoltzfus, H Chwaya, A Montresor, M Albonico, L Savioli, J Tielsch, E Pollitt. University of KwaZulu/Natal, Durban, South Africa; Cornell University, Ithaca, New York; Ministry of Health, Zanzibar; World Health Organisation, Geneva, Switzerland, School of Public Health, Johns Hopkins University, Baltimore, Maryland; University of California, Davis, California.

In a randomised placebo-controlled trial, Zanzibari preschoolers took part in a year long programme of daily iron supplementation and three-monthly deworming, which resulted in a reduction of more than 70% in the prevalence of severe anaemia. At the end of the 12 month study period there was significant improvement in language and motor development in the iron supplemented children (Stoltzfus et al, 2001). The present account examines the effect of the treatments on social and emotional behaviour in the same children, and on the development of more mature social and emotional functioning. At the start of the study and again 12 months later children were observed in their homes during the normal course of their activities and their behaviours recorded on a checklist. During the same household visit their caregivers responded to sets of questions about the child's level of social development and their emotional maturity.

An analysis of variance model was used to assess the association between anaemia and the socio-emotional measures at baseline, and the effects of iron and/or deworming treatment on the twelve-month scores. Both the iron and the deworming had significant effects on aspects of social and emotional function, but the effects of treatment were not additive, and were manifest in different measures.

Baseline haemoglobin was a significant predictor of measures of social development and sociability. The severely anaemic children had the lowest scores on these measure at twelve months, but there were significant improvements in the iron supplemented severely anaemic children on several measures of social and emotional development. Interestingly, the deworming appeared to have its greatest effect on the signs of distress in children rather than on their development per se. This treatment was associated with less crying and solitary behaviour in the severely anaemic children.

Reference: Stoltzfus RJ, Kvalsvig JD, Chwaya HM, Montresor A, Albonico M, Tielsch JM, Savioli L, Pollitt E. Effects of iron supplementation and anthelmintic treatment on motor and language development of Zanzibar preschool children. *British Medical Journal*, 2001, 323:1389.

Th15 ASSOCIATIONS BETWEEN IRON AND ZINC STATUS AND COGNITIVE PERFORMANCE IN SCHOOL-AGED CHILDREN IN INDONESIA AND AUSTRALIA. Saskia JM Osendarp, Katrine Baghurst, Widjaja Lukito and JanWillem van Klinken on behalf of the NEMO study team. Unilever Health Institute, Vlaardingen, The Netherlands; CSIRO Health Sciences and Nutrition, Adelaide, Australia and SEAMEO-TROPED RCCN UI, Jakarta, Indonesia.

Background: Iron and zinc have been associated with children's cognitive development and performance, particularly among under-nourished children in developing countries. Most research to-date has been focusing on children below 2 years of age and less is known about this association in school-aged children and better-nourished children. **Methods:** This study involved 375 children between 7-9 years of age from six urban primary schools in Indonesia and 135 children from 42 primary schools in South-Australia who were taking part in two similar randomized controlled intervention trials. At baseline venepuncture samples were collected for determination of iron status (hemoglobin, serum ferritin, serum transferrin receptor) and serum zinc status. Cognitive performance was measured using a battery of tests including tests to assess working memory, speed of processing, attention and concentration, executive functions, reasoning and fluid and crystallized abilities. Tests were adapted to the local language and piloted in both Indonesia and Australia. Child psychologists who were extensively trained, administered the tests during special sessions in the schools. A single testing session did not last more than one hour. **Results:** Preliminary findings indicate some small, but statistical significant positive correlations between measures of iron status and measures for executive function, speed of information processing and vocabulary in Australia and Indonesia and for measures for working memory in Indonesia. There were no significant associations between serum zinc and any of the cognitive test-scores in Indonesia. However, in Australia there were significant associations between zinc status and tests for working memory and visual attention, despite the fact that these children were mostly zinc replete. **Conclusion:** Indicators of iron status were associated with a number of cognitive abilities in young school-aged children in Indonesia and Australia. Serum zinc status was not associated with any of the measured areas of cognition in Indonesia whereas in Australia some associations between serum zinc and cognition were observed.

Th14 IRON STATUS AFFECTS COGNITION IN YOUNG ADULT WOMEN. LE Murray-Kolb(1), KE Whitfield(2), JL Beard(1). (1)Dept. of Nutritional Sciences and (2)Dept. of Biobehavioral Health, The Pennsylvania State University, University Park, PA, USA.

Background: Iron deficiency is the greatest single nutrient deficiency worldwide, affecting those in developing countries as well as developed countries. Those most affected are infants, children, and women of reproductive age. Although iron deficiency anemia has been linked to poor motor and mental development in children and adolescents, the relationship between iron status and cognition in adults is unknown. While iron is important during the rapid development of the brain, it remains essential for many cellular oxidative and synthetic processes occurring even in adulthood. Therefore, iron deficiency may alter cognition during adulthood. **Aims:** To define the relationship between iron status and cognitive functioning in young women. We also wanted to examine the relationship of the severity of iron deficiency to the severity of the outcome. **Methods:** This was a blinded, placebo controlled, randomized intervention trial conducted in iron sufficient (CN), iron deficient (ID), and iron deficient anemic (IDA) women. Eight computerized cognitive tasks from the Detterman's Cognitive Abilities Test were administered at baseline and again after 16 weeks of consuming iron supplements or placebo. Three domains were tested (attention, memory, and learning) through the use of Detterman's modal model of information processing. **Results:** Baseline testing was completed by 149 women (42 CN, 73 ID, 34 IDA) and 113 women (30 CN, 53 ID, 30 IDA) completed the entire study. Data were analyzed both cross sectionally as well as longitudinally. Cross sectional ANCOVAs revealed a relationship between iron status and attention as well as memory in adult women. Performance on the tasks was significantly better and time to complete the tasks was significantly shorter in the women with the highest iron status compared to the women with the lowest iron status. Performance was affected by low iron status even in the absence of anemia while time to complete the tasks was related to the level of anemia present. Longitudinal analysis (repeated measures ANCOVA) revealed an improvement in performance as well as a reduction in time needed to complete the attention, memory, and learning tasks for those women who significantly improved their iron status over time. **Conclusions:** This study demonstrates a relationship between iron status and information processing in adult women. It also reveals a relationship between the level of iron deficiency and the level of cognitive impairment. These findings are significant given the number of women who suffer from iron deficiency worldwide.

Th16 EFFECT OF ZINC AND/OR IRON-FOLATE SUPPLEMENTATION ON FAGAN TEST SCORE IN 39- AND 52-WEEK CHILDREN LIVING IN SOUTH-CENTRAL NEPAL. EH Siegel, RJ Stoltzfus, SK Khatri, J Katz, RL Canfield, SC LeClerq, and JM Tielsch. Johns Hopkins Bloomberg School of Public Health, Baltimore MD, Cornell University, Ithaca, NY, and Nepal Nutrition Intervention Project-Sarlahi, Kathmandu, Nepal.

Few studies have examined the effect of zinc and iron-folate supplementation on infant cognitive development; hardly any of these have used tests of information processing. The objective of this study was to determine whether supplementation with zinc and/or iron-folate had an effect on 39- and 52-week Nepali children's Fagan Test of Infant Intelligence (FTII) preference for novelty, fixation duration, lookaway, and sustained attention scores. We tested 362 rural children, 244 39-week and 326 52-week children, living in Sarlahi District, Nepal between January and November 2002. 208 children were tested at both 39- and 52-weeks. These children were enrolled in a cluster-randomized placebo-controlled clinical trial of daily supplementation with 5 mg zinc, 12.5 mg iron and 50 µg folic acid, zinc-iron-folate, or placebo. Compliance data revealed that children consumed the supplements on average 5 of 7 days a week. This amounted to a mean supplementation time of 9.1 weeks for the 39-week children and 16.4 weeks for the 52-week children. The results suggest that the four groups were not similar prior to data collection. Compared to the other groups, the zinc group had more girls than boys, more high caste members, children from families with a greater number of possessions, less severe stunting, higher hemoglobin values, lower erythrocyte protoporphyrin values, and higher compliance than the three other groups ($p < 0.05$). Bivariate analyses revealed no differences among the groups on FTII performance. Adjustment in linear regression models for cluster randomization, dose, sex, caste, socio-economic status, stunting, hemoglobin concentration, and erythrocyte protoporphyrin revealed differences between the three treatment and placebo groups on fixation duration for the 39-week children. For preference for novelty, lookaway time, and sustained attention, the 39- and 52-week children who received zinc and/or iron did not perform differently than the children who received the placebo. The results indicate zinc and iron-folate supplementation had an effect on the information processing of young children living in the South Central Terai region of Nepal. They merit further investigation to understand fully the effect of supplementation with these nutrients on the cognitive development of young children.

Th17 THE EFFECT OF MULTIPLE FORTIFIED SALT ON THE HEMOGLOBIN AND COGNITION OF SCHOOL AGED CHILDREN. M Vinod Kumar. Sundar Serendipity Foundation. Chennai, India.

Aim: To test the efficacy of salt fortified with multiple micronutrients in improving the iron status and cognition of school aged children. **Methods:** The experimental design was a pretest- posttest design with experimental and control groups on children in the age group 7-11years in residential schools in Chennai, India. There were 63 children in the experimental group and 66 children in the control group. Hemoglobin, Red blood cell count, hematocrit and tests for memory, intelligence and concentration were done at baseline and after 1 year of intervention. Deworming was done in both experimental and control groups of children every 6 months. Intervention was carried out by using common cooking salt fortified with iron, iodine, Vitamin A, Vitamin B1, Vitamin B2, Vitamin B6, Vitamin B12, niacin, folic acid and calcium pantothenate in the food cooked in the kitchen of the school of the experimental group for a period of 1 year. Day scholars who attended the day school but who did not reside in the residential school constituted the control group. The children of the experimental and control groups were matched for age, socioeconomic status, hemoglobin and intelligence using Ravens coloured progressive matrices for children at baseline. **Results:** The average hemoglobin in the experimental group before the study was 9.54 gms/dl. This increased to 10.23gms/dl after intervention ($p < 0.05$) where as in the control group it was 10.39g/dl at the start of the study but it declined to 10.14g/dl after 1 year and this drop was significant ($P < 0.05$). We find that in the memory tests, in 4 tests namely in bentons, cattells, picture recall and delayed response learning tests and in the letter cancellation test for attention the increment in scores in the experimental group is statistically significant ($p < 0.05$) than the control. The increment in scores in the experimental group was 15.53, 8.73, 21.23, 22.18, 4.7 respectively for the bentons, cattells, picture recall, delayed response and letter cancellation tests where as it was 8.48, 2.57, 7.27, 5.9 and 1.53 for the control group with the experimental group scoring significantly better than the control. ($P < 0.05$). **Conclusions:** The improvement in hemoglobin through the use of multiple fortified salt has resulted in improvement in the cognition of the children too.

Program Implementation

Thursday, 18 November

Th18 BARRIERS TO MATERNAL ANEMIA CONTROL IN RURAL MALI. VM Aguayo, A Telly, A Touré, and L Mahy. Unicef Regional Office for West and Central Africa (VMA), Helen Keller International-Mali (AT, AT, LM).

Background. In Mali, 73% of pregnant women are anemic (DHS, 2001). **Objectives.** To identify the major barriers to the effective control of maternal anemia in rural Mali. **Methods.** A population-based study and a health facility-based study in Bla and Fana (rural southern Mali). **Findings.** 81% of pregnant women were anemic. 54% of women were not able to explain what anemia was, 56% were not able to mention a symptom of anemia, 47% were not able to mention any action women can take to control anemia, and 34% had never heard about anemia. Only 38% of women in the 2nd and 65% of those in the 3rd trimester of pregnancy had had a prenatal consultation. Among them: a) 89% had been prescribed iron and folic acid (IFA) supplements and 62% (30% of total sample) had taken an IFA supplement in the past 24 hours; b) 93% had been prescribed chloroquine tablets and 68% (32% of total sample) had taken three chloroquine tablets in the past seven days; and c) only 3% have been prescribed drugs for intestinal parasite control. Only 27% of the prenatal care providers had received training on maternal anemia control. Supplements and drugs for anemia control were available in almost all facilities. However, one third of them had experienced 1-2 month supply shortages in the previous six months; 78% of the women interviewed after prenatal consultation reported that their health provider had not talked to them about anemia and/or malaria. **Conclusion.** In rural Mali, prescription rates for anemia control are high, women's adherence acceptable, drug supply problematic, women's/provider's knowledge about anemia poor, and providers' counseling to women sub-optimal or non-existent. The services that pregnant women "covered" by the national health system receive for the control of anemia can be significantly improved.

Th19 RESORTING TO RADIO CLUBS TO ENHANCE NUTRITIONAL STATUS IN TWO HEALTH DISTRICTS IN NIGER. I Baguirbi. Helen Keller International, Niamey, Niger.

Background: With low health coverage (about 47%) and high levels of nutritional deficiencies, (about 60% of anemia among women of childbearing age), nutritional problems are utmost priority in Niger. In response, HKI implemented a communication program, using several channels, including radio clubs, to improve behavior and enhance the nutritional status of households. **Objectives:** To enhance nutrition knowledge and change behavior among women of childbearing age. **Methods:** Established in 1960s by the government of Niger, radio clubs are designed to promote social mobilization for development actions, through the sensitization of rural populations. HKI uses radio clubs in 6 intervention villages with population of 10,480, within the social mobilization component of the 'food security initiatives'. Activities include a baseline study on anemia, the broadcast of educational messages and the establishment of community structures, including radio clubs and village animatoin committees (VAC). The radio clubs animators and the VAC are then trained in nutritional education and communication techniques. The members of the radio clubs organize listening sessions, followed by discussions one to three times per week. **Results:** Results of the evaluation show high participation: 80% of interviewed women attended the listening discussion sessions of the radio clubs. 73% of mothers respond that they clearly understood the messages and the practical interest they can draw from them. 78% of mothers report that they start practicing the advices given. Commonly discussed themes are vitamine A and iron (97.7%), diarrhea case management and preparation of ORS (95.4%), consumption of micronutrient-rich food (95%) and breastfeeding (93%). **Conclusion:** Radio clubs appear to be an important source of information for populations and the experience is being expanded to other villages. This experience has raised much excitement about possible use of similar clubs in existing community radio stations within other projects.

Th20 THE EFFICACY OF IRON AND STEEL POTS IN REDUCING PREVALENCE OF ANAEMIA IN VIETNAM: REPORT OF MIDLINE FINDINGS. PR Berti (1), S Zlotkin (2), MA Hoang (3), S FitzGerald (1), T Tuan (4), W Shariiff (2), TT Le (3), C Schauer (2), A Jenkins (3). PATH Canada, (1) Ottawa, Canada and (3) Hanoi, Vietnam; (2) University of Toronto, Toronto, Canada and Hospital for Sick Children, Toronto, Canada; (4) RTCCD, Hanoi, Vietnam.

Background: The use of cast iron cooking pots to increase the amount of iron in the diet and thereby reduce iron deficiency anaemia has been shown to be efficacious in studies in Ethiopia, Malawi and Brazil. While efficacious, cast iron pots have some undesirable characteristics, including slow to heat, prone to rusting and discolouring food, and being heavier than the commonly used aluminium pots. Some types of steel pots have been shown in lab studies to leach iron into food, while having more favourable cooking characteristics than cast iron. **Objective:** To evaluate the efficacy and acceptability of cast iron and blue steel cooking pots in Vietnam. **Methods:** In Hung Yen province, three communes were randomly assigned to each of the three study arms: cast iron pots, blue steel pots, positive control. Three target groups (women of reproductive age (WRA: 15-43 years), adolescent girls (11-14 years) and infants (6-24 months) were screened at baseline by hemoglobin (Hb) levels permitting selection of 15 or more anemic individuals in each target group in each study arm; serum ferritin (SF) and CRP were also measured. Iron pots and steel pots were distributed to households with at least one anemic individual, with guidelines to use the pot for cooking at least once per day. Logistics difficulties prevented monitoring visits, IEC and distribution of positive control from Baseline to Midline, four months later. At Midline compliance and blood data were collected. **Results:** At baseline, 55% of infants were anaemic (Hb<110 g/L) and 15% of adolescent girls and WRA were anaemic (Hb<120 g/L). Of those who were anemic, approximately half of the infants and one-quarter of the girls and WRA were iron deficient (SF<12 µg/L). Despite no promotion or IEC, one-third of the households used the pots daily. However, there was no treatment or compliance effect, perhaps due to the low levels of IDA in the teens and WRA, and infrequent consumption of foods cooked in the pots by infants. The trial is continuing for an additional three months, with an ongoing IEC program now operating. Compliance and blood data will again be collected at the end of the trial.

Th22 REDUCTION OF IRON DEFICIENCY ANEMIA AND IMPROVEMENT OF NUTRITIONAL STATUS OF CHILDREN IN CONFLICT SITUATION: IMPLEMENTATION, CHALLENGES AND SUCCESS IN YATTA TOWN, WEST BANK. M Jaber, M Magoni, B Teccardi, P Redalli, A Abu Yousef, A Abu Rayyan.

Issue: Due to the aggravation of the Palestinian-Israeli conflict the life and health conditions of Palestinian children are deteriorating. In the West Bank in 2002 43.8% of children 6-59 months old were anemic, 4.3% suffered from acute malnutrition (weight/height < 2 S.D.) and 7.9% from chronic malnutrition (height/age < 2 S.D.). A project for the reduction of malnutrition and iron deficiency anaemia was started by Ard el Aftal and Terres des Hommes Italy in June 2003 and is ongoing. **Description:** 2349 families of the area have been visited by social workers and 5111 children 0-59 months identified. 2903 children were referred to the clinic for medical evaluation and blood test, all the other received preventive iron supplementation for 3 months. 2240 children were examined at the clinic, 58% resulted anaemic, 5.3% suffered of acute malnutrition and 14.8% of chronic malnutrition. 1924 were admitted in the therapeutic phase of the project, receiving iron, vitamins C, A and D. Food supplementation was given to poor families. Follow-up compliance was higher than 90%, the average increase of haemoglobin was 1.4 g/L (p< 0.0001) after 3 months of treatment, with greater increase among the children admitted with lower levels. Acute malnutrition in children attending the program fell from 7.3% to 1.5% (p< 0.0001). **Lesson learned:** Levels of anaemia and malnutrition are very high and getting worse. One third of the referred children was lost and there is need to find way to reach them. Following active tracing of defaulters follow-up compliance was high and improvement of nutritional status and anaemia in admitted children was encouraging. **Conclusion:** To increase sustainability and efficacy of the project there is need to have more community participation: health and nutritional education must be enforced; male involvement promoted. The program need to be continued and extended to other areas.

Th21 COMMUNITY-BASED DISTRIBUTION OF IRON+FOLIC ACID IN NIGER: SUCCESS AND CHALLENGES. X Crespin, H Harouna, A Mamadouitaibou, N Zagré, SK Baker Helen Keller International, Niger, (SKB) HKI Regional Office, Dakar, Senegal.

Background: Niger is a Sahelian country, with a high prevalence of anemia among pregnant women (about 60%). In rural areas, only 39.6% of pregnant women have access to health services (1998 DHS) and 11% of those using health services have received iron+folic acid. Helen Keller International, in collaboration with the National Nutrition Division and with the support of Micronutrient Initiative, has tested an alternative supplementation mechanism to increase the percentage of pregnant women benefiting from iron+folic acid supplementation. **Objective:** To measure the feasibility, effectiveness and sustainability of an iron+folic acid community-based distribution to pregnant women. **Method:** The community-based distribution project started with a pilot phase in two health districts. The positive results served as a basis for the extension of activities to seven other districts. During this second phase, nine districts, or 345 villages were covered. The approach involved: community sensitization, baseline study on the knowledge of women on anemia and iron+folic acid, selection and training of traditional birth attendants, distribution of tablets and monitoring. **Results:** The success of this pilot phase is dependent upon the following: baseline study approach; sensitization of communities to secure their involvement; quality training of traditional birth attendants in charge of the distribution of iron+folic acid; close monitoring by health workers and regular supply of iron tablets. The same approach was used during the extension phase, with the same results. However, the implementation period was shorter in some areas because of funding constraints and did not allow for the establishment of a sustainable distribution mechanism. Such a mechanism will be designed and implemented in those areas still benefiting from funding. **Conclusion:** Results are very encouraging, despite unforeseen funding withdrawal that may jeopardize field-level activity implementation. A comparative update of funded and non-funded locations will be provided.

Th23 POSITIVE DEVIANCE APPROACH TO IMPROVE THE IMPACT OF IRON-FOLATE SUPPLEMENTATION IN SENEGALESE PREGNANT WOMEN. M Ndiaye, O Receveur, H Delisle. Université de Montréal – Département de Nutrition, Montréal, Canada.

Background: Iron-folate supplementation is a widespread strategy to control iron deficiency anemia among pregnant women, but there are several barriers to its effectiveness, notably compliance. A positive deviance approach was used to contribute to the effectiveness of the iron-folate supplementation program of MICAHA (Micronutrient and health) in a district of Senegal. **Aims:** To identify knowledge, attitudes and practices about anemia, iron supplements, parasites and diet, which could explain that Positive Deviants (PDs) avoid anemia, although their socio-economic status is similar to that of Negative Deviants (NDs). **Methods:** A cross-sectional study was conducted among 100 women randomly selected from the MICAHA program baseline survey. Hb level, measured by HemoCue, was used to identify PDs (Hb ≥ 110g/l) and NDs (Hb < 110g/l). Data were collected by individual questionnaire and focus groups (5). **Results:** A major finding was that a higher proportion of PDs than NDs attended antenatal care at the health center (95% vs 70%; p = 0.001), where they obtained health information and iron-folate pills. PDs had better knowledge on the role of iron supplements (90% vs 75%; p = 0.045) and were more compliant (93.3% vs 65.0; p = 0.001). PDs also had better knowledge on parasite infections, but the practices were the same. No significant differences in eating patterns were detected. The focus groups revealed that the PDs were more concerned than NDs about their health and therefore attended the health center more regularly despite the fact that its distance is a critical local constraint. **Conclusion:** An intervention based on the implication of PDs in iron-folate supplement distribution to pregnant women outside the health center and in the promotion of good health practices during pregnancy, according to the "hearth model", was proposed. Funded by World Vision Canada / CIDA.

Th24 COMMUNICATION STRATEGY TO PREVENT IRON DEFICIENCY ANEMIA IN WOMEN AND CHILDREN. *IY Núñez, MP Torres, JA Mora.* Ministry of Public Health, El Salvador, The Manoff Group Inc, Washington, MOST, Washington.

The Ministry of Public Health (MOH) of El Salvador, has identified anemia as one of the main nutritional problems, specially in women and children. The prevalence of anemia in children under 5 years old is 19.8%, but in children under 2 is 37% in 2003. In the last years, the MOH has implemented three main strategies to reduce anemia: Food fortification, iron supplementation and nutrition education. A recent evaluation of the supplementation program showed that coverage was very low and mothers did not give the supplements regularly to their children for many reasons. Therefore, a social marketing communication strategy was designed to enhance demand and compliance with iron supplements, and to improve diet with iron rich foods. Messages for families emphasize: a) Take the right dose; b) eliminate dietary inhibitors and increase iron absorption facilitators; and c) increase consumption of iron rich foods. Messages for health workers focus in: a) prescribing the right dose according to age; b) educating mothers about benefits of supplements and options to reduce side effects and c) assuring availability of supplements. Materials used are: a supplementation manual, an educational guide, radio spots and materials for personal counseling. The health workers (physicians, nurses and community health workers) have been trained in technical concepts of iron deficiency and communicational and counseling abilities. Other critical points of the strategy are: 1) improving quality of iron supplements; 2) Mothers encouraged to recognize "medicines" for preventive rather than curative purpose; 3) provision for all health workers to be trained in order to address side effects and poor compliance, which were found, through a formative research, to be critical constraints that could be addressed through the communication strategy.

Th26 COMMUNITY-BASED IRON+FOLIC ACID SUPPLEMENTATION AND NUTRITION EDUCATION FOR PREGNANT WOMEN. FINDINGS FROM MANICA PROVINCE, MOZAMBIQUE. *VM Aguayo, JA Roley, SP Meershoek, MC Pene, and PJ Horjus.* Helen Keller International-Mozambique (JAR, SPM, MCP, and PJH) and UNICEF Regional Office for West and Central Africa (VMA).

Background: Anemia is a severe problem in Mozambique; over 50% of pregnant women are anemic. Current MoH protocol recommends that all women take iron + folic acid (IFA) supplements in their last two trimesters of pregnancy and first trimester post partum. Most women do not take IFA supplements in sufficient quantities. **Objectives:** To improve access by pregnant women to IFA supplements, improve women's knowledge about iron deficiency/anemia, and evaluate the feasibility of achieving these goals through community elected health workers (ACs). **Methods:** 12 intervention neighborhoods and 13 control neighborhoods were included. A baseline survey was conducted before the initiation of the program with women of a 0-11 month old infant and their husbands about anemia and iron-related knowledge, basic socio-economic indicators, as well as diet quality. A similar follow-up survey was performed one year later with the addition of questions related to program quality. **Results:** Contact with an ACS was associated with an increased duration of IFA supplementation (3.3 vs 2.4 months) despite fewer prenatal consults (4.3 vs 4.8). 75% of women with ACS contact reported that they preferred to receive IFA supplements from an ACS rather than at the health post. Coverage at follow-up was lower than expected (27% overall) and no detectable impact was seen on anemia and iron related knowledge. **Conclusion:** Regular supervision of the ACs and the health posts was more challenging than expected. Improved supervision and communication between the health posts, program coordinators, and ACs, can increase program coverage while quality is improved and sustained, so as to make community-based IFA supplementation and iron/anemia education for pregnant women an effective option for decreasing anemia prevalence among pregnant women in Manica province.

Th25 WEEKLY IRON SUPPLEMENTATION AMONG PRIMARY SCHOOL CHILDREN IN BURKINA FASO: IMPROVING COVERAGE. *C Quédraogo, A Tarini, M Saka, M Ag Bendech, SK Baker.* Catholic Relief Services (CO and MS), Helen Keller International (AT, MAB and SKB).

Background: In Burkina Faso, several causes of anemia exist: insufficient food intake, intestinal and urinary parasites and malaria among others, causing reduced academic performance, and low economic productivity. To address this, an integrated school health program is underway in Kourwéogo and Gnagna Provinces, in which supplementation activities are conducted by teachers trained to this effect. **Methods:** Based on pre-established protocols, teachers give the following to the children: iron + folic acid, vitamin A, iodized oil capsules and anthelmintic drugs. Teachers fill out a weekly monitoring sheet. One innovative aspect of this approach is that parents are used to ensure that iron is distributed over 16 consecutive weeks, even during school holidays. **Results:** The coverage rates achieved prove that supplementation activities can be conducted by teachers. In 2001, 2002 and 2003 respectively, 94%, 86.5% and 97.9% of school children received iron supplementation for at least 15 weeks. This approach was refined in Kourwéogo province (that is easily accessible and has a schooling rate similar to the national average) and then replicated in the remote province of Gnagna that has poor academic performance and a high school dropout rate. The same phases of implementation and data collection tools were used for the replication. In 2003, 87.1% of school children received at least 15 tablets of iron supplements. **Conclusion:** Primary school teachers are able to conduct a supplementation and helminth control program, provided they are given a minimum of training and follow-up/supervision. Through this strategy a large number of children can be covered, and good compliance achieved.

Th27 EFFECTIVENESS OF SCHOOL-BASED IRON AND FOLIC ACID SUPPLEMENTATION FOR ADOLESCENT GIRLS: FINDINGS FROM MANICA PROVINCE, WEST-CENTRAL MOZAMBIQUE. *JA Roley, VM Aguayo, SP Meershoek, MC Pene, and PJ Horjus.* Helen Keller International-Mozambique (JAR, SPM, MCP, and PJH) and Helen Keller International-Africa Region (VMA).

Background. In Manica province, 47% of adolescent girls are or have been pregnant and 45% of adolescent girls attending school are anemic. **Objectives.** To assess the effectiveness of two school-based weekly iron and folic acid (IFA) supplementation regimes in adolescent girls. **Methods.** Two comparison groups: six schools in group 5 (5-month supplementation) and six schools in group 8 (8-month supplementation). The weekly supplement contained 60 mg of iron and 400 microgram of folic acid. All girls received a single dose of mebendazol (500mg) at T0 and T6. Supplementation implemented/supervised by school teachers. **Findings.** At T0, mean hemoglobin concentration and anemia prevalence in groups 8 and 5 were comparable (125.3 ± 12.6 g/l vs. 123.8 ± 12.8 g/l). Between T0-T3, girls in group 8 received IFA supplements weekly whereas those in group 5 did not. At T3, mean hemoglobin concentration in group 8 was significantly higher (126.3 ± 14.3 g/l vs. 121.5 g/dl ± 11.9 g/l) and prevalence of anemia lower (28% vs. 35%). At T8, after an additional 5-month supplementation period in both groups, mean hemoglobin concentration and anemia prevalence in groups 8 and 5 were not significantly different (126.5 ± 12.6 g/l vs. 124.9 ± 12.3 g/l; 23% vs. 27%). **Conclusion.** In Manica province, school-based weekly IFA supplementation is a feasible and effective intervention to prevent seasonal drops in hemoglobin concentration and increases in anemia prevalence. Short supplementation periods can have an important impact in girls' hematological status. The size of girls' hematological response was significantly lower than that observed in studies with similar population groups, initial anemia prevalence, supplement composition, and/or supplementation regime. The contribution of malaria and/or other micronutrient deficiencies to adolescent anemia in Manica needs to be documented and adequate measures for its control integrated into school-based programs for anemia control in adolescent girls.

Th28 REDUCING IRON DEFICIENCY ANEMIA AMONG PREGNANT MOTHERS AND CHILDREN IN GAZA AND WEST BANK(GWB): INNOVATIVE APPROACHES FOR EMERGENCY SITUATION. A Roberts, H Al Qedwa, I Shammala, M Qutteina, M Hadad, MARAM Project, Academy for Educational Development (AED).

Problem: Iron Deficiency Anemia (IDA) constitutes a public health problem in Gaza and West Bank. Pregnant mothers and children (under five years) who experience extreme difficulties, are the most vulnerable groups. Research revealed that around 50% of both groups are anemic. Mothers need to learn doable practices to protect themselves and their children. **Objectives:** To reduce the prevalence of IDA among pregnant mothers and their children by promotion of the IDA prevention practices. **Conceptual framework:** Five-steps communication approach has been adapted. The findings of the Trials of Improved Practices (TIPs) research showed a list of key practices that pregnant mothers demonstrated and key factors (benefits and barriers) affecting their behaviors. The TIPs results used to develop the strategy of Behavior Change and Communication (BCC) using AED's Behave framework. Moreover, this strategy was enhanced by the results of exposure and recall survey to include more community based actions and creative arts to pump up the volume of mass media interventions. **Program implementation:** The Maram project established a network with more than 150 community-based organizations and creative artistic groups who developed innovative approaches in BCC. A mix of interventions are being implemented in mass media, child-to-child, peer education, youth and media, creative arts, and mothers support groups. **Outcomes:** Thousands of beneficiaries in the most isolated areas are learning about "small doable actions" that they can practice to help prevent IDA. Moreover, It showed that mothers are able to change eating and drinking habits related to improving iron intake and demonstrate creative approaches related to tea intake/substitutes. Furthermore, the impact of some interventions has been measured (findings will be integrated). **Program implications:** List of best practices(including delay tea) in preventing IDA are being mainstreamed in-country and tools in health communication programming (including AED's the Behave framework, creative briefs etc.) are being adopted by variant stakeholders.

Th30 FOODS NATURALLY RICH IN IRON INCREASE HEMOGLOBIN CONCENTRATION AMONG ANEMIC INDONESIAN ADOLESCENTS. M Sari, S de Pee, R Yip, E Martini, Sugiatmi, D Soekarjo, Muhilal, MW Bloem. Helen Keller International (HKI), Jakarta, Indonesia, HKI Asia-Pacific Regional Office, Singapore, UNICEF Beijing, China, and Nutr. Research and Development Ctr, Bogor, Indonesia.

Objective: To investigate the effectiveness of consuming acceptable and affordable locally available meals rich in iron, especially heme-iron, from natural foods, in improving the iron status of adolescent girls in Indonesia. **Design:** A 6-month intervention where 384 adolescents girls in 5 schools were assigned to one of two groups; 249 girls in 3 schools received iron-rich meals and another 135 in 2 schools received iron-poor meals once per day for 6 days per week. The average amount of iron for rich-iron and iron-poor meals was 9.0 and 5.3mg, respectively. Vitamin C provided from the iron-rich and iron-poor meals was 4.1 and 4.6mg, respectively. **Setting and Subjects:** The study was carried out in five Islamic boarding Schools on Madura Island, East Java, Indonesia. Subjects were adolescent girls aged 12-15 years old who attended and lived in these schools. Weight, height, MUAC, Hb, serum concentration of retinol and carotenoids, information on socio-economic status, and vitamin A intake were collected before and after the intervention. **Results:** Baseline characteristics of the two groups were not different. Among those who were anemic at baseline, 48.0% of those in the iron-rich group became non-anemic, while 22.2% in the iron-poor group became non-anemic ($p < 0.05$). Serum retinol and β -carotene was significantly increased within subject after 6 months of intervention both in the iron-rich and iron-poor groups and the changes were larger in the iron-rich group ($p < 0.05$). **Conclusions:** Food naturally rich in iron can contribute to reducing the prevalence of anemia among adolescent girls.

Th29 IMPROVING NUTRITIONAL STATUS OF PALESTINIAN SCHOOL CHILDREN. M Rimawi. Ministry of Education and Higher Education, Palestine.

According to a survey conducted by John Hopkins and AIQuds University in 2002, critical levels of anemia by WHO classification were found among children in Palestine. Accordingly the Ministry of Education in coordination with Ministry of Health initiated a national intervention to provide micronutrient supplementation to school children from grade 1 to 12. The project was piloted during the school year 2003/2004 in 85 schools, with 26,000 students, and is planned to cover the entire student body in a gradual process starting September 2004. The total number of students expected to be reached is more than one million. The project is based on in-class supplementation, one dose/week, by using locally produced chewable tablets. During the pilot phase, children from six to ten years received one tablet per week, while those from eleven to eighteen years received two tablets per week. The formula consisted of: Iron(40 mg), Folic Acid (205mg), Zinc (15mg), Vitamin A(2mg), Vitamin B2 (10mg), Vitamin B 12 (0.2mg), Vitamin C (50mg). An additional major component of the initiative is related to nutrition education, focusing on the following messages: taking breakfast, taking iron-rich food, taking enhancers of iron absorption, and delaying tea intake two hours after meals.

Knowledge, Attitudes and Practice study and Hemoglobin measurement were carried out before and after the pilot intervention in order to guide in the scaling up process. Analyses of results is underway.

Th31 MANAGEMENT OF ANEMIA IN PREGNANT WOMEN: HEALTH AGENTS' PRACTICES AND OPINIONS. A Tarini, M Ag Bendech, SK Baker. Helen Keller International Burkina Faso (SKB) HKI Africa Regional Office Senegal.

Because of its consequences on maternal and child health and survival, addressing anemia during pregnancy is a priority issue for health services in Burkina Faso. Despite regular anemia management during antenatal consultation, anemia is still a serious problem. Health agents consider anemia as a major risk factor ranking fourth after hypertension, presence of edema and low weight gain. Most practitioners examine conjunctiva coloration (95.8%) and all state that they systematically prescribe iron+folic acid and chloroquine. In practice, we have observed that 67.9% of practitioners prescribe iron+folic acid against 64.3% for chloroquine. Women are not generally informed about potential adverse side effects and the need to take iron tablets regularly. After prescription, practitioners do not check whether the iron tablets have been taken or not. On very few occasions, dietary counseling is provided but it is limited, incomplete and impractical. **Conclusion:** Systematic identification of severe anemia through examining conjunctiva and systematization of preventive prescription of iron and chloroquine are necessary and need to be strengthened and sustained. Major gaps to be addressed include the lack of follow-up on the regular consumption of iron+folic acid and chloroquine, and the lack of appropriate diet counseling using visual aids and the promotion of foods readily available and accessible to the pregnant woman. **Recommendations:** 1) Provide permanent support to nutrition activities in health facilities; 2) Ensure in-service training of health agents on nutrition in general with special attention to anemia management; 3) Design basic technical material, especially visual aids and IEC materials, available in health facilities; 4) Ensure the improvement of coverage, duration and follow-up on the taking of iron+folic acid and anti-malarials through enhanced involvement of the community.

Th32 IRON DEFICIENCY ANEMIA PREVENTION AND CONTROL PROGRAM IN KAZAKHSTAN. Sh. Tazhibayev, T Sharmanov. Kazakh Academy of Nutrition, Almaty, Kazakhstan.

An estimated 35.5% of women and 48.9% of children under the age of five in Kazakhstan suffer from Iron Deficiency Anemia. Anemia Prevention and Control (APC) Program includes iron supplementation, wheat flour fortification, nutrition education and dietary diversification components, communication and social mobilization campaigns, and activities on monitoring and evaluation. UNICEF, JAPAN Foundation for Poverty Reduction and Asian Development Bank (ADB) support implementation of APC, and Kazakh Academy of Nutrition (KAN) is one of the main partner. Supplementation is more specifically targeted at young children at risk, adolescent girls and pregnant women. Flour fortification (with both iron and other micronutrients) was started at 15 large flour producers, with plans for further expansion: legislation for mandatory flour fortification is enacted in 2004. The Union of Grain Processors and Bakeries works with ADB, UNICEF and KAN in an effort to mass-produce fortified wheat flour in Kazakhstan. The communication campaign has been implemented with the support from the Technical Advisory Implementation Group which consists of members from: Ministries of Health, Culture, Information and Social Consent; KAN; Confederation of NGOs; flour producers; and the media.

Th34 SMALL ANIMAL REVOLVING FUND ADDRESSES IRON DEFICIENCY ANEMIA IN MALAWI. R Namarika, M Yiannakis, B Main, K Siekmans. World Vision Malawi, Lilongwe, Malawi, World Vision Canada, Mississauga, Canada.

Issue: Iron deficiency anemia (IDA) is a public health problem in Malawi. A 1996 survey showed 56% of children under five (U5) were stunted (HAZ<-2), 84% were anemic (Hb<11.0g/dL) and 59% of pregnant women (PW) were anemic (Hb<11.0g/dL). **Objectives:** One objective of World Vision's micronutrient and health (MICAH*) program is the reduction of IDA among women and children. The small animal revolving fund (SARF) is an innovative strategy to sustainably increase household (HH) access to animal source foods (ASF). **Framework:** MICAH focused on promoting small animal husbandry (poultry, rabbits, guinea fowl, goats) for HH consumption to increase iron intake from ASF, and provided inputs to women in a revolving fund manner. **Design:** MICAH provided selected families with a male and female pair. The first offspring were given to other families, creating a revolving fund. Future animal offspring were then for consumption. Community education was provided on the importance of ASF and animal care. Village committees monitored the program's repayment (in kind) system, consumption and rearing practices. A strong collaboration with the government has enhanced the program's influence by presenting a united nutrition and health approach, and building capacity of government and community workers and volunteers. **Outcome:** During the severe 1999 food shortage, many HHs sold or consumed all their animals, resulting in a significant set-back to the revolving fund system. A second distribution of animals was completed in 2002. As a result of the SARF strategy, over 10,000 households began rearing small animals. Surveys showed HHs with animals increased from 40% in 1996 to 69% in 2000 (p<0.05); 2003 reports indicate 76% of HHs have small animals. Increased HH consumption of ASF is evident in reports and in discussions with women. This strategy likely contributed to the reduction of anemia in PW from 59% (1996) to 42% (2000) (p<0.05) and in children U5 from 84% (1996) to 66% (2000) (p<0.05). **Implications:** MICAH's experience in promoting ASF consumption through SARF is worthy of replication and scaling up to address IDA. Local partnerships with communities and government are essential for this strategy's success. * MICAH is funded by the Canadian International Development Agency and World Vision Canada.

Th33 DESIGNING A PROGRAM FOR LARGE SCALE DELIVERY OF SPRINKLES. J van Hees, E Martini, D Foote, MA Bloem†, S de Pee*, R Moench-Pfanner*, S Halati, S Kosent, MW Bloem*, Helen Keller International, Jakarta, Indonesia; ‡Church World Service, Jakarta, Indonesia; *Helen Keller International Asia-Pacific Regional Office, Singapore; †National Institute of Health Research and Development, Ministry of Health, Government of Indonesia.

Problem: Up to 70% of young children in urban poor areas of Indonesia are anemic. The negative consequences of anemia for child health and development warrant urgent intervention, but only very few larger scale anemia prevention programs have yet been implemented in developing countries. **Objectives:** The overall aim is to design a program for large scale delivery of an in-home fortificant (sprinkles) to underfive children. Specific objectives include: to evaluate the effectiveness of sprinkles distribution on the nutritional status of underfives; and to identify appropriate distribution channels and promotion strategies for the sprinkles product. **Framework:** In-home fortification may be a highly feasible intervention to address child anemia, especially in urban Indonesia. Mothers are accustomed to sachet use in preparing foods. Local corner shops and/or the community health posts are potential distribution points that are in close proximity to, and regularly used by mothers. Household expenditure data from this population suggest that the product would be affordable for mothers, and current production of sprinkles by private sector partners within Indonesia adds to potential sustainability. **Program:** In three cities of Java and Sulawesi in 2004-2005, sprinkles will be distributed via local NGOs and community health posts in the context of their ongoing health and nutrition programs. **Methods:** Formative research in 2003 employed focus group discussions and in-depth interviews with key informants to develop a local product name (*Vitalita*, meaning *vitamins for underfives*), package design, and key message for promoting *Vitalita* as part of good child care, health care and nutrition. A social marketing campaign is being developed based on these findings. A monitoring and evaluation activity will be conducted in intervention communities to track the use of the product and the impacts on nutritional status of young children, including anemia. Lessons from developing the name and packaging and implementing the distribution/purchasing program are expected by late 2004. **Implications:** In home fortification ('sprinkles') is an innovative potential strategy to address the problem of child anemia, and evidence of its effectiveness will facilitate large scale expansion complementary to other nutrition and disease prevention efforts.

Th35 REHABILITATIVE ASSISTANCE, EDUCATIONAL PROGRAM IN RURAL GAZA-STRIP: THE PREVALENCE OF ANEMIA IN PALESTINIAN TERRITORIES IS CRITICAL. H Yusuf. Consulting Group from Care International and Johns Hopkins University and Jerusalem University. Maram Project, Jerusalem.

Background: Preliminary results of the nutrition assessment in Palestinian Territories showed that 54.7% of children in Gaza-strip are anemic (6-57 months) and 47.2% of pregnant women (15-47 year) are suffering from anemia, moderate to severe and mild. The case of Rafah-Governorate in Gaza South which the urban population and the isolated areas shows tendency for increased anemia compared to other governorates. Rafah area is an area known for its poverty and overcrowded. The high prevalence of anemia in this region is due to the socio-economic factors and the illiteracy, frequent pregnancy, early marriage by tribes, negative cultural belief and lack of proper information. Nutritional deficiencies have increased anemia (iron deficiency), which is one of the public health problems in Gaza-strip South. Statistically, anemia is more higher in the southern and acute and chronic malnutrition among pregnant women and children than most surrounding countries. **Objective:** (1) To control and prevent anemia in deprived areas in Palestinian Territories. (2) Decreasing the number of maternal deaths (1 in maternal death could be avoided if the mother was not anemic. (3) To monitor and evaluate the influence of health messages on the population. **Aims:** The purpose of this survey was to detect the prevalence of anemia (iron deficiency) in Palestinian territories, in some geographical areas which registered a high dominance of health disorders, and exploring the health determinants of anemia in the population of afflicted area. **Methods:** A baseline survey was conducted among 4665 women and children in deprived zone in the southern, a project activities of awareness raising campaigns in creative art, has contributed in increasing the number of women using breastfeeding exclusively the first six months time and making people conscious in giving them access and knowledge to foods rich in iron, which help absorption of iron. The education in: - increasing the consumption of iron-rich foods has provided the appropriately and effectively use that is available to them. **Results:** Program outputs included adequate health messages, drama sessions and art shows in 03 afflicted areas for 4665 women and children, 30 volunteer community leaders are contributed to provide counseling and guiding to the vulnerable groups of families in needs. **Conclusion:** Anemia is a serious public health problem among Palestinian pregnant women and children. The case of Rafah in the Southern was identified to cover 03 areas in health decline, and program activities are being well accepted by the population. (supported by Maram Project) Success stories -the introducing of creative arts in program has motivated other communities to join the field work; -health messages has serious repercussions on the educational -creating friendship and complicity between communities and stakeholders.

Th36 HUMAN MILK AS A SOURCE OF ASCORBIC ACID: NO ENHANCING EFFECT ON IRON BIOAVAILABILITY FROM A COMPLEMENTARY FOOD. L Davidsson, KA Jamil, SA Sarker, C Zeder, G Fuchs, R Hurrell. Laboratory for Human Nutrition, Institute of Food Science and Nutrition, Swiss Federal Institute of Technology, PO Box 474, CH-8803 Rueschlikon, Switzerland and International Centre for Diarrhoeal Disease Research, Bangladesh, Centre for Health and Population Research, (ICDDR,B), Mohakhali, Dhaka 1212, Bangladesh.

Background: Iron bioavailability from traditional complementary foods based on cereals and legumes can be expected to be low unless ascorbic acid rich foods are incorporated into the diet. **Objective:** To evaluate human milk as a source of ascorbic acid to enhance iron bioavailability from khichuri, a complementary food based on rice and lentils. **Design:** Erythrocyte incorporation of iron stable isotopes 14 days after administration was used as a proxy for iron bioavailability. Children (8-18 months old; n=31) were breastfed (32-90 mg ascorbic acid/kg human milk) immediately after intake of four servings of khichuri (labeled with ^{57}Fe ; test meal B) and offered water after intake of four servings of khichuri labeled with ^{58}Fe (test meal A). Test meals were fed during 4 days in the order AABBAABB or BBAABBAA. **Results:** Mean intake of human milk and ascorbic acid was 274 g (range 60-444 g) and 14 mg (range 4-28 mg). Mean molar ratio ascorbic acid:iron was 2.3 (range 0.7-4.6). Geometric mean iron bioavailability was 6.2 % versus 6.5 % ($p=0.76$; paired Student's t-test) from khichuri fed with and without human milk. **Conclusion:** Although human milk contributed significant quantities of ascorbic acid, no significant difference in iron bioavailability was found between khichuri consumed with water or with human milk. These results indicate that the molar ratio ascorbic acid to iron was not sufficiently high to overcome the inhibitory effect of phytic acid in khichuri (30 mg/serving) or that components of human milk modified the influence of ascorbic acid on iron bioavailability.

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Th37 ENZYMATIC TREATMENT OF HIGH-TANNIN SORGHUM INCREASES THE BIOACCESSIBILITY OF IRON. E Matuschek, U Svanberg. Department of Chemistry and Bioscience/Food Science, Chalmers University of Technology, Göteborg, Sweden.

Background: Iron deficiency anemia is highly prevalent in low-income countries, where low bioavailability of iron in the cereal-based diet is one of the main causes. This diet contains high amounts of compounds that inhibit iron absorption, e.g. polyphenols (tannins) and phytate. In high-tannin cereals, it is necessary to reduce both phytate and tannins to increase the bioavailability of iron. The inhibiting effect of tannins can be reduced with processes that change the structure of the tannins, e.g. by oxidation with polyphenol oxidases, enzymes that can be found in many fruits and vegetables. **Aim of the study:** The aim of the study was to investigate how addition of polyphenol oxidase, commercial or from fruit extracts, to dephytinized high-tannin sorghum affects the tannin content and the in vitro accessibility of iron. **Methods:** Incubation of dephytinized high-tannin sorghum was performed on sorghum slurries with commercial polyphenol oxidase or with simple water extracts from banana or avocado. The organic acids in the fruit extracts were extensively reduced by dialysis before addition to the sorghum. The bioaccessibility of iron was estimated by an in vitro method that simulates the human digestion system. Phenolic compounds were extracted with acetone/water, and tannins were separated from non-tannins on Sephadex LH-20. **Results:** Treatment of dephytinized high-tannin sorghum with polyphenol oxidase decreased the tannin content and resulted in a significant increase of in vitro accessible iron. The banana and the avocado extracts showed high polyphenol oxidase activities. Incubation with commercial polyphenol oxidase increased the in vitro accessible iron from 3.5% to 6.4%, and the effect was even larger with the fruit extracts. Incubation with banana extract resulted in 7.3% accessible iron and incubation with avocado extract resulted in 9.8% accessible iron. **Conclusion:** Incubation of high-tannin cereals with polyphenol oxidase, or fruit extracts containing polyphenol oxidase activity, can effectively reduce the tannin content. In combination with simple methods that reduce phytate, incubation with fruit extracts could be used at a house-hold level to increase the bioaccessibility of iron in staple cereals, and thereby be a part of a food-based strategy to avert iron deficiency anemia in low-income countries.

Th38 THE EFFECT OF PARTICLE SIZE REDUCTION AND ENCAPSULATION OF FERRIC PYROPHOSPHATE ON BIOAVAILABILITY IN RATS. R Wegmüller, MB Zimmermann, RF Hurrell. Human Nutrition Laboratory, Institute for Food Science and Nutrition, Swiss Federal Institute of Technology, Zürich, Switzerland.

Background: The iodine-deficiency disorders (IDD) and iron-deficiency anemia (IDA) affect more than one-third of the world's population. Iodization of salt is highly effective in reducing or eliminating IDD, but there is no comparable, proven method for controlling IDA. Dual fortified salt (DFS) with iodine (I) and iron (Fe) could be an effective fortification strategy. However, dual fortification of salt is technically challenging. In recent stability studies of DFS fortified with I and different Fe compounds, two forms of ferric pyrophosphate (FePP) performed well: one with a mean particle size (MPS) of $\approx 2.5 \mu\text{m}$ and one with a MPS of $\approx 0.5 \mu\text{m}$. The effect of a reduction in particle size from a regular FePP with a MPS of $\approx 21 \mu\text{m}$ to $\approx 2.5 \mu\text{m}$ on the bioavailability has not been tested. **Objective:** The objective of the study was to investigate the relative bioavailability (RBV) of FePP with varying particle sizes, and to test the effect of encapsulation on bioavailability of FePP, using the hemoglobin (Hb) repletion method in rats. **Methods:** Male weaning Sprague-Dawley rats were fed a low-Fe diet ad libitum for 24 days, and Hb was measured. Anemic rats were randomly allocated into 11 groups (n=8). The rats were fed the low Fe diet fortified with ferrous sulfate or one of the four different FePP compounds (MPS $\approx 21 \mu\text{m}$, $\approx 2.5 \mu\text{m}$, $\approx 0.5 \mu\text{m}$ and $\approx 2.5 \mu\text{m}$ encapsulated with palm oil) at two fortification levels (10 and 20 mg Fe/kg diet) for 14 days. Hb was then determined and the RBV was calculated by the slope-ratio technique. **Results:** The RBV of the $\approx 0.5 \mu\text{m}$ FePP was significantly higher than that of the other FePP compounds ($P < 0.05$), and was not different from ferrous sulfate. The RBV of the $\approx 21 \mu\text{m}$ FePP and the $\approx 2.5 \mu\text{m}$ FePP was 59 and 69%, respectively, significantly lower than ferrous sulfate and not significantly different from each other ($P > 0.05$). Encapsulation of the $\approx 2.5 \mu\text{m}$ compound with hydrogenated palm oil at a substrate:capsule ratio of 40:60, decreased the RBV significantly to 43%. **Conclusion:** Increasing the bioavailability of ferric pyrophosphate by particle size reduction may make this compound more useful for food fortification. Encapsulation at substrate:capsule ratio of 40:60 reduced bioavailability by about 40%.

Th39 TOWARDS ABSORPTION AND ENHANCED IRON ACCUMULATION IN RICE ENDOSPERM. SK Datta (1), M de Vasconcelos (1,2), MD Khalekuzzaman (1,3), N Oliva (1) and K Datta (1). (1) Plant Breeding, Genetics, and Biochemistry Division, International Rice Research Institute, DAPO Box 7777, Metro Manila, Philippines; (2) USDA-ARS SPA, Children's Nutrition Research Center, 1100 Bates Street, Houston, TX 77030-2600, USA; (3) Department of Botany, Rajshahi University, Rajshahi 6205, Bangladesh.

Iron deficiency is the most common nutritional problem in the world. The micronutrient concentrations in edible plant sources, such as rice, are often not enough to provide the recommended daily dietary allowances. Extensive screening is in progress to identify rice germplasm containing higher levels of iron and zinc under the HarvestPlus program. Some lines have already been identified that have potential levels of iron for use in breeding programs. However, after milling, the iron content of the rice grain declines dramatically to almost negligible values. For increasing the iron storage in the rice endosperm, we introduced the soybean ferritin gene driven by an endosperm-specific promoter, GluB-1 into an elite IRR1 bred indica rice and also in a popular Bangladeshi rice, BR29. All transgenic plants accumulated higher concentrations of iron and zinc in the grains, reaching as much as 12-22 µg/g iron and 55.5 µg/g zinc in transgenic seeds after polishing as compared to control seeds with 3-10 µg/g iron and 33.1 µg/g zinc. Immunoblot analysis showed the expression of ferritin protein (28-kDa) in the endosperm. Immunolocalization study revealed the higher deposition and distribution of iron in the endosperm tissues. Iron-deficient soils are widespread worldwide and account for about 30% of the world's arable land. Young rice plants are severely affected by the lack of sufficient iron in the soil. The ferric chelate reductase enzyme in the roots of dicotyledonous plants has a major role in increased iron absorption from iron-deficient soils. Experiments are now being carried out to study the uptake, transport, and translocation of iron in those transgenic plants.

Th40 BIOFORTIFIED RICE IMPROVES THE IRON STATUS OF IRON DEFICIENT WOMEN. LE Murray-Kolb(1), JL Beard(1), JD Haas(2), A Felix(3), A del Mundo(3), G Gregorio(4). (1)Dept. of Nutritional Sciences, The Pennsylvania State University, University Park, PA, USA; (2)Division of Nutritional Sciences, Cornell University, Ithaca, NY, USA; (3)University of the Philippines, Los Banos, Philippines; (4)IRRI, Los Banos, Philippines.

Background: A sustainable solution to dietary iron deficiency is needed to significantly reduce the worldwide prevalence of iron deficiency. Most programs to date have focused on supplementation and/or fortification. However, food supplementation programs are relatively expensive, noncompliance can be high, and interactions between supplements and endogenous food components are complex. Fortification programs can be highly effective but again require an infrastructure for delivery and perhaps some targeting. Using plant-breeding to increase the micronutrient density of staple crops may prove to be a major step toward alleviating iron deficiency worldwide. **Aims:** To determine if additional iron, contained in biofortified rice, would result in an improvement in iron status of young adult women under controlled conditions. **Methods:** This was a double-blind, longitudinal (9 mos.), controlled intervention study. Religious sisters were recruited from convents in and around Manila, The Philippines and were randomly assigned to receive either an iron enhanced rice (IR68144: 3.2 ppm Fe wet weight) or a commercially available variety of rice (C4: 0.6 ppm Fe wet weight). Sisters consumed their assigned rice at every meal for the entire 9 mos. Consumption of rice intake was determined on a daily basis by weighing. Weighed food intakes of the entire diet were also collected on 3 days every 2 weeks. Blood samples were collected at baseline, midpoint, and endpoint and used for the determination of ferritin (ft), transferrin receptor (TfR), iron, total iron binding capacity (TIBC), transferrin saturation (TSAT), body iron, and CBC. **Results:** As far as iron intake, the IR68144 rice provided an additional 1.4 mg of iron/d which represented a 10% increase in iron intake in the diets of the women consuming this rice (usual intake is 8-9 mg/d). As far as iron status, those women who were initially the most iron deficient (but not anemic) and who consumed the IR68144 experienced a significant increase in ft as well as body iron over time. This was not seen in the women consuming the C4 rice. **Conclusions:** We have shown that biofortified rice not only contributes to an increase in daily iron intake but that the iron is also bioavailable as evidenced by the significant increase in ft and body iron in women who were initially iron depleted but not anemic.

Fortification

Thursday, 18 November

Th41 REGULAR CONSUMPTION OF COMPLEMENTARY FOODS FORTIFIED WITH MICRONUTRIENTS IMPROVES IRON STATUS OF VIETNAMESE INFANTS. J Berger (1), PV Phu (2), B Salvignol (3), NV Hoan (3), NC Khan (4), PD Tuong (2), S Treche (1). (1) Institut de Recherche pour le Développement (IRD), France; (2) Hanoi Medical University, Vietnam; (3) Groupe de Recherche et d'Échanges Technologiques (GRET) France; (4) National Institute of Nutrition (NIN).

Background: In Vietnam, infants suffer from simultaneous micronutrient deficiencies. **Objective:** To investigate whether regular consumption of complementary foods fortified with micronutrients can improve the iron status of infants. **Design:** a blind controlled trial in Quang Nam province, Vietnam. 21 villages were randomly divided into a control group (C) and two groups receiving either an instant flour (FF) or a food complement (FC) fortified with micronutrients (vitamin A, B1, B2, B3, B5, B12, C, D, Fe, Zn, I, Mg, K). 5 mo. old breastfed infants were included in the study and groups FF and FC received daily for 6 mo at least two meals with the fortified complementary foods. Iron status was assessed by measuring hemoglobin (Hb), serum ferritin (SF) and transferrin receptor (TfR) in venous blood samples. **Results:** at baseline there were no significant differences between the three groups in Hb, SF, TfR. After 6 mo. iron status was significantly better in Group FF (n=120) and in Group FC (n=106) as compared with Group C (n=123). Hb was significantly higher in Group FF (112.5 ± 8.0 g/L) and in group FC (114.0 ± 7.0 g/L) compared to Group C (109.0 ± 8.0 g/L, p=0.0004). Prevalence of anemia had decreased by 28.3% in Group FF and 43.4% in Group FC more than in Group C (9.8%, p=0.03). SF was significantly higher in FF Group (19.8 mcg/L, [17.5-22.3]) and in Group FC (20.8 mcg/L [18.3-23.6]) compared to Group C (11.1 mcg/L [9.8-12.5], p<0.0001). The prevalence of SF<12 mcg/L had decreased by 18.3% in Group FF and 7.7% in Group FC whereas it had increased by 27.6% in Group C. Prevalence of TfR >8.5 mg/L had decreased by 1.7 and 0.9 % in Groups FF and FC and had increased by 2.5% in Group C. **Conclusions:** The regular consumption of micronutrient fortified complementary foods significantly improved iron status and decreased the prevalence of anemia and iron deficiency in infants in rural Vietnam (Supported by the French cooperation and the French committee for Unicef).

Th42 IRON AND VITAMIN A CONTENT OF FORTIFIED FLOUR IN SELECTED FLOURMILLS IN THE PHILIPPINES. FS Solon, LS Fermin, AA Bolima, CF Pastores, HC Maglalang. Nutrition Center of the Philippines, Metro Manila, Philippines and Micronutrient Operations Strategies and Techniques Project-USAID, Manila, Philippines.

Background: The Flour Fortification Program was developed under the Philippine Food Fortification Strategic Plan 2000-2004 to address both vitamin A (VA) and iron deficiencies through double fortification of flour with VA and iron. **Aims:** This project aimed to monitor flour fortification test run in 11 of 15 flourmills in the country in preparation for the implementation of the Food Fortification Law and to identify technical problems encountered during the fortification process and recommend solutions to improve the quality of the fortified flour produced. **Methods:** Plant visits were made in 11 out of the 15 flourmills in the country. Flour was fortified with hydrogen-reduced iron at 60 ppm and retinol palmitate Type 250 SD at 490 µg RE/100g flour. Iron content of the fortified flour was assessed using Atomic Absorption Spectrophotometry and VA content was assessed using High Performance Liquid Chromatography. The coefficient of variation was used to determine homogeneity of the mix. Sensory evaluation of flour was done using the triangle test. Bread baked from fortified and non-fortified flour was scored. **Results:** Five of the 11 flourmills met the recommended fortification level for iron. Of them, only 3 achieved homogenous mixing. Six flourmills did not meet the recommended iron fortification level but 3 of them were able to produce a homogenous mix. Only 4 of the 11 mills fortified flour with VA. Of them, 2 met the recommended VA fortification level. Only 2 mills met the recommended fortification levels for both VA and iron but only 1 of the 2 mills produced a homogenous mix. The sensory evaluation indicated that the fortification did not produce any unnecessary changes in the color and odor of the flour. Bread score results however, showed varying results for fortified and non-fortified samples among the mills in terms of the physical properties of the bread. **Conclusion:** The monitoring of flour fortification test run has ascertained the need for a standardized flour fortification procedure due to several critical technical problems identified. Further, the need for periodic quality assurance and control is recognized for a more effective and sustainable flour fortification program. (Funding provided by MOST-USAID).

Th43 EFFECT OF PACKAGING MATERIALS ON THE RETENTION OF VITAMIN A, IRON AND IODINE IN FORTIFIED SOY SAUCE. *M.V. Capanzana, MC Saises, JA Vaguchay, CS Quindara, TV Fallaria.* Food and Nutrition Research Institute, Dept. of Science and Technology, Bicutan, Taguig, Metro Manila, Philippines.

Background: The prevalence of micronutrient malnutrition in the Philippines, prompted the study on the fortification of soy sauce with micronutrients. Soy sauce is one of the favorite sauces for direct consumption and food preparation among the rich and poor alike. Fortifying soy sauce with vitamin A, iron and iodine can contribute to efforts to decrease the prevalence of micronutrient malnutrition. **Objectives:** To determine the effects of packaging materials and storage conditions on the retention of vitamin A, iron and iodine in fortified soy sauce prepared in the laboratory. **Methods:** The soy sauce was fortified with vitamin A, iron and iodine and the changes in the physico-chemical, microbiological and sensory properties of the fortified soy sauce stored using transparent glass and plastic bottles, exposed under fluorescent light and sunlight were investigated. **Results:** After one year of storage, iodine content decreased from 68 to 66 µg (glass bottle), and to 65 µg (plastic bottle) per 15 g serving size for samples exposed to fluorescent light. Iron content of a 15 g soy sauce decreased slightly from 4.7 to 4.1 mg (glass bottle) and to 3.9 mg (plastic bottle) under fluorescent light and from 4.3 to 3.8 mg (glass bottle) and to 3.8 mg (plastic bottle) under sunlight. Significant decrease in Vitamin A content of the fortified soy sauce was noted. For 15 g soy sauce, the vitamin A decreased from 198 to 109 µg (glass bottle) and to 84 µg (plastic bottle) for samples exposed to fluorescent light and from 272 to 72 µg (glass bottle) and to 66 µg (plastic bottle) for samples exposed to sunlight conditions. Fortified soy was rated like very much (6) to like extremely (7) by trained laboratory panelists in terms of color, flavor, odor and general acceptability even after one year of storage. The fortified soy sauce was also found microbiologically safe for the same period of storage. **Conclusion and Recommendation:** Iron and iodine were substantially retained in fortified soy sauce after one year of storage in glass and plastic bottles exposed under fluorescent light and sunlight. Significant reduction in vitamin A content was noted in soy sauce kept in plastic and glass bottle and stored under fluorescent light and sunlight. The result of the study will serve as basis for large-scale production of fortified soy sauce in the Philippines.

Th45 SCALE-UP OF PRODUCTION OF SALT DOUBLE FORTIFIED WITH IODINE AND IRON. *L.L.Diosady, T.Oshinowo,* University of Toronto, Department of Chemical Engineering and Applied Chemistry, Toronto, Canada, *M.G.Venkatesh Mannar.* Micronutrient Initiative, Ottawa, Canada.

Interactions between iron compounds and iodine added to salt rapidly results in the loss of iodine through sublimation, and the decrease of iron bioavailability. The colour of salt also often changes to unacceptable hues. We have developed techniques for producing stable double fortified salts containing 50 or 100 ppm iodine and 1000 ppm iron in the form of ferrous fumarate, that are stable under field conditions, and are nearly indistinguishable from refined salt in terms of colour, stability, physical and organoleptic characteristics. A premix is prepared by granulating ferrous fumarate with modified starch, and microencapsulating it with soy stearine containing titanium dioxide to make coated white particles with particle size distribution closely matched to that of refined salt. This premix is added to salt at a ratio of 1:150, resulting in a stable double fortified salt. If the salt contains hygroscopic or iron containing impurities the iodine compound can be also encapsulated it to protect it. The process was scaled up from laboratory procedures using disc agglomeration and spray coating, to pilot plant and eventually full-scale industrial equipment. Wurster type fluidized bed agglomerators and coaters were used in three phases, to produce batches of premix. Batch sizes were increased from 5kg, to 50kg and finally to 300kg, representing 45tons of double fortified salt. After adjusting process parameters product yield in the appropriate particle size range was greater than 90%. Product stability was confirmed in laboratory and field studies. We are now ready for commercial test marketing of the products in three markets.

Th44 RETENTION OF VITAMIN A, IRON, AND IODINE IN FORTIFIED "BIHON" NOODLE. *M.V. Capanzana, MC Saises, JV Vaguchay.* Food and Nutrition Research Institute, Dept. of Science and Technology, Bicutan, Taguig, Metro Manila, Philippines.

Background: Vitamin A, iron and iodine are the persistent micronutrient problems in the Philippines. The most at-risk are pre-school children, below 6 years old and mothers of reproductive age. Noodles are commonly consumed food by Filipinos, particularly children and lactating women. Bihon noodle is pure starch and has minimal amounts of vitamins and minerals. Improving the vitamin A, iron and iodine levels of bihon, through food fortification, will benefit majority of the noodle-eating Filipinos, especially the nutritionally deficient population groups. **Objectives:** To determine the retention of vitamin A, iron and iodine in fortified bihon noodle during storage at ambient conditions. **Methods:** The bihon noodle was fortified with vitamin A, iron and iodine in a large scale production, packed in transparent polypropylene (PP) plastic and the changes in the physico-chemical, microbiological and sensory properties were investigated for a period of 1 year under simulated market conditions. The acceptability of the product and the retention of the nutrients after cooking was determined. **Results:** Vitamin A was not substantially retained after processing due to the high extrusion temperature and the drying method used. Iron and iodine were substantially retained after processing and drying. After one year of storage, iron content of golden bihon did not change at 5.0 mg/ 50 g serving size for sun-drying method but decreased for mechanical drying method. Iron content of white bihon decreased slightly both for mechanical and sun dried. Iodine content of golden bihon decreased (46 to 44 µg -sun drying, 47 to 41 µg -mechanical drying, per 50 g). For white bihon, iodine content decreased slightly (40 to 38 µg -sun drying, per 50 g). Fortified bihon was rated liked very much (6) to like extremely (7) by trained panelists in terms of color, flavor, odor and general acceptability. Iron and iodine in fortified bihon were retained after cooking. The product was found microbiologically safe after one year of storage. **Conclusion and Recommendation:** Iron and iodine in white and golden bihon were retained for 1 year under simulated market conditions at ambient temperature. Vitamin A was not retained after processing and storage. The results of the study can be used as basis for commercial production of fortified bihon noodle in the Philippines.

Th46 EFFECT OF FOLIC ACID FORTIFICATION OF WHEAT FLOUR ON ANEMIA PREVALENCE IN WOMEN. *E.Hertrampf, M Olivares, S Castillo.*

Background: Food fortification for mass consumption has been adopted increasingly as a strategy for preventing micronutrient deficiencies. In Chile, wheat flour is fortified with iron (as ferrous sulfate) B1, B2 and niacin since the 50's and recently (2000) with folic acid (FA) (2.2mg/kg). Fortified bread consumption (200g) of women of fertile age supply 360 µg of FA and 4.9 mg of iron. However, its effectiveness on the prevention of nutritional anemias has been scarcely explored. **Aim:** To evaluate the effectiveness of FA fortification on the prevalence of anemia in women of fertile age. **Design:** A group of 578 healthy women, aged between 15-45 y, with at least one child, from low socioeconomic level in the city of Santiago was studied before and one year after FA fortification. Hemoglobin (CellDyn), serum ferritin (ELISA), serum and red cell blood folates and B12 (Bio-Rad QuantaPhase II B-12/Folate radio assay) were assessed. **Results:** Prevalence of anemia was 12.3% (n=71) increasing to 19.7% (n=114) (p<.001) post- fortification. Changes of possible etiologies in the anemic subjects (Hb< 12 g/dL) are presented:

Etiology	Pre FA (%)	Post FA (%)
Folate def. (RCB folate < 181 nmol/L)	8.5	0*
IDA (SF < 12 µg/L)	47.9	41.2
B-12 (serum B12 < 148 pmol /L)	1.4	2.6
IDA + folate	5.6	0*
IDA + B12	5.6	8.8
IDA + Folate + B12	1.4	0
Unclassified	29.6	47.4*

*p< 0.05

Conclusions. Folic acid fortification of wheat flour eradicated folate deficiency anemia and did not modify prevalence of B12 deficiency anemia. The total increased of anemia prevalence was not associated to Fe, folate or B12 deficiencies. The effect of inflammatory/infectious processes not studied here could be the etiology of the unclassified anemias.

Th47 INCREASED PREVALENCE OF IRON DEFICIENCY DUE TO WITHDRAWAL OF IRON FORTIFICATION OF FLOUR IN SWEDEN. L.Hult n, L. Hallberg, Department of Clinical Nutrition, Institute of internal medicine, Sahlgrenska Academy at G teborg University. G teborg, Sweden.

Flour has been fortified with iron in Sweden since 1944. Since 1970 the level has been 6.5 mg/100 g flour. An early estimation suggested that 42% of the total dietary iron intake derived from fortification of flour.

Carbonyl iron which was used has good properties according to animal studies, but a rather poor bioavailability according to studies in man.

The effect of iron fortification upon target groups such as females with large menstruations and female adolescents with poor dietary habits was uncertain.

On 1st January 1995 the voluntary fortification was withdrawn. Iron status was examined before and six years later in adolescent girls having high iron requirements. Post menarcheal girls aged 15-16 years in the 9th grade in 13 schools were examined in 1994 (n=625) and in the same schools in 2000 (n=540). Iron deficiency was defined as serum ferritin concentration < 16 µg/L in those who had no history of an infection the preceding four weeks. Since a change in iron status may be due to other factors, the study included also diet, physical activity, age at menarche, intake of iron supplements and use of contraceptive pills.

There was an increase in iron deficiency from 39.6 % to 48.9 % (p < 0.001). Present analyses indicate that the withdrawal of iron fortification in Sweden was the main cause of the observed increase in iron deficiency in adolescent girls. Possible sources of error have been examined and excluded.

The withdrawal of iron fortification seems to increase in the prevalence of iron deficiency in target groups such as menstruating women.

People being homozygous for iron loading genes might on the other hand start accumulating excess iron more slowly, when the diet is no longer fortified.

Th48 EFFICACY OF DAILY VS WEEKLY HOME FORTIFICATION OF WEANING FOODS WITH SPRINKLES AMONG INFANTS AND YOUNG CHILDREN IN BANGLADESH. SMZ Hyder (1), F Haseen (2), M Rahman (2), L Zeng (1), SH Zlotkin (1). 1. The Research Institute, Hospital for Sick Children and Centre for International Health, University of Toronto, Toronto, Canada; 2. BRAC, Dhaka, Bangladesh.

Background: Daily home fortification of weaning foods with micronutrients supplied as 'Sprinkles' is efficacious in the treatment and prevention of iron deficiency anemia (IDA) among infants and young children. However, there is evidence suggesting that a weekly regimen of conventional iron supplementation (iron drops) can be as efficacious as daily use. **Objective:** To compare the efficacy of daily vs. once a week home fortification of weaning foods with micronutrient Sprinkles over 8 weeks among 12-24 month old anemic infants (Hb < 110 g/L). **Methods:** In a rural location in Bangladesh, 13 villages with anemic infants (hemoglobin <110 g/L) were randomly assigned to either daily (n=70, 12.5-mg iron), or weekly (n=66, 30-mg iron once a week and placebo sachets for remaining 6 days) doses of Sprinkles. Hemoglobin concentration (Hb), serum ferritin (sFt) and transferrin receptor (sTfR) were assessed twice – at baseline and at 8 weeks. Hb was assessed on a drop of capillary blood by HemoCue®. Venous blood samples were collected to measure sFt by radioimmunoassay and sTfR by enzyme-linked immunosorbent assay methods. **Results:** Overall, Hb increased in the daily and weekly groups by 16 g/L and 12 g/L (p<0.000) and anemia decreased by 54% and 53%, respectively (p<0.000). At 8 weeks, although Hb was higher in daily (p=0.072), anemia prevalence did not differ between the groups (p=1.00). In a subset of infants with initial Hb <100 g/L (n=39 daily and 34 weekly), there was an increment in Hb by 21 g/L and 16 g/L (p=0.05) and the prevalence of anemia (Hb <100 g/L) decreased by 85% and 62% (p=0.034) in the daily and weekly groups, respectively. In this same sub-set, sFt increased by 11 µg/L and 6 µg/L in daily and weekly groups (p=0.025), while sTfR decreased by 3.1 mg/L and 2.8 mg/L in daily and weekly groups, respectively (p=0.325). **Conclusion:** Although both daily and weekly use of Sprinkles was efficacious, daily administration resulted in better iron stores and superior Hb response in moderately anemic infants.

Th49 EFFICACY OF 'SPRINKLES' HOME FORTIFICATION TO REDUCE ANEMIA AND MICRONUTRIENT DEFICIENCIES IN YOUNG CHILDREN IN INDONESIA. E Martini, D Foote, S de Pee*, J van Hees, S Halati, R Moench-Pfanner*, D Yeung†, S Kosen†, MW Bloem*. Helen Keller International, Jakarta, Indonesia; *Helen Keller International Asia-Pacific Regional Office, Singapore; †HJ Heinz Co., Toronto, Canada; ‡National Institute of Health Research and Development, Ministry of Health, Government of Indonesia.

Problem: Up to 70% of young children in urban poor areas of Indonesia are anemic. The negative consequences of anemia for child health and development warrant urgent intervention, but very few successful anemia prevention programs in poor settings have yet been conducted. **Objectives:** To evaluate the efficacy of daily use of an in-home fortificant ('sprinkles') on anemia, growth, and micronutrient status (plasma ferritin, retinol, and zinc concentrations) of children 6-30 months old. **Framework:** In-home fortification may be a highly feasible intervention to address child anemia, especially in urban Indonesia. Mothers are accustomed to sachet use in preparing foods. Local corner shops and/or the community health posts are potential distribution points that are in close proximity to, and regularly used by mothers. Household expenditure data from this population suggest that the product would be affordable for mothers, and current production of sprinkles by private sector partners within Indonesia adds to potential sustainability. **Program:** The efficacy study is the first phase of a program to test the efficacy and effectiveness of daily use of Vitalita (translated: vitamins for underfives) sprinkles. Vitalita sprinkles contain 1 RDA (1-3 year olds, US/Canada) of iron, vitamin A, zinc, vitamin C, and 10 other micronutrients. The Vitalita name and package design were developed through formative research in 2003. **Methods:** 551 intervention and 266 control children aged 6-30 months from slum areas in Jakarta were enrolled during the baseline survey (Dec '03 to Feb '04). Anthropometry of mothers and children was measured, venous blood samples drawn, and information on household socio-economic status, dietary intake, and health status was collected. A supply of Vitalita is delivered to mothers on a weekly basis (for consumption on a daily basis), and consumption is recorded by mothers using a weekly calendar. The endline survey will be conducted Jul-Aug '04. Results will be available thereafter. **Implications:** In-home fortification is an innovative potential strategy to address the problem of childhood anemia, and evidence of its efficacy will facilitate large scale expansion complementary to other nutrition and disease prevention efforts.

Th50 EFFECTIVENESS OF NaFeEDTA FORTIFIED FISH SAUCE IN CONTROLLING IRON DEFICIENCY IN VIETNAM. PV Thuy (1), J Berger (2), Y Nakanishi (3), NC Khan (1), S Lynch (4), NT L m (1). (1) National Institute of Nutrition (NIN), 48 B Tang Bat Ho, Hanoi, Vietnam; (2) Institute of Research for Development (IRD), RU; (3) ILSI CHP, Japan; (4) Eastern Virginia Medical School, USA.

Background: Iron deficiency (ID) anemia is the most prevalent nutritional problem in Vietnam. One cost-effective strategy to control ID is the fortification of staple foods or condiments. **Objective:** The present study was designed to determine whether iron fortified fish sauce (FS) would improve the iron status of women of reproductive age (WRA). **Design:** This was a double blind intervention with randomization by village. The study was conducted in 2 communes in the Red River Delta area of Vietnam. The villages were randomly divided into 2 groups. All families in each village were supplied with type I (15 g N/L) FS for 18 mo. The FS for Group C was unfortified. For Group F the FS was fortified with NaFeEDTA (0.5 mg Fe/ml). Each household received sufficient FS to provide 15 ml per family member per day. Households in which at least one member was a WRA were invited to participate in the study. Venous blood was obtained from 387 women (189 in Group C, 198 Group F) at baseline, 6, 12 and 18 mo. for the measurement of Hb and iron status. **Results:** At baseline, there were no significant differences between the two groups in Hb, SF, TfR, or body iron store (BIS). Hb and the iron status improved significantly in Group F after 18 mo. Mean Hb was 4.9 g/L higher (P<0.02) and the prevalence of anemia had decreased by 15.6% (P<0.0001). Mean SF was increased by 33.1 µg/L (P<0.0001) and prevalence of SF <12µg/L was 15.6% less (P<0.0001). The calculated mean BIS of women who had an iron deficit at the outset of the trial (BIS <0) increased by 341 mg to 105 mg (P<0.0001). **Conclusions:** Daily consumption of FS fortified with NaFeEDTA and provided to households significantly improved the iron status of WRA in a rural area of Vietnam. The greatest improvement occurred in the first 12 mo. Dietary fortification with NaFeEDTA does not lead to continued iron accumulation once iron deficiency has been corrected and iron stores have been replenished. (Supported by ILSI CHP and the Nippon Foundation)

Th51 CONSUMER ACCEPTANCE OF A HOME FOOD IRON FORTIFICANT. DL Yeung **, J Yap *, C Cheng **, * H.J. Heinz Company, People's Republic of China. ** H.J. Heinz Company, Pittsburgh, Pennsylvania, United States of America.

Iron deficiency (ID) and iron deficiency anemia (IDA) remain prevalent nutritional problems in many parts of the world. Among infants and young children, IDA can have adverse effects on growth and development. Mental deficits exhibited in infancy can be long lasting. Efforts are being made to combat these problems. However, in the past decade little success was made. Currently there is interest in developing home fortificants that are versatile, inexpensive, efficacious and effective. One of these is the Sprinkles, which contain iron fumarate coated with a soy lipid and other micronutrients. The Sprinkles are packaged in small sachets and are intended to be added to ready-to-eat home-prepared complementary foods once a day. A consumer acceptance test was conducted by AC Nielsen in 5 cities in China. A total of 1376 mothers with secondary education and of infants aged 6-24 months and young children 2-5 years in Shanghai, Chengdu, Guangzhou and Wuhan were recruited. They were interviewed by trained interviewers 4 times during the period of the study. During the initial interview of the mothers a concept test of the Sprinkles and instructions for use were provided. The Sprinkles were provided for home test for the acceptance by infants and children in 4 successive weeks. Diaries were kept and empty sachets were retrieved by the interview each week. Comments on the acceptance, behavior of the children and reactions of the children were recorded. The results showed that the mothers were enthusiastic about the product. They found the Sprinkles convenient and nutritionally desirable. The infants and young children accepted the foods with added Sprinkles well. 50% of the mothers commented that their infants' appetite improved. Approximately 40% of them indicated that their infants were more active, playing more and were stronger. Some slept better. Only a small number of mothers (2%) complained that their infants had loose bowels and dark stools. Most mothers would consider buying it if it was in the market place. The results were generally positive and consideration is given to making the Sprinkles accessible in China.

Th53 STABILITY OF IRON FORTIFIED ROLLER MILLED WHEAT FLOUR IN PAKISTANI STORAGE CONDITIONS. A Zeb, F Mahmood and NA Khan. Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan and the Micronutrient Initiative, Pakistan Program.

Background: Iron Deficiency Anemia (IDA) is a problem of serious public health significance in Pakistan with 35-65% among women and 49 and 51% among children. As per capita consumption of wheat flour in Pakistan is among the highest in the world which centrally processed for over 50% population, it is considered as an ideal vehicle for iron fortification. **Aim:** To measure the stability of fortified flour and fortification iron under local conditions of distribution, packaging, storage, baking and consumption. **Methods:** Roller Milled wheat flour fortified with three types of iron premixes i.e. 30 ppm ferrous sulfate +1.5ppm folic acid (FS), 20 ppm Ferrous Sulfate-EDTA+1.5ppm folic acid (FSE) and 60 ppm elemental iron +1.5ppm folic acid (EI) as well as unfortified control were locally produced and stored at room conditions for 3 months at Peshawar, Pakistan. Packing materials were tin boxes and polypropylene bags. Samples were analyzed for various biochemical, microbiological and organoleptic parameters in the beginning and at fortnightly intervals. **Results:** proximate composition, phytic acid, wet and dry gluten contents and peroxide value (POV) were not altered by the fortification. Acidity was least in the control followed by FS flour. Conversion of fortification iron into ferric form was highest in FS reaching to a maximum of 3.2%. Moisture contents were higher in all the fortified flours than control (P<0.05), not varying significantly among fortificants, FS-samples having the lowest average moisture percentage. Fungal counts/g remained least in FS as compared to all other flours including control. The bread overall acceptability was highest for control and FS, whereas the FSE and EI fortified breads were rated inferior (P<0.01) to control. No fortificant had a clear-cut edge over the others in this respect. **Conclusion:** The iron fortified wheat flour is quite stable in Pakistani production, distribution, storage and preparation conditions for a period of more than one month, although the flour remained acceptable for three months. A national scale flour fortification program is recommended.

Th52 VILLAGE-LEVEL MICRONUTRIENT FORTIFICATION IN MALAWI. M Yiannakis, M Dhaka, R Namarika. World Vision Malawi, Lilongwe, Malawi.

Issue: Micronutrient malnutrition is a public health concern in Malawi. A 1996 survey showed 56% of children under 5 were stunted, 59% of pregnant women were anemic. **Objective:** To provide essential micronutrients to high-risk groups in rural areas through village-level fortification, decrease micronutrient malnutrition and increase access to fortified foods. **Framework:** Malawi's staple food, maize, is being fortified at rural hammer mills. Eleven community mills have been fortifying approximately 480MT of maize annually, for consumption by all household members. Fortificants include iron, B-vitamins, folate, zinc, and vitamin A, all inadequate in the typical diet. To create demand for fortified maize, targeted education took place in surrounding communities. Quality control measures ensure safe and acceptable fortified maize meal. The project is implemented as part of the CIDA-funded World Vision (WV) micronutrient and health (MICA) program, which includes multiple strategies to address micronutrient malnutrition among women and children. **Outcome:** Results indicate the acceptability of fortification activities as evidenced by: 1) Strong interest expressed in education surrounding fortification in the communities (knowledge levels risen from 30% to 99% in 3 years; 2) Growing demand for fortified maize by women utilizing the hammer mills; 3) Nearly 100% utilization, measured by the amount of maize fortified relative to the total amount of maize milled in the pilot sites (from 3% 3 years ago; 4) Support expressed by millers operating hammer mills; 5) The priority fortification issues have gained at a national level in the MOH over the past year; 6) Low cost/beneficiary at US\$0.29/yr; 7) Improved anaemia rates in non-pregnant women (6-20% compared to National 27%). **Implication:** To address the problem of anemia and micronutrient malnutrition in Malawi, a multifaceted approach has been taken. Dietary strategies such as fortification play an important role by complementing existing primary health care strategies. A community-based approach to fortification enables essential nutrients to reach the rural population through fortification already available to the urban population. This innovative initiative has the potential to significantly improve the nutrition and health of Malawians through a cost-effective and sustainable approach.

Th54 IRON FORTIFIED EXTRUDED RICE. D Moretti, TC Lee, MB Zimmermann, J Nuessli, RF Hurrell. Institute of Food Science and Nutrition, Swiss Federal Institute of Technology (ETH) Zurich, PO Box/ Seestrasse 72, 8803 Rueschlikon, Switzerland and Department of Food Science, Rutgers, the State University of New Jersey, New Brunswick, New Jersey.

Background: Rice can be fortified by producing simulated extruded grains. However, good sensory properties and high iron bioavailability have been difficult to obtain. **Objective:** To develop an iron fortified rice closely resembling natural rice using iron compounds of high bioavailability. **Design:** Ferrous sulfate, ferrous sulfate encapsulated in hydrogenated palm oil, ferrous sulfate encapsulated in liposomes, micronised ferric pyrophosphate (2.5µm), micronised dispersible ferric pyrophosphate (Sunactive FeTM, <0.5µm), NaFeEDTA, were evaluated. Rice premixes containing 0.5 and 1 g Fe/100g to be mixed, respectively, with natural rice at a 1:100 or a 1:200 ratio, were manufactured with a single screw extruder with 19 mm diameter opening and a 20:1 length/diameter ratio, using a 3:1 screw. A die made of brass (dimensions 9.76 x 1.62 mm) and a special cutter were used to form the premix grains. Extruded rice grains were evaluated by color measurements (ΔE), texture profile analysis, and iron loss by rinsing was quantified. Blended grains were sensorially evaluated in both cooked and uncooked form using triangle tests with a panel of 18 Caucasian subjects. **Results:** The micronised ferric pyrophosphates showed the lowest ΔE values compared to basmati or long grain, perfumed rice. Fortification with all other compounds resulted in a dark brown discoloration. In the triangle test, perfumed long grain rice fortified with either micronised ferric pyrophosphate at a 1:200 premix ratio could not be distinguished from the unfortified rice in the uncooked, or the cooked form (P>0.05). The cooked simulated grains also had comparable texture to cooked natural grains, and <3% iron loss on rinsing was measured from uncooked grains. **Conclusions:** Fortified extruded rice grains with excellent sensory characteristics can be produced using either 0.5µm or 2.5µm ferric pyrophosphate. Bioavailability studies are underway to determine the optimal fortification level and the potential of such grains for improving the iron status of rice eating populations.

Th55 DUAL FORTIFICATION OF SALT WITH IODINE AND MICRONIZED FERRIC PYROPHOSPHATE: A RANDOMIZED, DOUBLE-BLIND, CONTROLLED TRIAL. M Zimmermann, R Wegmüller, C Zeder, N Chauouki, F Rohner, T Torresani, R Hurrell. Human Nutr Lab, Swiss Federal Institute of Technology Zürich, Switzerland; The Ministry of Health, Rabat, Morocco; University Childrens Hospital, Zürich, Switzerland.

Background: In many developing countries, children are at high risk for both goiter and anemia. In areas of subsistence farming in rural Africa, salt is one of few regularly purchased food items and could be a good fortification vehicle for iodine and iron. **Objective:** We tested the efficacy of salt dual fortified with iodine and micronized ferric pyrophosphate to reduce the prevalence of iodine and iron deficiencies in children. **Design:** In rural northern Morocco, we fortified local salt with 25 µg iodine/g salt (as potassium iodate) and 2 mg iron/g salt (as micronized ferric pyrophosphate; mean particle size ~ 2.5 µm). After storage and acceptability trials, we compared the efficacy of the dual fortified salt (DFS) to iodized salt (IS) in a 10-month, randomized, double-blind trial in iodine-deficient 6-15 yr-old children (n=158) with a high prevalence of anemia. **Results:** After storage for 6 months, there were no significant differences in iodine content or color lightness between the DFS and IS. During the efficacy trial, the DFS provided ~ 18 mg/d of Fe; Fe absorption was estimated to be 2%. In the DFS group at 10 months, mean hemoglobin increased by 16 g/L (p<0.01), iron status and body iron stores were significantly increased (p<0.01), and the prevalence of IDA was reduced from 30% to 5% (p<0.001). In both groups, urinary iodine (p<0.001) and thyroid volume (p<0.01) improved significantly from baseline. **Conclusion:** A DFS containing iodine and micronized ferric pyrophosphate can be an effective fortification strategy in rural Africa.

Th56 HOME-FORTIFICATION USING SPRINKLES CONTAINING 12.5 MG OF IRON SUCCESSFULLY TREATS ANEMIA IN GHANIAN INFANTS AND YOUNG CHILDREN. Stanley Zlotkin (1), Anna Christofides (1), Claudia Schauer (1), Kwaku Poku Asante (2), Seth Owusu-Agyei (2). 1. The Research Institute, Hospital for Sick Children and Centre for International Health, University of Toronto, Toronto, Canada; 2. Kintampo Health Research Center, Health Research Unit, Ministry of Health, Ghana.

Background: The current WHO/UNICEF recommended daily dose of iron for program settings where the prevalence of anemia is greater than 40% is 12.5 mg of iron (based on ferrous sulfate), for infants and young children from 6-24 months of age. Sprinkles are a new multiple micronutrient approach to home-fortification of complementary foods for children containing iron as microencapsulated ferrous fumarate. The dose of iron in Sprinkles should be large enough to treat anemia within a relatively short period of time yet be safe for prophylactic use in non-anemic children. **Objective:** To evaluate and compare the initial hematologic response from three different doses of Sprinkles, and two forms of iron compared to the reference standard (ferrous sulfate drops) in anemic infants 6-18 months of age. **Design:** 133 anemic infants (Hb 70-100 g/L), 6-18 months of age were randomized to one of 5 groups: (1) 12.5, (2) 20, or (3) 30 mg Fe in the form of microencapsulated ferrous fumarate Sprinkles; or (4) 20 mg Fe in the form of ferric pyrophosphate Sprinkles; or (5) 1 mL ferrous sulfate drops equivalent to 15 mg Fe as the positive control group. Hemoglobin, ferritin and transferrin receptor were measured after 3 weeks and at the end of the intervention at 2 months to assess change in iron status. **Results:** Mean Hb concentration increased significantly in all groups from baseline to 3 weeks and end of the intervention period (p<0.0001). There was no effect of dose on final hemoglobin response. Successful treatment of anemia (Hb>100g/L) occurred in 56%, 58%, and 65% of children in the 12.5, 20, and 30 mg Fe ferrous fumarate Sprinkles groups, respectively; 60% in the 20 mg Fe ferric pyrophosphate Sprinkles group; and 66% in the ferrous sulfate drops group. Adherence was higher in the Sprinkles groups (90%) compared to the drops group (69%). **Conclusion:** Sprinkles provided at a dose of 12.5 mg Fe as microencapsulated ferrous fumarate provides an adequate amount of absorbable iron to improve the iron status of anemic infants within a short intervention period. This dose is in accordance with current WHO/UNICEF recommendations for program settings. Favorable adherence may promote the acceptability and effectiveness of Sprinkles as an alternative to drops in children.

Multiple Micronutrients

Thursday, 18 November

Th57 EFFICACY OF MULTIPLE MICRONUTRIENT SUPPLEMENTATION ON HAEMOGLOBIN AND MICRONUTRIENT STATUS AMONG ANAEMIC ADOLESCENT GIRLS IN BANGLADESH. F Ahmed (1), MR Khan (2), M Akhtaruzzaman (2), R Karim (2), GC Marks (1), CP Banu (2) and B Nahar (2). 1. Nutrition Program-Division of International Health, School of Population Health, University of Queensland, Australia and 2. Institute of Nutrition and Food Science, University of Dhaka, Dhaka, Bangladesh.

Background: Multiple micronutrient deficiencies are common in developing countries. There has been a suggestion that adolescent girls should be considered as one of the target groups for multiple micronutrient supplementation to prevent anaemia and other micronutrient deficiencies and to enhance stores before the start of pregnancy. **Aims:** To investigate the efficacy of multiple micronutrient supplementation in improving the haemoglobin and other micronutrient status of anaemic adolescent girls in Bangladesh. **Methods:** 198 anaemic school girls aged 12-18 years from rural areas in Dhaka district were entered into a randomised, double-blind intervention trial, who received twice-weekly supplements of either iron (30 mg elemental iron as ferrous sulfate) and folic acid (400 micro-gram), or multiple micronutrient (containing 15 nutrients with a composition as proposed by UNICEF/WHO) for 12 weeks. Blood haemoglobin and various micronutrient levels were measured at baseline and at the end of the study. **Results:** At recruitment, the girls in the two groups had similar levels haemoglobin and other micronutrients. At the end of the study, the girls with multiple micronutrient had significantly greater increase in serum vitamin A, plasma vitamin C, RBC-folic acid and vitamin B2 levels (as assessed by EGR-AC) compared to that of the girls with iron and folic acid alone. No significant differences in change for haemoglobin, serum ferritin and plasma B12 were found between the two groups. At the end of the study, the prevalence of iron, vitamin A, vitamin C, and B2 deficiencies were reduced more significantly in multiple micronutrient group than in the iron and folic acid group. However, after 12 weeks a sizeable proportion of the girls still remained anaemic, and deficient in various micronutrients. **Conclusion:** Twice-weekly dose of multiple micronutrient supplements for 12 weeks can improve the overall micronutrient status including haemoglobin level but to a limited extent. More frequent doses may be needed to achieve the full benefit of this intervention.

Th58 CAN MEGADOSE OF VITAMIN A ENHANCE THE IMPACT OF IFA & VITAMIN C SUPPLEMENTATION ON IMPROVING HB LEVELS? U Kapil, G Goindi, S Kaur, P Singh. Department of Human Nutrition, All India Institute of Medical Sciences, New Delhi, India.

In India more than 75% of adolescents suffer from Iron deficiency anemia (IDA) and supervised Iron folic acid (IFA) supplementation is known to reduce anemia by 20-25 %. There is scientific evidence that addition of vitamin C (VC) to iron supplementation improves the Hb status. It has been documented recently that addition of Vitamin A (VA) mobilizes iron from stores and may have synergistic effect with vitamin C on hematological response to iron supplementation. A randomized single blind efficacy trial was conducted in a residential school in the National Capital territory of Delhi . The adolescent girls in the age group of 17 to less than 19 years were included in the study. In the school, the randomization was done at the class level . Group A received mega dose of VA at the beginning of the study and a daily dose of 100mg elemental iron , 500 mcg of folic acid and 60 mg of VC. Group B received all the drugs except mega dose of VA. The period of intervention was 100 days. The hemoglobin estimation was done at the 0 day, on the 50th and 100th day of the study using direct Cyanmethemoglobin method. The statistical analysis was carried out by using paired t-test approach. The mean Hb concentration at the 0 day in the group A and B was 11.6 ± 1.38 g/dl and 12.2 ± 1.1 g/dl , respectively. The mean Hb concentration after 50 days of supplementation in group A and Group B was 13.2 ± 0.83 g / dl and 13.5 ± 0.9 g/dl , respectively. The mean Hb concentration after 100 days of supplementation in group A and Group B was 13.4 ± 1.07 g/dl and 13.5 ± 0.9 g/dl , respectively. However ,the increase of Hb in group A was 0.5 g/dl more as compared to the group B indicating the synergistic role played by the VA with vitamin C in improving the Hb levels. The results of this study needs to be further substantiated by undertaking similar studies in adolescent subjects suffering from moderate anemia. Key Words: VA synergistic effect, Iron deficiency, Adolescent.

Th59 DAILYMULTI-MICRONUTRIENTSUPPLEMENTATIONFORADDRESSING MICRONUTRIENT DEFICIENCY AND GROWTH FALTERING IN INFANTS: THE FOUR-COUNTRY IRIS TRIAL POOLED DATA ANALYSIS. *CM Smuts* (1), *CJ Lombard* (1), *MA Dhansay* (1), *AJS Benadé* (1), *J Berger* (2), *LT Hop* (3), *G López de Romaña* (4), *J Untoro* (5), *E Karyadi* (5), *J Erhardt* (5), *R Gross* (6). 1. Medical Research Council, Parow, South Africa; 2. Institute of Research for Development, France; 3. National Institute of Nutrition, Hanoi, Vietnam; 4. Instituto de Seguridad Alimentaria Nutricional, Universidad Agraria La Molina, Lima, Peru; 5. SEAMEO-TROPED, University of Jakarta, Jakarta, Indonesia; 6. UNICEF, New York City, USA.

Background: In developing countries, growth faltering of infants between 6-12 mo of age coincides with the period of dietary transition commonly characterized by deficiencies in a number of micronutrients. The IRIS (International Research on Infant Supplementation) Trial was conducted in Indonesia, Vietnam, South Africa and Peru to test the hypothesis that correcting multi-micronutrient deficiencies would help to prevent growth faltering. **Design:** Foodlets were developed containing multi-micronutrients (MM) in pre-coded blisters, and distributed to the participating countries. Infants aged 6-12 months (n=1134) were randomized into one of four treatment groups, viz., placebo (n=283); 2 RDA weekly MM (n=283; WMM); 1 RDA daily MM (n=283; DMM) and 1 RDA daily iron only (n=288; DI). **Results:** Anemia prevalence was over 50% in all groups at baseline, with a 44% absolute reduction from baseline in the DMM group, compared to 35% in DI, 30% in WMM and 10% in Placebo. Hb concentrations improved significantly in all treatment groups compared to Placebo, with the greatest effect in the DMM. Plasma ferritin decreased significantly from baseline in the Placebo and WMM groups, but increased significantly in the DMM and DI groups. Plasma homocysteine decreased significantly in the DMM and WMM, but for the remaining biochemical indicators, viz., retinol, riboflavin, tocopherol and zinc, only the DMM had improved treatment effects at 6 mo. The DMM group demonstrated a greater weight gain than the other treatment groups (p=0.0356), growing at an average rate of 207 g/mo compared to 192 g/mo for the WMM and 186 g/mo for both DI and Placebo groups. **Conclusions:** Daily multiple micronutrient supplementation via foodlets in infants during the second semester of life was more effective than weekly multiple micronutrient supplementation in reducing anemia and improving nutrient status of the infants in the four country pooled data analysis. Furthermore, daily multiple micronutrients significantly reduced the degree of weight growth faltering among infants. Study supported by UNICEF, New York City.

Th61 DAILY IRON AND DAILY MULTIPLE-MICRONUTRIENT FOODLETS ARE EFFICACIOUS IN IMPROVING BODY IRON STORES OF INDOONESIAN INFANTS AGED 6-12 MONTHS. *M Wijaya-Erhardt*, *JG Erhardt*, *J Untoro*, *E Karyadi*, *L Wibowo* and *R Gross*. SEAMEO-TROPED RCCN-University of Indonesia, Jakarta, Indonesia, World Bank, Jakarta, Indonesia and UNICEF, New York City, USA.

Background: There is still uncertainty for the best procedure to alleviate iron deficiency anemia. Further, more reliable quantitative methods are needed to assess iron status and the impact of trials. **Aims:** A new approach through foodlet (food-like tablet) was used to compare the efficacy of daily iron to those of daily and weekly multiple-micronutrient supplementations in improving iron status of Indonesian infants aged 6-12 mo. For evaluating iron stores in mg per kg body weight, the ratio of transferrin receptor (TfR) to plasma ferritin was calculated. This ratio is a more sensitive and specific parameter for iron status than is each measurement alone. **Methods:** In this double blind trial 260 infants were randomly allocated to 1 of 4 groups: daily 1 RDA multiple-micronutrient foodlet (DMM), weekly 2 RDA multiple-micronutrient foodlet (WMM), daily 10 mg iron foodlet (DI), or placebo. Hemoglobin, plasma ferritin, TfR, and C-reactive protein (CRP) were obtained at baseline and at 23 wk. Ferritin, TfR and CRP were measured together with a self developed inexpensive Sandwich ELISA. CRP > 12 mg/L indicating inflammation was excluded for body iron calculation. **Results:** At baseline, 58.1% of subjects were anemic (Hb < 110 g/L) and there was no significant difference in body iron stores among groups. At the end, DI had the highest increment in body iron stores (4.02 mg/kg, p = .000) followed by DMM (2.33 mg/kg, p = .000). WMM prevented the deterioration of iron stores (0.33 mg/kg), whereas the mean tissue iron significantly declined in placebo group (-2.21 mg/kg, p = .000). The changes of body iron were statistically different among groups but the changes of hemoglobin were not. **Conclusion:** Body iron stores calculation in this study improved the precision of the laboratory diagnosis of iron absorption and detecting iron deficiency anemia.

Th60 INTERACTIVE EFFECTS OF IRON, ZINC AND CALCIUM ON ITS AVAILABILITY FROM A RICE-BASED MEAL: AN IN VITRO ASSESSMENT. *TP Trinidad**, *MG Naluz***. *Food and Nutrition Research Institute, Department of Science and Technology, Bicutan, Taguig, Metro Manila 1631 Philippines; ** Graduate School, Adamson University, San Marcelino, Manila, Philippines.

Mineral-mineral interaction studies can be used for multi-nutrient supplementation and fortification of staple foods to combat mineral deficiency in the Philippines. There is a need to study the level or concentration of one mineral that can give a synergistic or antagonistic effect on the availability of another mineral. The objective of the study is to determine the interactive effects of iron (Fe), zinc (Zn) and calcium (Ca) on its availability from a rice-based meal. The meal consisted of rice, fish and vegetable. The meal was freeze-dried and analyzed for total Fe, Zn and Ca using AOAC methods. Increasing levels of Fe or Zn or Ca at constant amount of Fe or Zn or Ca were added to the rice-based meal and was subjected to an in vitro enzymatic digestion and dialysis simulating conditions that prevail in the small intestine, to determine dialyzable Fe, Zn and Ca used as a measure of Fe, Zn and Ca availability. Fe availability significantly increased with increasing levels of Fe (2-8 mg/100 g) but there was a decreasing trend on Fe availability with increasing levels of Zn (5-15 mg/100g) and Ca (500-1000 mg/100g) added to the meal (P<0.05). Similar results were obtained with Zn (P<0.05). On the other hand, Ca availability significantly decreased with increasing amounts of Ca in the meal, and increasing levels of Fe and Zn did not affect Ca availability (P<0.05). The different levels of Fe, Zn and Ca used in the study were based on concentrations present in Filipino foods. In conclusion, increasing amounts of Fe significantly increased Fe availability; increasing amounts of Zn increased Zn availability; increasing amounts of Ca decreased Ca availability. Increasing levels of Zn and Ca inhibit Fe availability; increasing levels of Fe and Ca inhibited Zn availability; and increasing levels of Fe and Zn did not affect Ca availability.

Th62 CHANGES IN IRON DEFICIENCY ANEMIA AND ZINC STATUS IN CHILDREN SUPPLEMENTED WITH IRON AND/OR ZINC IN THE AMAZON REGION. *N Zavaleta*, *A Shankar* Instituto de Investigacion Nutricional, Lima and, Ctr for Human Nutr, Johns Hopkins School of Public Health, Baltimore.

Malaria is reemerging in most endemic countries of South America, malaria kills approximately a million children under five years of age every year. Many children living in malaria endemic regions also suffers of nutritional deficiencies such as iron deficiency anemia and zinc deficiency. Malaria can exacerbate anemia and affect nutrition, immunity and development of these children.

We conducted a supplementation trial of iron and zinc to children 0-14 years old with the objective to measure anemia and morbidity. We present the changes on anemia and zinc status of this population.

The study was conducted in a rural community located near the city of Iquitos, in the Peruvian Amazon region. It was a mask controlled study of daily supplementation to children with a) Fe 15 mg as sulfate, b) 20 mg Zn, c) Fe and Zn, d) Placebo. 852 children, were randomly assigned to one of these groups at entry. Duration of the supplementation was 8 months. At entry, children had similar characteristics, by group of supplementation in age, SES, health and nutritional status. Overall initial anemia was 45.8% and there were not differences by group of supplementation or sex, but the highest prevalence was observed in younger children. The table summarizes changes in prevalence of anemia and Zn deficiency in this population.

	Fe Group	Fe + Zn	Zn	Placebo
% anemia (Initial)	43.7	45.9	46.4	46.0
% anemia (Final)	26.2	26.5	40.1	37.6
% Zn deficiency (Initial)	40.8	30.3	26.0	29.6
% Zn deficiency (Final)	13.3	8.1	14.0	44.9

Conclusion: Fe and Zn supplementation is an effective intervention to control Fe and Zn deficiency in this population.

Th63 ANEMIA IN MONGOLIAN CHILDREN 0-5 YEARS: A STUDY OF THE ROLE OF IRON, FOLIC ACID AND VITAMIN B12. M Nyamsuren, C Emary, G Bat, World Vision Mongolia, Nutrition Research Center of the Public Health Institute, Government of Mongolia, Ulanbataar, Mongolia and World Vision Canada, Toronto, Canada.

Background: Iron, folic acid and vitamin B12 are micronutrient deficiencies associated with anemia. While anemia is a significant health problem in Mongolia, its etiology in relation to these 3 micronutrients is poorly understood. **Aim:** To determine the prevalence of anemia in children under 5 years of age (U5) with respect to iron, folic acid and vitamin B12 deficiency. **Methods:** A 53-cluster survey was conducted in randomly selected aimags. Probability proportional to size methods were used to attain a representative study sample. Interviews were conducted using a pre-tested survey questionnaire. Hemoglobin (Hb) levels were determined using a 'Hemo-cue' photometer. For this study, classification of anemia was in accordance with WHO guidelines on the cut-off values of Hb adjusted for long-term altitude exposure (Hb < 11.8 – 11.0 g/dL, dependent on altitude of survey area). Serum ferritin (SF) was measured using solid phase enzyme immunoassay. Radioassays were performed to determine serum folate and vitamin B12 levels. **Results:** A 25% prevalence of anemia was detected in children U5, with significantly higher prevalence found in children age 6-11 months, 39% (n=114) and 12-17 months, 40% (n=116, p<0.001). Forty percent of children studied were iron deficient (SF <24ng/ml) (n=681). Twenty-five and 18% were deficient in folic acid (serum folic acid <3.4 nmol/L) and vitamin B12 (<120 pg/ml) (n=622). The prevalence of iron deficiency was 1.65 times greater in anemic children versus non-anemic children (p<0.001). The prevalence of severe iron deficiency, SF <12 ng/ml, was higher in anemic children while mild iron deficiency, SF 18-24 ng/ml, was greater in non-anemic children (p<0.001). No significant difference was found between anemic and non-anemic groups in relation to folic acid and vitamin B12 deficiencies respectively. **Conclusion:** Iron deficiency is an important factor in the development of anemia among Mongolian children, whereas study findings suggest that vitamin B12 and folic acid deficiency play a lesser role. Programming interventions should target the 6-18 month age group, as rates of anemia are highest among these groups. Strategies to address iron deficiency must be an integral component of Government policy and program strategies to address anemia in Mongolia.

Th65 DETERMINANTS OF IRON DEFICIENCY ANEMIA IN THE PHILIPPINES. JR Madriaga, CVC Barba, MIZ Cabrera, RL Cheong, JM Marcos, JA Desnacedo and LA Perlas. Food and Nutrition Research Institute, Department of Science and Technology, Philippines.

Background: The 1998 National Nutrition Survey conducted by the Food and Nutrition Research Institute, Department of Science and Technology, revealed an alarmingly high prevalence of iron deficiency anemia (IDA) among 1-5 year old children (31.8%), pregnant women (50.7%) and lactating women (45.7%). While prevalence rates are documented, there are no studies on the possible factors that could have contributed to the existence of these conditions. **Objective:** To identify the significant variables associated with iron deficiency anemia among children, pregnant, and lactating women. **Method:** Using the 1998 NNS data, descriptive statistics (means and standard errors, prevalence and confidence intervals) were provided to describe the nutritional status. Correlation analysis was used to determine the association of factors affecting nutritional status. The probabilities of risk associated with vitamin A deficiency and other related variables were determined using logistic regression analysis. **Results:** Among children, the determinants are: age (the younger the child, the higher the risk to iron deficiency anemia); sex (males have greater risk); weight and height (underweight and stunted children are of greater risk); and vitamin A in terms of plasma retinol levels (the higher the level of plasma retinol, the lower the risk to IDA). Among pregnant women, the determinants are: age, gravida, stage of gestation and use of supplements. The younger pregnant mothers (<20 yrs), the higher number of pregnancies, those who are in their later stage of pregnancies (2nd and 3rd trimesters), and those who are not taking vitamin/mineral supplements are more prone to iron deficiency anemia than others. Among lactating women, the determinants are: period of lactation and vitamin A status. Lactating women on their 1st 6 mos of lactation and those women with deficient to low plasma retinol levels are of higher risk to IDA. **Recommendations:** The findings suggest the need to focus on the groups at greater risk and to intensify implementation of intervention programs to improve the iron and nutritional status of children, pregnant and lactating women.

Th64 DETERMINANTS OF ANEMIA AND ASSOCIATED FACTORS AMONG CHILDREN 0-59 MONTHS IN RURAL TANZANIA. E Macha, S Kimboka, G Ndossi, C Mgoba. Tanzania Food and Nutrition Centre.

Objective: To determine factors influencing anemia and their associations among children under five years in Mazombe division. **Methods:** A Cross sectional study involved 999 children aged 0-59 months and their mothers aged 15-49 years selected randomly from the households within four wards of Mazombe division. Measurements on haemoglobin levels, malaria parasitaemia, helminths infestation and nutritional status were carried out using standard equipment and procedures to determine the prevalences. A questionnaire was used to collect information on socio economic conditions. **Results:** The prevalence of overall anaemia among children was 57% where 36% had moderate anemia and 4% severe anemia indicating a problem of public health significance according to WHO criteria. Twenty percent of children had malaria and 23% had helminths infestation. A similar pattern of prevalence and a strong association was noted between children and their mothers with regard to anemia and parasitic infections suggesting the influence of environmental factors on the aetiology of anemia. The limitation of using haemoglobin levels as a single indicator for determining anaemia might have underestimated the true prevalence of iron deficiency among children in Mazombe population. Although a high prevalence of PEM was found among children in this study (stunting 53%, underweight 31%, wasting 3%), it was only significantly associated with parasitic infections and worst forms of anaemia. Anemia was strongly associated with younger age of child less than or equal to 23 months, malaria, helminths infestation and residence. However risk factors became more evident with different levels of anemia and more specific to parasitic infections. There was also a significant geographical difference in prevalences of anaemia, malaria and helminths infestation. Early introduction of complementary foods, poor waste disposal, maternal factors, low food security and poor nutrition status of children were risk factors for anemia. **Conclusion:** Although malaria and helminths infections were the main risk factors for anemia, household level factors such as infant feeding practices, environmental sanitation, food security and nutritional status of the child need to be considered in parallel programs targeting children below 2 years of age who are more at risk.

Th66 DETERMINANTS OF MICRONUTRIENT STATUS OF 0-5-YEAR-OLD CHILDREN. WL Molano, CMT Lopez, AY Pacificador Jr, et al. Food and Nutrition Research Institute, Manila, Philippines, MOST-USAID, Manila, Philippines and University of the Philippines at Los Banos, Philippines.

Background: The survey conducted by the Food and Nutrition Research Institute in 1998 revealed that aside from protein-energy malnutrition (PEM), micronutrient deficiencies continue to afflict the preschoolers. Anemia prevalence among these children was at the alarming rate of 31.8%. Vitamin A Deficiency (VAD) prevalence based on plasma retinol level (<10µg/dL) was 8.2% among these children. There is a lack of information on the possible factors that could have contributed to their condition. Although it is generally accepted that poverty and other socio-economic factors play a large part in malnutrition, in-depth studies relating these factors with nutritional status have been found wanting. **Objective:** To identify the significant variables associated with micronutrient status, particularly vitamin A and iron, among preschool-age children. **Methods:** Contingency coefficients were estimated to determine the association between variables of interest. Multiple regression analysis was used to find the best fitting model to describe the relationship between micronutrient status and the set of independent variables. **Results:** The micronutrient status of preschool-age children was significantly associated with their nutritional status based on three anthropometric indices, i.e., weight-for-age, height-for-age and weight-for-height classifications. The fitted model showed that children who are not underheight, are taking multivitamin and vitamin C supplementation, have access to a sanitary toilet facility, have caregivers who are aware of iodized salt program, and are vitamin A-sufficient are less likely to be anemic. **Recommendations:** There should be an extensive effort to fully implement and closely monitor the government's Operation Timbang and Growth Monitoring Program on one hand, inasmuch as the nutritional status of children was found to be significantly associated with the micronutrient status. There is a need to strengthen the delivery of the package of health and nutrition intervention services, such as through the Garantisadong Pambata, to minimize episodes of infections, as well as improved waste disposal and increased advocacy for usage of iodized salt.

Th67 PREDICTORS OF ANEMIA IN RURAL KENYAN CHILDREN: MALARIA, INFECTION, VITAMIN B12 AND A, AND MEAT INTAKE. C Neumann, J Long, R Weiss, S Murphy, L Jiang, C Gewa, E Reid, J Siekmann, A Zubieta, L Allen, N Bwibo. UCLA School of Public Health, Los Angeles, USA; WHNRC/UC Davis, Davis, USA; Univ. of Nairobi, Kenya.

Anemia of multiple etiologies is widespread in Kenyan children. **Background & Methods:** Relationships between hemoglobin (Hb) and micronutrient (MN) and meat intakes, malaria and stool parasites were studied in 554 schoolers 6-11y and in 283 toddlers 9-35 mo. Children were participants in a feeding intervention study of animal source foods over 2 years. In schoolers, relationships between Hb and serum/plasma levels of Fe, Zn, Cu, folate, vitamins B12 and A, and C-reactive protein (CRP) were studied longitudinally. Food intake was measured every 1-2 months by 24-h recall. Hb was assessed by Hemocue, erythrocyte morphology by microscopy, and malaria antigens by the Vision Biotech Malaria Rapid dip-stick test. **Statistical Analyses:** Regression and bivariate mixed models were used to analyze relationships between Hb and MN status, and for nutrient and meat intakes. **Findings:** Baseline anemia (Hb <110g/L) was present in 72% of toddlers and 49% of schoolers, macrocytosis in 4% of toddlers and 11% of schoolers, and microcytosis in 11% of both groups. Percent macrocytosis was negatively correlated with Hb in schoolers ($P < 0.056$, $r = -0.5$), indicating that the anemia associated with vitamin B12 and/or folate deficiency tends to be more severe than microcytic anemia. Malaria was present in 13% of the toddlers and 32% of the schoolers, and 17.8% schoolers had elevated CRP (> 10 g/L). Hookworm, Ascaris, and Trichuris were present in 5-10% of children but stool parasites were not significantly correlated with Hb. **Hb & MN Relationships:** In schoolers, Hb were significantly positively correlated with plasma Fe, Zn, folate, vitamins B12 and A at the end of years 1 and 2 of the study. Cu was negatively correlated with Hb, as were CRP and malaria ($p = 0.02-0.05$). Both Cu and CRP are elevated in acute infection. In toddlers, Hb at follow-up was predicted by heme Fe and meat intakes ($p < 0.03$). In schoolers, Hb showed weak but significant positive correlations with protein, folate, animal source vitamin A, phytate, and fiber. **Conclusions:** Malaria and infection are major predictors of anemia, but low plasma Fe, folate, vitamins B12 and A all contributed substantially to low Hb. Meat intake in toddlers was positively related to Hb, suggesting low meat intakes are an important cause of anemia of this group. Funding: USAID Global Livestock CRSP, USAID, Grant PCE-G-98-00036-00, USDA-CSREES-NRI Grant 2003-35200-14183.

Th69 IMPACT OF MATERNAL IRON STATUS ON CHILDCARE PRACTICES OF NURSING MOTHERS FROM THE LOWER SOCIO ECONOMIC GROUPS OF DELHI. K Paintal(1), S J Passi(2); (1)Senior Research Fellow – ICMR; (2)Reader in Nutrition, Dept. of Foods and Nutrition, Institute of Home Economics (University of Delhi). F-4 Hauz Khas Enclave, New Delhi – 110 016, India.

The future of human societies depends on the children being able to achieve optimal physical growth and psychosocial development. A woman's health status, quality of care provided by her/received by the infant is closely interlinked to the infant's health, growth and survival. Breast feeding is foundation of Infant Care and optimal caring practices help to provide the child with adequate level of energy and various nutrients that go a long way in protecting him/her against the early onset of malnutrition. **Objectives:** To study the association of maternal health status and child care practices on the growth patterns of young infants aged 0-6 month(s). **Methodology:** In a longitudinal cohort study, 87 infants from urban slums ($n = 42$) and rural areas ($n = 45$) were followed from birth till 6 months of age. Monthly home visits were made and data on the maternal dietary intake, their breast-feeding/infant feeding, child-care practices and in case of the infants, information on the patterns of breast milk consumption and morbidity trends were collected. As an indicator of maternal/child health status, mother's/infant's anthropometry and maternal haemoglobin levels was also assessed. **Results:** The dietary intake data indicated that compared to the RDA, the mean energy intake of the subjects was 48.9%, protein 61%, iron 31%, vitamin A 91% and vitamin C 26.5%. The mean hemoglobin level of the mothers was 10.1 ± 2.17 mg/dl and BMI was 19.63 ± 3.01 . The results indicated that the mean Hb status of the nursing mother had a bearing on her care giving practices - anemic mothers were more likely to delay the initiation of breast feeding (79.0%), administer prelacteals (85.5%) and discard the colostrum (61.8%; $p < 0.05$). These anemic mothers were at 1.13 odds (95% CI; 0.20 to 6.42) of early introduction of complementary foods and 2.1 odds (95% CI; 0.69 to 18.05) of early termination of breast-feeding. A large proportion of these mothers (61.8%) reported that their milk was insufficient to meet the infant's needs and thus, they introduced animal milk/tea/water, etc in their infants' diets. In the case of anemic mothers, the frequency of breast-feeding episodes as well as the mean duration of each breast-feeding episode was much lesser as compared to the non-anemic ones. Although, the infants registered a steady growth in all the anthropometric parameters, the incidence of morbidity was almost universal; majority of the babies had suffered from more than two episodes of illness - the average number of morbidity episode in the six-month period being 3.8. Compared to the non-anemic mothers, infants of anemic mothers had 1.44 odds of morbidity (95%CI; 0.12-17.10). **Conclusion:** Nutritional status of the mother and her care-giving abilities influence her breast-feeding patterns/decisions that affects the infants' health, development, morbidity and subsequently the growth patterns.

Th68 PREVALENCE AND RISK FACTORS OF ANEMIA AMONG WOMEN AND CHILDREN IN BENIN. I Ngnie Teta, B Kuate-Defo, O Receveur. University of Montreal, Canada.

Objective: In sub-Saharan Africa, anemia among women and children constitutes a major obstacle to development because of its magnitude and its consequences. The aim of this study was to estimate risk factors for anemia in Beninese women and children at the individual and contextual level. **Methods:** For that purpose, we carry out a multilevel analysis of nationally representative data recently collected in Benin through the Demographic and Health Surveys 2001 (DHS). Potential risk factors used in the construction of the models are at the individual level (woman or child), the household, and the community levels. anemia was determined by the hemoglobin level in capillary blood of 3125 women aged 15-49 and 2284 children under 5 by the photometric technique Hemocue. anemia prevalence was adjusted depending on altitude and classified as mild, moderate or severe. **Results:** Overall anemia prevalence was 41% in women, 73% in pregnant women, 61% in breast-feeding women and 82% in children. Analyses show that no risk factors seems to be associated with mild anemia other than pregnancy. Risk factors of moderate anemia (pregnancy, religion, women education, breast-feeding) were different from those of severe anemia (pregnancy, age, religion, hygiene, husband education, country life). 94% of children with severe anemic mother are also anemic. **Conclusion:** Multilevel analysis is known to generate more appropriate estimates for variables that are nested within various levels. In our analysis, it also reveals some programmatically meaningful risk factors for severe anemia (husband education, country life) that were ignored by typical multivariate analysis.

Th70 ANAEMIA AND BODY MASS INDEX OF SRI LANKAN ADOLESCENTS. CL Piyasena, AMASB Mahamithawa. Nutrition Department, Medical Research Institute, Colombo, Sri Lanka.

Background: Nutrient requirements of adolescents vary depending on the growth rate, degree of physical maturity, body composition and activity level. Nevertheless, the priority given in intervention programmes is appreciably low. This situation has no doubt contributed to the current nutrition status of adolescents in Sri Lanka. **Aims:** Current study was conducted to determine the anaemial status and its association with BMI in adolescents. **Methods:** A total of 3052 adolescents were recruited to the study using multi stage stratified sampling method spreading over 141 primary sampling units across 17 districts of Sri Lanka. Eight districts were excluded owing to ethnic conflicts. Selected households were visited by the field investigators and a structured questionnaire was administered to the principal care-giver. Weight, height measurements and haemoglobin estimations (HemoCue method) were taken following standard techniques. Prevalence of anaemia was determined using WHO cut off points and applying an altitude correction where applicable. **Results:** Study revealed an overall mean haemoglobin concentration of 12.9 g/dl (SD = 1.3) with the anaemia prevalence of 22.3%. No identifiable pattern was seen with age. Urban adolescents showed a higher prevalence of anaemia than others. BMI showed that 60.7% were within the age specific normal range and 33.3% of adolescents were thin, 4.9% were overweight and 1.1% was obese. Overweight adolescents had the highest anaemia prevalence (24.3%) while thin adolescents had a prevalence of 23.6%. The lowest anaemia prevalence was seen in obese adolescents (17.8%). **Conclusions:** Adolescents are a nutritionally vulnerable group as one third of them are below the accepted BMI levels and prevalence of anaemia was remarkably high. Overweight and thin adolescents are more prone to be anaemic than the others.

Th71 SEASONALITY, MATERNAL IRON INTAKE, HAEMOGLOBIN STATUS VIZ. PREGNANCY OUTCOME OF THE WOMEN FROM POORER STRATA. B Tamber Aeri, SJ Passi. Institute of Home Economics (University of Delhi), F-4, Hauz Khas Enclave, New Delhi-110016, India.

In the present study an effort has been made to find the maternal factors influencing birth weight of the new-born as well as to find out whether fluctuations in seasonal availability and thus the consumption of micronutrient rich fresh foods bring about any variation in the pregnancy outcome. **Methodology:** Secondary data from birth records have been gathered from a major government hospital in Delhi (n=33,786) for the years 1989,1998 and 1999 and a government maternity center (n=2769) for five consecutive years 1997-2001. Further, primary data were also gathered from a cohort of 201 pregnant women followed from early pregnancy till childbirth. The haemoglobin status of these women was assessed by the cyanmethaemoglobin method. **Results:** The secondary data so gathered indicate that the birth weight was significantly affected by the maternal age, pre-delivery weight, haemoglobin status, parity, period of gestation and PIH (p<0.05). Further, monthwise segregation of the secondary data indicated that the babies born in February - March had the highest birth weight and the lowest incidence of LBW deliveries while those born in August had the lowest mean birth weight and the highest incidence of LBW deliveries in all the periods under study (segregated/the pooled data; p<0.05). The in-depth data indicated that a majority of the women were (85%) were anaemic and were not even regular in the consumption of the iron-folate tablets being distributed to them. Multiple linear regression analysis of the dietary data gathered at different periods of gestation indicated that the dietary intake during the 30±2 weeks (r²=0.315), especially the intake of micronutrients like iron, vitamin A and riboflavin had a significant influence on birth weight. Further, a stepwise multiple linear regression analysis indicated that haemoglobin status at all periods of gestation as well as vitamin A intake at term; the past obstetric history; and the weight gain at 30±2 weeks of gestation were significantly associated with birth weight. **Conclusion:** The study thus indicates that seasonal variations in the availability of MN rich fresh foods could influence the pregnancy outcome as indicated by the variations in birth weight. It is therefore necessary that women are educated regarding the importance of a good wholesome diet including the consumption of seasonal micronutrient rich foods.

Th72 ROLE OF IRON DEFICIENCY IN THE ETIOLOGY OF ANEMIA IN SCHOOL CHILDREN IN NORTHEAST THAILAND IS OVERESTIMATED. P Winichagoon, R Cook*, T Pongcharoen, A Boonpradern, S Govachirapant, RS Gibson*. Institute of Nutrition, Mahidol University at Salaya, Nakhon Pathom, Thailand and Department of Human Nutrition. University of Otago, Dunedin, New Zealand*.

As in many developing country, the etiology of anemia is multifactorial. Nutrient deficiencies, infectious diseases, malaria and hemoglobinopathies may play a role. Hemoglobinopathies are common in NE Thailand, but their contribution to anaemia prevalence, relative to iron deficiency, in community-based studies has not been reported. We have investigated the roles of key micronutrients in children with normal hemoglobin (Hb) and hemoglobinopathies in the etiology of anemia in rural children in NE Thailand. Primary school children (286 girls and 281 boys) aged 6-13 y, recruited from ten rural schools in Ubonratchathani province participated. Variables measured in non-fasting venipuncture blood samples were: complete blood count, serum ferritin, transferrin receptor, serum C-reactive protein (CRP), and hemoglobin type using the Variant B-Thalassemia Program. Children with CRP >10 mg/L (n=12) were excluded. Of the children, 60% had Hb AA, 35% had Hb E-trait (HbAE) and 5% were homozygous for HbE (HbEE). Overall, 31% of children were anemic. Anemia was present in 96% of the EE group, 36% of the AE group, and 21% of the AA group. A linear relationship exists between serum transferrin and both Hb and MCV, but not with serum ferritin. Microcytic hypochromic anemia predominated. All of the EE group, 55% of the AE group and 35% of the AA group had MCV <80 fL. Nevertheless, prevalence of iron deficiency anemia based on low Hb and low serum ferritin (<12 µg/L) was <2%. Hemoglobin E and serum retinol were the most important explanatory factors associated with anemia (p<.01) in the AA and AE groups, even though only 3% of the children were classified as vitamin A deficient (serum retinol < 0.7 µmol/L) and a further 20% had marginal vitamin A status (serum retinol 0.7-1.05 µmol/L). 57% of children had low serum zinc based on fasting status, age and gender-specific cutoffs. Anemia associated with hemoglobinopathy, suboptimal vitamin A and iron status, together with zinc deficiency are still prevalent in the NE Thai school-aged children. 31% of the children were at risk of two or more concurrent micronutrient deficiencies. Supported by Micronutrient Initiative & University of Otago.

Recent Surveys

Thursday, 18 November

Th73 IRON DEFICIENCY ANEMIA IN PRE-SCHOOL CHILDREN AND WOMEN OF ERITREA. Zemui Alemu, Salma Mohammed, Ministry of Health, Eritrea.

Background: Iron Deficiency Anemia (IDA) is the most common nutritional deficiency worldwide. Children and women at reproductive age are the most vulnerable group for IDA. **Aim:** to evaluate the extent of IDA in pre-school children and women at reproductive age of Eritrea. **Methods:** A national cross-sectional population-based survey was conducted in December 2002. Following a double stage cluster sampling procedure 1866 children from 6-59 months of age and 1748 women from 15-49 years old were enrolled. IDA was assessed by hemoglobin concentration (HemoCue), corrected by altitude, and iron rich-food intake (Food Frequency Questionnaire). Additionally, anthropometric measurements were taken and children's growth status was evaluated by the indices weight-for-age, height-for-age and weight-for-height, and women by the Body Mass Index (BMI), according to WHO criteria. **Results:** The prevalence of anemia in children was 33.9% (95%CI 31.8 – 36.1), mainly mild form. In pregnant women, the prevalence was 11.8 (95%CI 8.0 – 17.1) and in non-pregnant 13.5% (95%CI 11.8 – 15.3). Male (p= 0.019) and youngest (p= 0.000) children tend to have lower hemoglobin concentration compared to those counterparts. The consumption of iron rich-food and iron absorption enhancers was low. Only 50.0% (95%CI 47.7 – 52.3) of children consumed animal and 8.0 (95%CI 6.8 – 9.3%) plant iron-rich sources, at least 3 times/week. According to the WHO/NCHS cut-off point (-2 SD), 38.2% (95%CI 36.1 – 40.3) of children were underweight, 38.4% (95%CI 36.3 – 40.3) stunted and 9.7% (95%CI 8.5 – 11.1) wasted. Growth faltering was associated with IDA. Stunted (p= 0.000), wasted (p= 0.000) and underweight (p=0.000) children are more likely to have low Hb concentration. Among women, the prevalence of undernutrition (BMI< 20) was 53.8% (95%CI 51.3 – 56.3). BMI was positively correlated with Hb concentration (rho= 0.13, p=0.000). **Conclusion:** IDA represents a public health concern in Eritrea. Intervention programmes towards preventing and control IDA should have priority in the country.

Th74 IRON DEFICIENCY - A PROBLEM AMONG URBAN ADOLESCENT GIRLS AND WOMEN OF CHILDBEARING AGE IN SRI LANKA. T Thoradeniya, S Atukorala, R Ramanayake. Department of Biochemistry & Molecular Biology, Faculty of Medicine, University of Colombo, Sri Lanka, Colombo Municipal Council, Sri Lanka.

Background: Iron deficiency/anaemia in adolescent girls and women of child bearing age is likely to have adverse effects on health and wellbeing and subsequent outcome of pregnancy. However, studies on iron deficiency among adolescent girls and women of childbearing age are limited. **Aim:** To assess the prevalence of iron deficiency and its aetiological factors in adolescent girls, and women of childbearing age in Colombo, Sri Lanka. **Methods:** Random samples of adolescent girls aged 15-18.9 y (schoolgirls n=162, school leavers n=115) and non-pregnant, non-lactating women aged 19-25 y (n=274) of low socioeconomic status (SES) were selected. Their SES, food habits and general nutritional status were assessed and a venous blood sample collected for the estimation of haemoglobin (Hb), serum ferritin and plasma homocysteine (as an indicator of folate deficiency). **Results:** The prevalence of anaemia (Hb <120 g/L) in the study population (n=551) was 12.9 %. School leavers had a significantly higher prevalence of anaemia (p=0.028) than school girls (18.3 % vs. 9.3 %), while the prevalence among women was 12.8 %. Depleted iron stores (serum ferritin <12 µg/L) and elevated plasma homocysteine concentrations (>15 µmol/L) were noted in 25.4 % and 24.1 % of subjects respectively. The percentage of subjects with low serum ferritin was highest among school leavers and lowest among school girls. There was a significant positive association between Hb and log serum ferritin concentration (p=0.000) when all subjects were considered, while a positive association with level of education (p=0.005) was noted only in adolescent girls. There was no significant association between Hb and plasma homocysteine concentration. Serum ferritin concentration was positively associated with body mass index (p=0.000). **Conclusion:** Iron deficiency was associated with a poor general nutritional status. School leavers had a higher prevalence of anaemia and a lower iron status than schoolgirls and this could be attributed at least partly to their lower educational level and unsatisfactory food habits. These studies highlight the need for nutrition and health education outside the school setting. (Supported by International Atomic Energy Agency)

Th75 WEANING PRACTICES IN RURAL AND URBAN CÔTE D'IVOIRE AND ITS IMPLICATION FOR IRON BIOAVAILABILITY. F. Camara, D Gnakri. UFR Sciences et Technologies des Aliments, Université d'Abobo-Adjamé, Côte-d'Ivoire.

The introduction of varied diet during first two years of life plays a central role in the iron supply. The present study aimed to describe weaning foods and quantify iron intake and dietary factors that modulate its absorption for weanlings in a Sub-Saharan setting in a population where mothers and preschool children are anaemic. In this context, a food intake survey was made with infants (N=429) aged 4 to 24 months in socio-economically poor zones of Côte d'Ivoire, namely in two rural areas (Bouaké and Boundiali) and an urban area (Abidjan). All infants were breast-fed but received complimentary foods at the time of the survey. According to anthropometric indicators, malnutrition increased steadily with age, parallel to decreasing breast-milk intake. Weaning was achieved with the normal family meal. A 3-days weighed food record was done for 63 infants, and consumed food items were analysed for iron, ascorbic acid, energy, polyphenol and phytic acid. The cereal based diets provided more calories and more iron than tuber crop based diets. The iron intake ranging from less than 1 mg/d to 5.3 mg/d and the energy intake of 400 to 800 kcal/day were well below WHO recommendations (7-10 mg/day and 682-1350 kcal/day respectively) for all age groups and areas. Ascorbic acid intake (8 – 23mg/d) was also below recommendations, and phytic acid intake (27 – 222mg/d) was particularly high in cereal based diets in the North. Polyphenol intakes of 16 – 80mg/d were measured.

Iron intake and the expected iron bioavailability are both low for the studied infants owing partly to the fact that no special weaning food was prepared. It appears highly probable that anaemia due to iron deficiency in the diet is widespread among the studied weanlings. Sensitization programs should be launched and simple, inexpensive weaning foods developed, which respects the particular necessities of infants.

Th77 CONCOMITANT PREVALENCE OF IRON AND ZINC DEFICIENCY IN PREGNANT AND NON-PREGNANT WOMEN IN RURAL INDIA. U Kapil, P Pathak, P Singh. Department of Human Nutrition, All India Institute of Medical Sciences, Ansari Nagar, New Delhi-110029, INDIA.

Background: Maternal anemia and low serum zinc concentrations is associated with poor pregnancy outcome. Limited data is available on the concurrent prevalence of deficiency of iron and zinc in pregnant women (PW) and newly married non-pregnant women (NPW). Hence, the present study was conducted. **Objective:** To assess the concurrent prevalence of deficiency of iron and zinc amongst PW and NPW in rural India. **Methodology:** A community based cross sectional study was conducted in a rural block of India. Two hundred and eighty three PW with gestation 28 weeks and more, and 288 were included. Data was collected on socio-demographic profile, obstetric history, dietary intake by utilizing standard methodology and pre-tested questionnaire. Serum zinc and serum ferritin were estimated by utilizing the standard methods. Serum zinc and ferritin levels less than 70.0 µg/dl and 15 ng/ml, respectively were considered as indicative of deficiency. Dietary intake of micronutrients was assessed utilizing the standard 1-day 24-hour dietary recall method. The study was conducted during November 2001 to October 2002. **Results:** It was found that 73.5 and 73.4 percent of the PW and 41.5 and 63.8 percent of the NPW were deficient in zinc and iron, respectively according to the serum levels. The concurrent deficiencies of zinc and iron was found in 54.9% of PW and 29.6% of NPW. The data on dietary intake revealed that 86.2% and 75.2% of the PW and 75.7% and 58.3% of the NPW were consuming less than 50% of the RDA for zinc and iron, respectively. There was no correlation found between zinc and iron in both PW and NPW (PW: Pearson's correlation coefficient $r=0.093$, $p=0.14$) and (NPW: Pearson's correlation coefficient $r=0.003$, $p=0.96$). **Conclusion:** A high prevalence of deficiency of zinc and iron was found amongst PW and NPW. Evidence suggest that zinc and iron interact when together administered in therapeutic doses. It is recommended that Zinc and iron should be supplemented independently in developing countries to avoid this interaction. **Key Words:** Zinc deficiency, Iron deficiency, pregnant women.

Th76 VARIATION IN IRON DEFICIENCY ANEMIA PREVALENCE IN SCHOOL CHILDREN FROM NEIGHBORING VILLAGES IN NORTHERN MOROCCO. SY Hess, L Alaoui, RF Hurrell. Human Nutrition Laboratory, Swiss Federal Institute of Technology Zurich, Switzerland; and Human Nutrition, Institute of Agriculture and Veterinary Hassan II, Rabat, Morocco.

In the Rif mountains of northern Morocco iron deficiency anemia (IDA) was considered a major public health concern. In school-age children (6-14 yrs), 50-62% were found to be anemic in 2 villages, and 25-35% suffered from IDA (Zimmermann et al., 2003). Similar results were found in a second study in the same site in April 2003 (Zimmermann et al., unpublished data).

In neighboring villages of the same region 6 to 14 yr old children in 21 primary schools (n=1979) were examined in November 2003 to identify iron-deficient anemic children for an iron fortification trial. Mean hemoglobin, serum ferritin and zinc protoporphyrin concentration was 131 ± 12 g/L, 31 ± 27 µg/L and 63 ± 74 µmol/mol heme, respectively. Only 119 (6 %) children were identified to have a hemoglobin concentration below the recommended cut-off by WHO. Prevalence of iron deficiency and IDA was 13% and 4%, respectively. Although these schools were all located in apparently similar rural villages within 10 to 50 km distance from the previously screened schools, IDA was significantly less frequent. These findings indicate that even within one region of a country IDA prevalence can vary significantly. The reasons for the different IDA prevalence are not known however, unlike in the Zimmermann et al. studies, the villages in the present study were situated on or within easy reach of a major trunk road and the population may have had access to a more varied diet.

Such variations complicate the quantification of IDA prevalence estimates at the national or regional level and thus make the evaluation of the usefulness of public health interventions such as food fortification more difficult.

Zimmermann MB, Zeder C, Chaouki N, Saad A, Torresani T & Hurrell RF (2003) Dual fortification of salt with iodine and microencapsulated iron: a randomized, double-blind, controlled trial in Moroccan schoolchildren. *American Journal of Clinical Nutrition* 77, 425-432.

Th78 IRON DEFICIENCY ANEMIA AMONG CHILDREN UNDERFIVE IN INDONESIA: AN ALARMING CALL FOR ACTION. E Martini, S de Pee, S Halati, M Sari, A Stormer, A Rice, R Moench-Pfanner, S Kosen, MW Bloem. Helen Keller International-Indonesia (HKI), Ministry of Health/Government of Indonesia (GOI), Jakarta, Indonesia.

Background: Iron deficiency anemia (IDA) has a large impact on human productivity, psychomotor and mental development, immunity, growth and learning capacity. IDA is the most common nutritional deficiency in Indonesia.

Aims: To assess the prevalence of anemia using data from the GOI/HKI Nutrition and Health Surveillance System (NSS) in 4 urban slum sites and 8 rural provinces in Indonesia, representing 70% of the total population.

Design: NSS cross-sectional data from Sep 1998-Aug 2003 were analyzed. Data on nutrition, health, socio-economic conditions etc. were collected quarterly, from 155,000 households per year. Blood was obtained by finger prick from children in a 20% sub sample of households and hemoglobin concentration (Hb) was assessed using a HemoCue. Children with Hb<110 g/L were classified as anemic. **Results:** In the first round of data collection, Nov 1998-Mar 1999, the weighted prevalence of anemia among children 12-23 months old was 70% in the rural areas and 75% in the urban slum areas. There were some initial signs of decline in the urban slum areas in the Dec 1999-Feb 2000 and Jul-Sep 2000 periods (down to 57%), but then the prevalence increased again to 66% and remained at that level. There was no decline observed in the rural areas. In the last round of data collection, from Jun-Aug 2003, the weighted prevalence among 12-23 months old children was 66% in the rural areas and 77% in the urban slum areas. **Conclusion:** The prevalence of anemia among children underfive has remained very high over time since 1998, especially among children 12-23 months old, and no significant changes were observed over the past 6 years. A combination of fortification, supplementation and dietary diversification is needed to combat this universal deficiency and to limit the long term economic cost of the consequences of anemia for the population. In addition, anemia increases the risk of lead poisoning, particularly among young children. This poses an additional and large threat, especially in urban poor areas. **Supported by:** USAID Cooperative Agreement No: 497-A-00-99-00033-00

Th79 IRON STATUS OF CHILDREN UNDER-5 IN NIGERIA: RESULTS OF THE NIGERIA FOOD CONSUMPTION AND NUTRITION SURVEY. B Maziya-Dixon (1), RA Sanusi (2), IO Akinyele (2), EB Oguntona (3) and E Harris (4). 1. International Institute of Tropical Agriculture, Ibadan, Nigeria; 2. University of Ibadan, Ibadan, Nigeria; 3. University of Agriculture-Abeokuta, Abeokuta, Nigeria; 4. Beltsville Human Nutrition Research Center, USDA, Beltsville, MD, USA.

Iron deficiency is a serious and widespread public health problem in developing countries. To reduce the prevalence of iron deficiency in Nigeria, the International Institute of Tropical Agriculture (IITA), in collaboration with the Federal Government of Nigeria (FGN), the United States Department of Agriculture (USDA), and various universities and institutions in the country conducted a baseline nationwide food consumption and nutrition survey in 2001 to inform strategies to address iron deficiency in Nigeria. One of the objectives of the survey was to assess the iron status of children under-5 years of age. A total of 12 States, 72 Local Government Areas, 216 Enumeration Areas, and 6480 households with a mother and child pair were sampled. Blood samples were collected for the determination of serum ferritin. At the national level, approximately 36.3% of children under-5 was at different stages of iron deficiency, with 13.4% already having depleted iron stores (serum ferritin value of less than 20 ng/ml) and 22.3% having serum ferritin concentrations less than 10 ng/ml, suggestive of iron deficiency. The proportion of children with varying degrees of iron deficiency was 47.3% for the dry savanna, 30.4% for the moist savanna, and 33.4% for the humid forest. Iron deficiency was highest in the dry savanna (32.2%), followed by the moist savanna (18.5%) and humid forest (18.7%). The same trend was observed for children with depleted iron stores (< 20 ng/ml); there were more in the dry savanna (15.1%) than in the moist savanna (11.8%) and humid forest (14.7%). The proportion of children with varying degrees of iron deficiency was 34.1% for the rural, 36.2% for the medium, and 40.5% for the urban areas. Iron deficiency (serum ferritin concentration < 10 ng/ml) was highest in the urban areas (27.8%) followed by the medium (23.0%) and rural (18.7%) areas. In conclusion, iron deficiency is a public health problem in Nigeria. While the proportion of children with low serum ferritin levels varies agro-ecologically and across sectors, it is a significant public health problem in all agro-ecological zones and sectors.

Th81 NATIONAL PREVALENCE OF ANEMIA IN CHILDREN BETWEEN 12 AND 35 MONTHS OLD AND CHILDBEARING WOMEN. C Rojas Dávila, I Bernui, L Llanos, M Ysla, E Vara, M Calderón, V Riega. Centro Nacional de Alimentación y Nutrición. Instituto Nacional de Salud. Ministerio de Salud. Lima, Perú.

Background: Anemia due to the iron deficiency in children aged less than 5 y, and childbearing women are important public health problems in Peru. This is because of an inadequate food consumption. **Aims:** To determine hemoglobin concentration and the national prevalence of anemia in children between 12 and 35 months old and childbearing women. **Methods:** Descriptive and transverse study, with departmental inference because of lack of information at this level. This information was part of the National Food Consumption Survey in children between 12 and 35 months old and childbearing women, made by Centro Nacional de Alimentación y Nutrición of Instituto Nacional de Salud from Perú. The sample was conformed by 2 908 children and 2 909 women probabilistically in two stages chosen. Hemoglobin levels were adjusted according to the altitude. Cut-off points to define anemic child and pregnant women were < 110 g/L and < 120 g/L for the other women. **Results:** The national mean hemoglobin concentration for the children was 106 g/L. The national prevalence for children anemia was 57,1%. There were no difference in the prevalence of anemia between genders, but there was difference between ages. The children between 12 and 23 months (66%) had higher prevalence than the children between 24 to 35 months (49%). The national mean of hemoglobin concentration for women was 124 g/L. The 32,9 % of women had anemia. The departments with the highest prevalence were Puno (62%), Pasco (60%) y Huancavelica (53%). **Conclusions:** Anemia among children of 12 to 35 months and women of childbearing age are still public health problems.

Th80 PREVALENCE OF HEMATINICS DEFICIENCY AMONGST FEMALE STUDENTS AND ITS CORRECTION. BC Mehta, RM Kabeer, Y Patel; Smt Santokben Chhotalal Mehta Hematology Department & Dr JC Patel Medical Research Department, BSES MG Hospital, SV Road, Andheri (West), Mumbai 400 058, India.

Nutritional anemia is common in India. While iron deficiency has been well recognised and documented as the cause of nutritional anemia, prevalence of deficiencies of other hematinics is not systematically investigated. It was felt that malnutrition is likely to involve other hematinics besides iron. Hence, we decided to investigate a group of apparently healthy young female students for anemia and hematinics deficiencies. Two hundred and seventy-two young female students (age 6-25 years) were investigated for anemia and hematinic deficiencies. Results are shown below:-

Parameter	Hemoglobin	MCV	MCH	Ferritin	B12	Folic acid
Subnormal value	<12.0 g/dl	<80.0 fl	<27.0 pg	<15.0 ng/ml	<258 pg/ml	<3.5 ng/ml
No. of students with subnormal value	94(34.6%)	153(56.3%)	167(61.4%)	161(59.2%)	133(48.9%)	34(12.5%)

Anemia was found in 34.6%. Low MCV and MCH were detected in 56.3% and 61.4% of girls respectively. Subnormal values of ferritin, B12 and folic acid was found in 59.2%, 48.9% and 12.5% of students respectively. Study indicates a high prevalence of hematinics deficiency in young girls. This is not surprising as malnutrition is the underlying cause of the deficiencies. Effect of iron deficiency on the intestinal absorptive function as well as gastric secretory function could also contribute to deficiencies of vitamin B12 and folic acid.

212 students, belonging to one institute were treated with a hematinic containing 105 mg elemental iron, 300 mcg folic acid and 10 mcg vitamin B12 given 3 days/week for six months. 153 students completed the study. They were divided into 3 groups- control group with Hb 12.0 g/dl or more and ferritin 15.0 ng/ml or more, iron deficiency group with Hb 12.0 g/dl or more and ferritin <15.0 ng/ml, and iron deficiency anemia group with Hb <12.0g/dl and ferritin <15.0 ng/dl. Significant increase in Hb was seen only in IDA group, while MCV, MCH, ferritin, folic acid and vit B12 increased significantly in all three groups. Significant increase in MCV and MCH in control and ID group suggests that even these groups had iron deficient erythropoiesis although their Hb was 12.0 g/dl or more.

Th82 MORTALITY RISK IS NOT AFFECTED BY IRON-FOLATE SUPPLEMENTATION AMONG PRESCHOOL CHILDREN IN NEPAL. JM Tielsch, RJ Stoltzfus, SK Khatri, J Katz, SC LeClerq, R Adhikari, SR Shresta, Siegel E, LC Mullany. Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, Cornell University, Ithaca, New York, and Nepal Nutrition Intervention Project-Sarlahi, Kathmandu, Nepal.

Background: Iron deficiency and anemia are common in young children living in the Indian subcontinent. Few data are available regarding the morbid and mortal consequences of this deficiency state, especially in areas with a high burden of infectious disease. Prior to policy decisions regarding universal supplementation it is critical to understand the risks and benefits of such programs. **Aims:** To determine the efficacy of daily iron-folate supplementation on mortality among children 1-36 months of age in southern Nepal. **Methods:** A population-based, randomized community trial was conducted in 30 VDCs of Sarlahi District in southern Nepal. The study area was divided into 425 sectors and sectors were randomized to receive one of 4 treatments: daily zinc, daily iron-folate, daily zinc + iron-folate, or daily placebo. All enrolled children received their sector's assigned treatment. Children were enrolled at baseline or as they turned one month of age. Children were followed until 36 months of age and then discharged. **Results:** The Data & Safety Monitoring Board suggested that the iron-folate containing arms of the trial be stopped because of lack of impact. This was done in mid-November 2003. The placebo, iron-folate and zinc + iron-folate groups are compared. A total of 25,718 children were enrolled resulting in a total of 30,218 child-years of follow-up. Compared to placebo, there was no difference in mortality for the iron-folate group (RR=1.00) or the zinc+iron-folate group (RR=0.98). **Conclusion:** There is no evidence that iron-folate supplementation affects mortality risk in this population of preschool children where there is little malaria infection but high burdens of other infectious disease.

Th84 DIFFERENT EFFECTS OF IRON AND ZINC SUPPLEMENTATION ON GROWTH IN ANEMIC AND NON-ANEMIC INFANTS. SEAMTIZI study group: MA Dijkhuizen*, P Winichagoon, FT Wieringa, E Wasantwisut, B Utomo, NX Ninh, A Hidayat, and J Berger. Dept. Int. Med., UMCN, Nijmegen, Netherlands; Inst. Nutr., Mahidol Univ. Bangkok, Thailand; Univ Indonesia and Univ Trisakti, Jakarta, Indonesia; Nat. Inst. Nutr., Hanoi, Vietnam and Inst. Rech. Dev., Lab. Nutr. Trop., Montpellier, France. * Corresponding author, other authors are listed in reversed alphabetical order. SEAMTIZI: South-East Asia Multi-country Trial on Iron and Zinc supplementation in Infants Study Group.

Background: Growth faltering is prevalent in developing countries, starts within a few months of birth, and interventions should start <18 months of age. Zinc and iron deficiency have been implicated in growth faltering, but effects of supplementation have not been consistent. **Aim:** To determine the effects of iron and zinc supplementation on growth in infants. **Design:** Pooled analysis of a double-blind placebo-controlled multi-country trial with 4 study sites in Indonesia, Thailand and Vietnam. Infants (4-6 mo old, n=2603) were supplemented with iron (10 mg) and/or zinc (10 mg) daily for 6 mo. **Results:** Mean height-for-age z-score (HAZ) decreased from -0.84 (\pm 0.81) to -1.33 (\pm 0.86) in all groups over the supplementation period. Overall, neither iron or zinc supplementation affected the progressive growth faltering. Also, supplementation did not improve length growth in infants stunted at recruitment. However, anemia at recruitment modified the effect of both zinc and iron supplementation on HAZ (P<0.01 and P=0.09). Zinc supplementation in infants anemic at recruitment improved HAZ by as much as 0.22 (0.05-0.40, P=0.01) as compared to anemic infants not receiving zinc. In contrast, zinc supplementation in infants not anemic at recruitment appeared to have a negative effect on HAZ (-0.18 (-0.35-0.00), P=0.05). The same pattern emerged for iron supplementation, but was less strong. Gender and birthweight significantly affected length growth (P<0.01 for both) but did not modify the effects of iron or zinc supplementation. **Conclusion:** Although neither iron nor zinc supplementation prevented progressive growth faltering, zinc supplementation improved growth in anemic infants. However, in non-anemic infants, zinc supplementation can be counter-effective. Inconsistent effects of iron and zinc supplementation on growth may be explained by differences in anemia prevalence. Targeting anemic infants will improve effectiveness of zinc and iron supplementation programs.

Th83 EFFECT OF IRON SUPPLEMENTATION ON MENTAL AND MOTOR DEVELOPMENT IN CHILDREN: EVIDENCE FROM RANDOMIZED CONTROLLED TRIALS. HPS Sachdev, T Gera*, Maulana Azad Medical College, N Delhi and SL Jain Hospital*, N Delhi.

Background: Iron supplementation trials document variable effects on development. **Aim:** Synthesize evidence evaluating the effect of iron supplementation on mental and motor development in children. **Methods:** Systematic review of randomized controlled trials with random effects pooled estimates. **Results:** A total of 17 trials on 2827 children were identified, with no evidence of publication bias. The pooled standardized weighted mean difference (WMD) of the change in 'mental development score' (iron vs placebo) was 0.30 (95% CI = 0.15, 0.46; p<0.001; p<0.001 for heterogeneity). On sensitivity analysis, this benefit was associated with oral route, longer duration of therapy, older age (> 2 years), lower baseline hemoglobin, and presence of iron deficiency. Meta-regression showed lower baseline hemoglobin and iron deficiency to be significant predictors of a positive effect. For Bayley Mental Development Index (MDI), the pooled WMD between the iron and control groups was 0.95 (95% CI = -0.56, 2.46; p=0.217). Iron deficient anemic children showed greater improvement in MDI scores (WMD = 3.77, 95% CI = -0.50, 8.04, p=0.08). The pooled standardized WMD of the change in the IQ scores in older (>5 years) children was 0.41 (95% CI = 0.20, 0.62; p<0.001). Children with anemia (hemoglobin <11 g/dl) and iron deficiency had a greater improvement with iron supplementation, but on meta-regression these were not significant explanatory variables. The pooled estimates did not show any significant difference in the motor scores of the iron and placebo groups. Sensitivity analyses and meta-regression did not alter this inference. **Conclusions:** Iron supplementation resulted in a modest improvement in mental development in older children but there was no benefit on motor development.

Th85 A LOW-COST FORTIFIED BABY PORRIDGE IMPROVED IRON STATUS AND MOTOR DEVELOPMENT OF 6-12-MONTH-OLD INFANTS. M Faber, JD Kvalsvig, CJ Lombard and AJS Benadé. Nutritional Intervention Research Unit and Biostatistics Unit, Medical Research Council, Cape Town, and Child, Youth and Family Development, Human Sciences Research Council, Durban, South Africa.

Background: The critical period for developing childhood malnutrition coincides with the introduction of complementary foods. Porridge made with maize meal, which is a bulky food low in nutrient density, is used as complementary food in many African countries, including South Africa. A low-cost fortified maize meal baby porridge was developed with the aim to reach consumers in the lower socio-economic sector. **Objective:** To determine the effect of a low-cost fortified maize meal porridge on the nutritional status and development of infants in a rural community in South Africa. **Methods:** 6-12-month-old infants were randomly assigned to two treatment groups. Infants in the fortified group received a quick-cooking maize meal porridge that was fortified to supply, among other, 100% of the Recommended Dietary Allowance (RDA) for iron, zinc and vitamin A. Infants in the control group received the same porridge, but without the added micro-nutrients. Participants consumed the porridge daily for 6 months. Of the 361 infants who were enrolled in the study, 81% completed the study (fortified group n=144; control group n=145). Data were analysed on an intention-to-treat basis. **Results:** The micro-nutrient fortified porridge improved serum ferritin and haemoglobin concentrations. The prevalence of anaemia decreased from 45.1% to 16.7% (P=0.001) in the fortified group, while there was no significant change in the prevalence of anaemia in the control group. Motor development, as determined by parent ratings, improved in the fortified group (P=0.014). Serum retinol and zinc concentrations, growth and morbidity showed no intervention effect. **Conclusion:** With an appropriate promotion campaign, the porridge can potentially have a significant impact on reducing iron deficiency and improving the development of infants and small children in South Africa. This study was carried out with the aid of a grant from Thrasher Research Fund; Tiger Brands under Purity Baby Food Brand developed and supplied the porridge.

Th86 POSITIVE EFFECTS OF ZINC AND IRON-FOLIC ACID SUPPLEMENTATION ON TIME TO WALKING AND INFANT BEHAVIOR AMONG 5-18 MO OLD ZANZIBARI INFANTS. P. Kariger (1), D. Olney (1), R. Stoltzfus (1), S. Sazawal (2), R. Black (2), J. Tielsch (2), E. Frongillo (1), L. Allen (3), S. Khalfan (4), N. Ali (4), E. Pollitt (3). (1) Cornell Univ, Ithaca, NY, (2) The Johns Hopkins Univ, Baltimore, MD, (3) Prog in Inter Nut, Univ of CA, Davis, CA, (4) Pemba PHL-IdC, Zanzibar, Tanzania.

While there is some evidence that micronutrient supplementation during infancy is related to improved motor, social and emotional development, the findings are inconsistent. This study examined the effects of micronutrient supplementation on walking and social/emotional development in poorly nourished infants. Participants were Zanzibari infants enrolled in a double blind, randomized 2x2 factorial trial of 12 mo of daily supplementation with Zn and/or Fe+folic acid. Trained observers documented walking onset by recording infants' motor milestones bi-monthly using a 14-item scale. 16 behaviors were coded using 15 s intervals during 2-4 hr observations 5 times over the year. Treatment effects on days to walking since the first visit were examined with survival analyses. 313 infants with complete data were stratified by baseline age (mo): 5-7 (n=103), 8-9 (n=96) and 10-11 (n=114). The model covariates were sex, SES, age, baseline Hb and HAZ, and attained milestone. For the three age groups, respectively, the mean (SD) for Hb (g/L) was 94 (15), 91 (17), 91 (16) and for HAZ was -1.1 (1.0), -1.3 (1.0), -1.5 (1.1). Treatment effects varied by age. 5-7 mo olds receiving Fe+folic acid+Zn walked ~ 42 days earlier than same-aged infants receiving the placebo (p=0.029, RR=1.91, 95% CI (1.07, 3.42)). 10-11 mo olds supplemented with Fe+folic acid walked ~ 40 days sooner than those receiving the placebo (p=0.001, RR=2.83, 95% CI (1.53, 5.23)). Standard repeated-measures analyses were used to examine treatment, age, and treatmentXage effects on the developmental patterns of each social/emotional behavior. Covariates were sex, age, and baseline SES, Hb, HAZ and WHZ. 395 children had complete data. 85% were anemic and 9% were severely anemic (Hb<70.0 g/L); 38% were stunted and 5% were wasted. The sample was stratified by baseline age (mo): 5-9 (n=115), 10-14 (n=154) and 15-19 (n=126). A borderline significant treatmentXage effect was found for % time carried (p=0.059) in the youngest cohort. All children were carried less over time but declines were greatest for children receiving supplementation. These findings suggest the effects of micronutrient supplementation on development in nutritionally at-risk infants are significant and positive, but vary by age, treatment and developmental outcome. Funded by Gates Found. and USAID Ofc of Hlth & Nut.

Th88 ANEMIA RATES SIGNIFICANTLY REDUCED IN NICARAGUA. J Bonilla, A Barrera, A Largaespada, GE Navas, J Mora. USAID/MOST, Nicaragua Ministry of Health, Institute of Nutrition of Central America and Panama (INCAP).

Anemia has been a problem of public health significance in Nicaragua, where prevalence rates in 1993 averaged 34% in women of reproductive age and 31% in children. Iron intake was 10.5 mg per capita/day (6.4 mg in children). Assuming that iron deficiency accounted for most anemia, in 1994 the Ministry of Health (MOH) developed the National Micronutrient Plan which focused on three interventions for anemia control: iron supplementation of pregnant women and children under five, fortification of wheat flour with iron and B vitamins, and a communications strategy to generate demand for iron supplements and improve dietary iron intake. Supplementation policies were formulated, guidelines for health personnel prepared, and extensive training of health professionals and MOH service personnel completed. Mandatory fortification of wheat flour was established in 1997 but the iron compound used was later found to be poorly absorbed and a more bioavailable compound was introduced in October 2003. Communications efforts and educational actions were less systematically implemented. Supplementation coverage and quality gradually improved. Special efforts have been made to address existing demand and compliance constraints by involving trained community health volunteers (CHVs), locally called "brigadistas", in active counseling and follow-up. The key role of CHVs in improving program effectiveness was demonstrated in 2001 through a USAID/MOST funded rural pilot project with active non-governmental organization (NGOs) participation and anemia rates in children halved in four months. The model was initially expanded to 50 communities and then scaled-up by the MOH and NGOs nationwide. By 2003, supplementation coverage reached >80% in pregnant women and >60% in children, fortification was properly implemented, and national anemia rates dropped to 16% in women and to 23% in children. The significant progress in reducing anemia may be attributed to effective supplementation and food fortification. Further reductions in anemia rates may be achieved through improved fortification, effective management of the supplement supply and logistics system, and expanded coverage through non-traditional delivery mechanisms.

Th87 IMPLEMENTING STRATEGIC COMMUNICATION PLAN TO REDUCE ANAEMIA IN PREGNANT WOMEN IN GHANA. K Quarshie (1), R Agble (1), A Nyaku (2), (1) Nutrition Unit, Ghana Health Service, (2) MOST, The USAID Micronutrient Programme, Ghana.

Introduction: The Ghana Health Service in collaboration with the relevant stakeholders and with support from MOST/USAID has developed an integrated strategy on anaemia control targeting pregnant women, preschool children and school aged children. **Objectives:** The main objective is to reduce the prevalence of anaemia by 25% in each of the selected target groups. **Components:** The main components are: a) daily or weekly iron and folic acid supplementation for pregnant women and school aged children respectively b) twice annual deworming of school aged children c) malaria control, d) fortification of selected foods e) Promoting increased production and consumption of iron rich and vitamin C-rich foods and g) promoting good hygiene and environmental sanitation. **Operational strategies:** To implement these components, capacity building for all implementers and their managers, a sustainable Information, Education and Communication (IEC) programme, resource mobilization, collaboration, coordination and research are being pursued. **Major Activities:** a) A training manual has been developed and is being used to train health workers at regional, district and sub district level. b) A set of messages comprising a jingle and radio spots, to be used in national, regional and local FM stations have been developed. In addition, posters, public information leaflet, counseling cards, car stickers and carrier bags have been produced. These are being supported by newspaper articles, features and radio discussions on anaemia. c) The current Ghana Beauty Queen is being given orientation to enable her embark on educational campaign on anaemia control in women of child bearing age. She is scheduled to give talks in selected antenatal care facilities throughout the country. She will also be assisted to run seminars for associations of beauticians, hairdressers and dressmakers in urban centres in all regions that she visits. d) The programme has been launched by the Director General for Health Services in one of the health institutions in Accra. e) An evaluation will be carried out at the end of the campaign to assess its impact. **Conclusion:** It is expected that after a six month period, capacity of health workers would be enhanced, ante-natal services would be improved and awareness created among the general public especially pregnant women on five key behavioural objectives.

Th89 EFFECTIVENESS OF SOY SAUCE FORTIFIED WITH NAFEEDTA FOR REDUCING ANEMIA IN WEST JAVA, INDONESIA. S de Pee, M Sari, E Martini, D Foote, D Yeung, MW Bloem, Helen Keller International, Indonesia, Asia-Pacific and New York, HJ Heinz Co., Toronto, Canada.

Background: Iron deficiency anemia is a major problem in many developing countries with severe health and economic consequences. Fortification of condiments is one way to address this problem and NaFeEDTA is a very bioavailable, and therefore preferred, iron fortificant. Soy sauce is widely consumed in Indonesia and found very suitable for fortification with NaFeEDTA. The brand most widely consumed is ABC and the preferred packaging is the sachet containing 16 mL of soy sauce. **Aim:** Assessing the effectiveness of consumption of soy sauce fortified with NaFeEDTA at the highest organoleptically feasible level (16.9 mg Fe/100 mL). **Design:** Sachets containing fortified soy sauce are distributed through the normal market channels in Bandung district, West Java. Baseline data were collected in April 2003 from 600 households with underfives that were randomly sampled from 15 villages (40 households each). Hb was assessed on all underfives, their mothers and available fathers. Fortified soy sauce distribution to the warehouses started in May 2003 and market saturation at the corner shops (warung) was regularly assessed. Endline measurements of Hb will be taken in mid 2004. **Preliminary results:** Baseline data showed that 414 households consumed ABC soy sauce packed in sachets and 186 did not. These households had a total of 401 and 187 children aged 6-59 mo, with a mean Hb of 106.5 and 110.3 g/L, respectively. Average consumption of soy sauce was 1 sachet per 2 days for a family of 5 people, or 1.6-2.1 mL/adult/d and 0.8-1 mL/underfive/d. At current fortification levels, that would be equivalent to an intake of 0.34 mg Fe/adult/d or 0.17 mg Fe/underfive/d. However, the EDTA will also enhance absorption of other iron present in the meal. In August 2003, 75% of the corner shops sold fortified soy sauce. Final results, in particular on the impact on Hb of children and adults, will be available in October 2004.

Th90 **BAOBAB FRUIT PULP (ADANSONIA DIGITATA L.) IMPROVES IRON STATUS IN NIGERIAN CHILDREN.** NM Nnam. Department of Home Science and Nutrition, University of Nigeria, Nsukka.

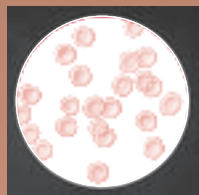
Background: In some regions of Nigeria, iron deficiency anemia rates in children are as high as 50%. Studies have shown that iron deficiency in most cases is due to low bioavailability of dietary iron rather than low intake. About 90% of the total dietary supply in Nigeria comes from plants, which contain nonheme iron that is poorly absorbed. There is need for an intervention programme, which will improve the nonheme iron bioavailability. **Aim:** To determine the efficacy of baobab fruit pulp drink as good source of vitamin C (337mg vit. C/100g pulp) to improve bioavailability of iron in diets of children. **Methods:** Three hundred school children (6-8yrs) in Nsukka rural community primary school were screened, and 142 with hemoglobin (Hb) <11g/dl were selected for the study. These subjects (142) were dewormed and divided into two equal groups of 71 children each. One group served as the control and the other as the test group. The Hb levels of the groups were comparable. The test group was fed 250ml of baobab fruit pulp drink (BFPD) after a meal based on cereal/legume/vegetable for 3 months. The other group (control) was fed the meal only for the same 3 months. The Hb and the serum ferritin (SF) of both groups were estimated before and after the intervention period. **Results:** The test group had mean Hb of 10.85g/dl at baseline and 64.79% of the subjects had SF below 12µg/L. After 3 months of intervention with BFPD, the mean Hb increased to 12.92g/dl and 22.54% of the subjects had SF below 12µg/L. The control group had slight increase in Hb (10.86g/dl vs 11.01g/dl) with no change in SF. **Conclusion:** Baobab fruit pulp is a good, cheap, natural and nutritious source of vitamin C that improved Hb of school children in Nigeria. The fruit pulp is locally available and could be incorporated into many traditional dishes to diversify diet and improve bioavailability of iron.

Th92 **REDUCED ANAEMIA THROUGH BIENNIAL DEWORMING BRINGS BRIGHTER FUTURE FOR PRE-SCHOOL CHILDREN IN NEPAL: DEWORMING IMPACT EVALUATION STUDY.** S Pandey (Ministry of Health), P Mathema, K Okamura, PO Blomquist, (UNICEF Nepal), R Shrestha (Nepal Technical Assistance Group).

Background: To address high prevalence of anaemia in pre-school children, biannual deworming of children aged 2-5 years with a single dose of Albendazole 400 mg is gradually being integrated with the national vitamin A programme. Vitamin A capsules are distributed by over 48,000 community health volunteers in April and October, with consistently high coverage over 85%. As of October 2003, deworming is covering 64 out of 75 districts, and will cover the whole nation by April 2004, reaching more than 2 million children twice a year. **Aim:** In 2003, MoH initiated an evaluation study, supported by UNICEF, to assess the impact of deworming on anaemia and helminth infection. **Methodology:** Repeated cross sectional surveys were conducted in four districts. Baseline data was collected prior to the April 2003 distribution when deworming was integrated for the first time in those districts. A mid-line survey was conducted after the April 2003 distribution, and an end-line after the October 2003 round. In each district, 30 clusters were selected by PPS method. In each cluster, 16 households were randomly selected. Helminth infection and the hemoglobin levels were assessed in 1635, 1840 and 1872 children aged 2-5 years sampled in the baseline, mid-line and end-line surveys. **Results:** The mid-line and end-line surveys showed that 86% and 87% of the targeted children had received deworming drugs. Significant reductions were seen in helminth infections after the two rounds, both in prevalence and intensity. The impact on anemia was drastic with reduction from 47% prevalence at baseline to 29% and 11% at mid-line and end-line. Mean hemoglobin increased from 11.0 g/dl at baseline, to 11.4 g/dl at midline and 12.2 g/dl at endline. **Conclusion:** Globally, deworming of pre-school children has received limited attention. Nepal's model of integrated deworming with the biannual vitamin A programme conducted by community volunteers is a cost-effective and sustainable approach to universal deworming of preschool children. Apart from initial training cost of 16 cents per child, the only recurrent cost is the cost of the drug, which is one cent per child. This study has shown dramatic impact, with anemia being reduced by 77% after only two rounds of deworming. This brings a brighter future for young children of Nepal, with considerable improvements in growth and development.

Th91 **INTEGRATED PROGRAMMING, INCLUDING HOMEBASED FORTIFICATION USING 'SPRINKLES', IS AN EFFECTIVE STRATEGY FOR ADDRESSING ANEMIA IN MONGOLIAN CHILDREN.** M Nyamsuren, C Emary, G Bat, S Gerein, S Zlotkin, M Chan. World Vision Mongolia, Nutrition Research Centre of Public Health Institute, Government of Mongolia, Ulanbataar, Mongolia, World Vision Canada, and The Hospital for Sick Children, Research Institute, Canada; Departments of Paediatrics, Nutritional Sciences, and Centre for International Health, University of Toronto, Toronto, Canada.

Problem: World Vision baseline surveys (BL) conducted in 2 different programming areas, BL1 (October 2000), and BL2 (October 2001) confirmed that anemia is a significant public health problem among Mongolian children under 5 years of age (U5). **Objectives:** To reduce the prevalence of anemia in children U5, a comprehensive nutrition program was implemented using the following strategies: 1. Prevention of anemia through home-based fortification to children 6 months to 3 years of age (40mg Fe/day, 15 months) using 'Sprinkles', a powdered micronutrient supplement. 2. Treatment of anemic children 3 to 5 years using iron syrup (25 mg/day, 3 months). 3. Capacity building. 4. Social marketing. **Design:** Baseline surveys were followed by a 3-year implementation period. Community based nutrition workers distributed 'Sprinkles', conducted household monitoring visits and facilitated community health and nutrition training. Iron syrup and iron/folate tablets were provided to anemic children 3 to 5 years of age and to pregnant/lactating women through Government health structures. Capacity building of medical personnel was accomplished through training on the diagnosis/treatment of anemia. Social marketing using multi-media campaigns raised public awareness of micronutrient deficiency. A follow-up survey was conducted in October 2003 in both baseline areas to evaluate program effectiveness. **Results:** Within BL1 and BL2 program areas respectively, the prevalence of anemia (Hb<11.5 g/dl) in children U5 decreased from 42.5% (n=1278) and 47.9% (n=1155) at baseline to 24.2% (n=964) and 25.5% (n=909) at final survey (p=0.00). Ninety percent of eligible children in the intervention areas received 'Sprinkles' supplements for a mean duration of 13 months. **Implications:** Results indicate that program strategies, including home-based fortification using 'Sprinkles', are effective for addressing anemia in children U5.



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