Report of the 2003
International Nutritional
Anemia Consultative Group
Symposium

Integrating Programs to Move Iron Deficiency and Anemia Control Forward

6 February 2003
Marrakech, Morocco

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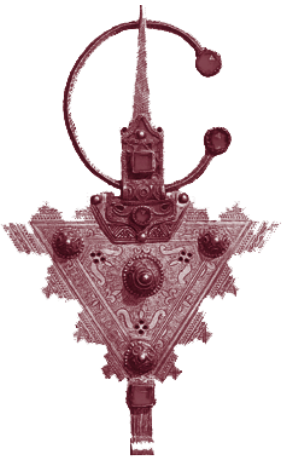
International Nutritional Anemia
Consultative Group Symposium



Integrating Programs to Move Iron Deficiency and Anemia Control Forward

6 February 2003

Marrakech, Morocco

Rapporteur:

Dr. Michael Zimmermann

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Meeting Organizers

INACG Steering Committee

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The INACG Symposium was co-hosted by INACG and the Local Organizing Committee of the Moroccan Ministry of Health and representatives of United Nations technical agencies, the private sector, multilateral agencies, and nongovernmental organizations in Morocco, with funding from the Government of Morocco. The Office of Health, Infectious Disease and Nutrition, Bureau for Global Health, U.S. Agency for International Development, and the Moroccan Ministry of Health assumed major responsibility for organizing the symposium.

The INACG Secretariat and the Local Organizing Committee gratefully acknowledge the additional contributions of the following organizations:

UNICEF

The Micronutrient Initiative

The Procter & Gamble Company

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

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)

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

Safety of Iron Supplementation Programs in Malaria-endemic Regions (1999)

Guidelines for the Use of Iron Supplements to Prevent and Treat Iron Deficiency Anemia (1998)

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)

Lutte Contre l'Anémie Ferriprive par la Technologie de Fortification Alimentaire (1992)

Lucha Contra la Anemia por Deficiencia de Hierro Mediante Tecnología de Fortificación de Alimentos (1992)

Guidelines for the Control of Maternal Nutritional Anemia (1989)

Lutte Contre l'Anémie Nutritionnelle Chez la Mere: Quelques Conseils (1990)

Pautas para el Control de la Anemia Nutricional en el Embarazo (1990)

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

Prevención 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)

Carence en Fer Chez la Femme (1983)

Deficiencia de Hierro en la Mujer (1985)

Iron Deficiency and Work Performance (1981)

Iron Deficiency in Infancy and Childhood (1979)

La Carence en Fer Chez le Nourrisson et Chez l'Enfant (1985)

Deficiencia de Hierro en la Infancia y la Niñez (1985)

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 Moroccan Ministry of Health, through the Local Organizing Committee, collaborated in the organization of the symposium and helped to generate active participation from Morocco and other countries in the region.

The INACG Secretariat gratefully acknowledges additional contributions from UNICEF, The Micronutrient Initiative, The Procter & Gamble Company, and H.J. Heinz Company.

The INACG Steering Committee at the time of the meeting was composed of Dr. John Beard; Dr. Frances R. Davidson, INACG Secretary; Dr. Lena Davidsson, INACG Steering Committee Chair; Dr. Eva Hertrampf; Dr. Marian Jacobs; Dr. Sean Lynch; and Dr. Rebecca Stoltzfus. The Steering Committee 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.

Dr. Michael Zimmermann served ably as the rapporteur for the meeting, generously offering his skills to provide a comprehensive summary of the symposium for this publication. Dr. Lena Davidsson contributed detailed review of the meeting report on behalf of the INACG Steering Committee.

Finally, the symposium would not have been a success without the active participation of the attendees. We hope the event provided a quality forum for sharing new ideas for iron deficiency and anemia control from around the world.

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

2003 INACG Symposium

Thursday, 6 February 2003

PROGRAM

6 February

0745	Registration/Exhibits Open
0815	**Welcome** Dr. Frances R. Davidson
0830	**Infectious Disease, Iron Deficiency, and Anemia Control** Chair: Dr. Lena Davidsson
0830	Keynote Address: The Killer Cycle of Infectious Anemias in Developing Countries: Hookworm, HIV-AIDS, and Malaria Dr. Peter Hotez
0900	Effect of Iron Supplementation on the Incidence of Infections in Children: A Systematic Review Dr. Tarun Gera
0920	Malaria, Iron Deficiency, and Anemia Control: An Update Dr. Jane Crawley
0935	Panel Discussion
1015	**Poster Session 1 and Break**
1130	**Update on Issues Related to Iron Deficiency and Anemia Control** Chair: Dr. Sean Lynch
1130	Iron Deficiency and the Global Burden of Disease Dr. Rebecca Stoltzfus
1145	Recent Advances in Iron Fortification Dr. Richard Hurrell
1200	Complementary Food Supplements Dr. André Briend
1215	Report from the IDPAS Working Group on Strategies to Prevent and Control Iron Deficiency in Children Less Than Two Years of Age Dr. Gary Gleason
1230	Discussion
1300	**Lunch**

Thursday, 6 February 2003 (continued)

1500	**Reducing the Prevalence of Anemia: Planning and Implementing a Strategic Communication Approach. Report from INACG Workshop, Cape Town** Chair: Ms. Pauline Kuzwayo
1500	Moving from Theory to Practice: The Role of Strategic Communication Mr. James Hyde
1520	Presentation of the Cape Town Model for Planning and Implementing a Strategic Communication Approach Mrs. Rosanna Agble
1540	Panel Discussion Dr. Abdelwahab Zerrari Mrs. Rosanna Agble Dr. Amenatou Cisse Ms. Rose Namarika
1620	Summary Ms. Pauline Kuzwayo
1630	Concluding Remarks Dr. Lena Davidsson
1700	**Poster Session 2 and Break**
1800	End of INACG's formal sessions Remove posters and exhibits

THURSDAY MORNING POSTERS*

POSTERS

6 February

** Readers can use the codes next to presentation titles to locate abstracts of the presentations beginning on page 35.*

Posters on Integrated Programs

Th1 Effective Iron Supplementation Conducted by Brigadistas in Rural Nicaragua
Dr. Josefina Bonilla

Th2 Traditional Birth Attendants Can Successfully Ensure Community-based Supplementation of Pregnant Women with Iron/Folate
Dr. Xavier Crespin

Th3 Community-based Integrated Approach Reduces Anemia in Children and Women in Ghana
Mr. Michael Neequaye

Th4 A Rapid Assessment of Iron Folate Supplementation for Pregnant Women in Ghana
Mrs. Kate Quarshie

Th5 Combined Primary Health Care Interventions for Controlling Iron Deficiency Anemia in Senegal
Dr. Gu'elaye Sall

Th6 Reaching Young Children with Deworming Medicine: Cost-Effective and Sustainable Distribution Through Biannual Vitamin A Supplementation in Nepal
Ms. Kyoko Okamura

Th7 Using Data to Advocate for Anemia Control in Cameroon
Mr. Daniel Sibetcheu

Th8 Integrated Micronutrient Program Reduces Anemia in Malawi
Ms. Kendra Siekmans

Th9 Hemoglobin Concentrations Are Increased in Indonesian Children with Vitamin A and Deworming Interventions
Dr. Sherry A. Tanumihardjo

Th10 Impact of an Integrated School-Health Program on the Prevalence of Anemia Among School Children in Rural Burkina Faso
Mrs. Marguerite Kaboré

Posters on Supplementation

Th11 Effect of Iron Supplementation on Growth of Iron-Deplete and Replete Bangladeshi Children
Dr. Tahmeed Ahmed

Th12 Iron Supplementation During Pregnancy in the Estate Sector of Sri Lanka: Is It Effective?
Prof. Sunethra Atukorala

Th13 Iron Status Alters Cognitive and Behavioral Functioning in Women During Reproductive Years
Dr. John Beard

Th14 Evaluation of Anaemia Among Pregnant Women in Doukkala Region in Morocco
Dr. Salwa Belgnaoui

THURSDAY MORNING POSTERS (continued)

Th15 Multi-Micronutrient Supplementation in Vietnamese Infants
Dr. Francis Delpeuch

Th16 School Participatory Approach for Iron Supplementation Program Using A Social Marketing Strategy
Dr. Naffisa Eid

Th17 Improving Compliance to Iron Pill of Pregnant Women: The Importance of Husband Role
Dr. Hamam Hadi

Th18 Efficacy of Multi-Micronutrient and Single Iron Supplementation on Nutritional Status and Morbidity of Indonesian Infants
Ms. Lindawati Wibowo

Th19 Weekly Preventative Iron-Folate Supplementation for Women and School Girls of Reproductive Age in Cambodia
Dr. Kevanna Ou

Th20 Maternal Iron Deficiency Anaemia Alters Mother-Infant Interaction and Infant Development
Dr. Eva Perez

Th21 An Action Research to Control and Prevent Iron Deficiency and Iron Deficiency Anemia in Women of Reproductive Age in a Factory in Thailand
Mrs. Utoomporn Sittisingh

Th22 Multi-centre Study on Multi-micronutrient Supplementation in Small Children: South African Experience
Dr. Cornelius M. Smuts

Th23 Weekly Preventative Iron-Folate Supplementation in Women of Reproductive Age Working in Cambodia
Mr. Dara Touch

Th24 Cost-Effectiveness of an Iron Supplementation Program for Women and Children in a Rural District of Vietnam
Dr. Le Thi Chi Phuong

Th25 Zinc and ß-Carotene Added to Iron Supplementation During Pregnancy Improves Birthweight and Morbidity of Infants
Dr. Frank T. Wieringa

Posters on Infectious Diseases

Th26 Prevalence of Subclinical Inflammation as Indicated by Elevated Serum Alpha-1 Acid Glycoprotein (AGP) and Implications for Iron Status Assessment in Nicaraguan Children
Dr. Namanjeet Ahluwalia

Th27 Iron Status of Malaria Patients in Douala Town
Dr. Inocent Gouado

Th28 Anemia Among HIV Infected and Uninfected Post Partum Women: Prevalence and Health Implications
Dr. Jean H. Humphrey

POSTERS

6 February

THURSDAY MORNING POSTERS (continued)

POSTERS

6 February

Th29 Determinants of Anemia Among Mothers and Children in a Low-Income Population of the Bolivian Lowlands as Guides to Developing Community Interventions
Ms. Gwen Ellen O'Donnell

Th30 *Helicobacter Pylori* Infection, Gastric Acid Secretion, and Iron Absorption in Bangladeshi Children
Dr. Shafiqul Alam Sarker

Th31 Parasitic Infection and Anemia in School Aged Children in Maceió, Brazil
Dr. Leonor Maria P. Santos

Posters on Dietary Modifications

Th32 Iron Nutrition in Morocco: Intakes, Sources and Bioavailability
Prof. Larbi Alaoui

Th33 A Food-based Approach to Improve Iron Status in Egyptian Children
Dr. Osman M. Galal

Th34 Dietary Intake of Bioavailable Iron in Mexican Children 12 to 59 Months of Age
Dr. Christine Hotz

Th35 Iron Bioavailability from Root Nodules of Soybean (GLYCINE MAX)—Evaluation in a Rat Hemoglobin Regeneration Bioassay
Ms. Amy Proulx

Th36 Home-based Diversified Complementary Foods as a Means to Address Anemia and Growth Faltering in a Developing Country
Dr. Nigar Sultana

Th37 Iron Availability from Brown Rice and Iron-fortified Instant Noodles
Dr. Trinidad P. Trinidad

Posters on Reproductive Health

Th38 Acceptability of Daily Iron+Folate vs Multiple Micronutrient Supplements by Malian Pregnant Women
Dr. Victor M. Aguayo

Th39 Multiple Nutrient Supplementation in Pregnant Anaemic Women
Dr. Samuel Koranteng Ameyaw

Th40 High Prevalence of Low Hemoglobin Concentration Among Indonesian Infants Aged 3-5 Months Is Related to Maternal Anemia
Dr. Saskia de Pee

Th41 Self-reported Menstrual Losses Predict Iron Status in Premenopausal U.S. Women
Dr. Janet R. Hunt

Th42 The Relationship Between Timing of Clamping of the Umbilical Cord at Birth and Iron Status at 6 and at 10 Months of Age
Dr. Julia Kilbride

THURSDAY AFTERNOON POSTERS

Posters on Assessment

Th43 Dietary Intake and Iron Status (Using Soluble Transferrin Receptor Assay) of Pregnant Mothers in a Fishing Community in Sri Lanka
Dr. Jaanaki Gooneratne

Th44 Are Haemoglobin and Haematocrit Interchangeable Indicators of Anaemia Prevalence in Australian Aboriginal Adolescents?
Dr. Dorothy Mackerras

Th45 An Improved Method for Assessing Transferrin Receptor in Whole Blood Spots
Dr. Thomas W. McDade

Th46 Associations Between Iron (Fe) and Zinc (Zn) Status
Dr. Harold Sandstead

Th47 Mathematical Modelling to Predict Population-based Response to Micronutrient Interventions
Ms. Claudia Schauer

Th48 Use of Capillary Blood to Assess Iron Status in Rural Kenya: Combined Measures of TFR, ZPP:H, HB, and CRP
Dr. Bettina Shell-Duncan

Th49 Assessment and Application of a Simple Test to Detect Anemia in Developing Countries
Prof. Clive E. West

Th50 A Novel Stable Isotope Approach to Measure Erythrocyte Iron Mass During Pregnancy
Dr. Thomas Walczyk

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Th51 Concurrent Iron and Micronutrient Deficiencies in Filipino Schoolchildren With Normal and Deficient Iodine Status: The Need for Combined Interventions
Prof. Sofia V. Amarra

Th52 National Survey on Anaemia Morocco 2000
Mr. Mustapha Azelmat

Th53 Interaction Between Iodine and Iron Deficiencies: Evaluation of Fortification Strategy of Salt with Iodine in Morocco
Ms. Imane Bahbouhi

Th54 Estimation of Bioavailability of Dietary Iron and Iron Status in Women from an Agricultural Region of Morocco
Dr. Rekia Belahsen

Th55 Prevalence of Anaemia Among Schoolchildren of Sri Lanka, 2001-02
Dr. Renuka Jayatissa

Th56 Pattern of Anaemia in Children Under Five Years in Sri Lanka
Dr. A.M.A.S.B Mahamithawa

POSTERS

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THURSDAY AFTERNOON POSTERS (continued)

POSTERS

6 February

Th57 Anemia in Guinea: A Severe Public Health and Social Development Problem. Can It Be Controlled Through a Programmatic Focus on Adolescent Girls?
Ms. Lina Mahy

Th58 Prevalence of Anaemia Among Infants Aged 4-12 Months in Kilosa District in Rural Tanzania
Mr. Peter S. Mamiro

Th59 Anemia in Adolescent Schoolgirls in Rural Mozambique: A Cross-sectional Survey
Mr. Stephan Meershoek

Th60 Assessment of Anaemia Status of Sri Lankans
Dr. Chandrani L. Piyasena

Th61 Anemia in Morocco: The Case of the Khenifra Region in the Middle Atlas
Ms. Meryem Raksi

Th62 Prevalence of Hemoglobinopathy Among Anaemic Children in Northeast Brazil
Dr. Patricia H.C. Rondo

Th63 Prevalence of Anemia Among Children and Pregnant Women in Mongolia
Dr. Mungun Tuya

Posters on Food Fortification

Th64 Stability of Iron Fortified Rice (IFR) Packed in Four Types of Packaging Materials
Dr. Mario V. Capanzana

Th65 Development of Iron and Vitamin A Fortified Table Sugar: The Philippine Experience
Dr. Mario V. Capanzana

Th66 Process Evaluation of the Distribution of Micronutrient Sprinkles in Over 10,000 Mongolian Infants Using a Non-governmental Organization (NGO) Program Model
Ms. Claudia Schauer

Th67 The Effect of Retinol Added to Iron Fortified Corn Porridge on Erythrocyte Incorporation of Iron in African Children with Sub-clinical Vitamin A Deficiency
Dr. Lena Davidsson

Th68 Influence of Na2EDTA on Iron Absorption from Ferrous Fumarate and Ferrous Sulfate Fortified Infant Cereal
Ms. Meredith C. Fidler

Th69 High Relative Bioavailability of Encapsulated Ferric Pyrophosphate with Reduced Particle Size (SunActiveFe®)
Ms. Meredith C. Fidler

Th70 Elemental Iron Powder Used for Food Fortification: Does Physicochemistry Predict Bioavailability?
Dr. Janet R. Hunt

THURSDAY AFTERNOON POSTERS (continued)

Th71 A New Concept of Ferric Pyrophosphate Fortification in Foods (SunActive Fe®)
Dr. Lekh Raj Juneja

Th72 Community-based Fortification of Maize Flour at Village Mills in Tanzania
Mr. Bernard Kindoli

Th73 Iron Containing Multiple Vitamin and Mineral Fortified Powder Drink: Bioavailability, Stability and Product Acceptance Evaluation
Dr. Haile Mehansho

Th74 The Contribution of Iron from a Multi-Micronutrient-fortified Condiment Spread to the Total Dietary Iron from Main-Dish Recipes of Urban and Rural Low-Income Guatemalan Households
Dr. Monica Orozco

Th75 Comparison of Dosing Frequency and Safety of Sprinkles on Iron Status in Preschool Children in Northern China
Ms. Claudia Schauer

Th76 Iron Absorption from Intrinsically Labeled Microencapsulated Ferrous Fumarate (Sprinkles) in Anemic and Non-anemic Infants
Dr. Melody Tondeur

Th77 The Effect of Bread Fortified with Ferrous Bisglycinate or Reduced Iron on the Iron Status of Young Schoolchildren
Dr. Martha E. Van Stuijvenberg

Th78 KAP Study About Fortified Food: Use and Promotion
Dr. Abdelwahab Zerrari

Th79 Dual Fortification of Salt with Iodine and Encapsulated Iron: A Randomized, Double Blind, Controlled Trial in Moroccan Schoolchildren
Dr. Michael Zimmermann

POSTERS

6 February

2003 INACG Symposium, 6 February 2003, Marrakech, Morocco

International Nutritional Anemia Consultative Group

The International Nutritional Anemia Consultative Group (INACG) held its third international symposium in Marrakech, Morocco, on 6 February 2003. Nearly 675 policy makers, program managers, and scientists from over 70 countries participated in the symposium, which explored "Integrating Programs to Move Iron Deficiency and Anemia Control Forward."

Welcome

In opening the symposium and welcoming the attendees, Dr. Frances R. Davidson, Secretary of INACG, recalled that at the previous INACG meeting, held two years earlier in Hanoi, Vietnam, she had commented on the isolation of the scientific community working on iron deficiency and iron deficiency anemia (IDA) and the lack of communication between fields that have an important impact on each other, including infectious diseases, vitamin A deficiency, and iron deficiency and IDA. She was pleased to acknowledge the progress that has been made since then, particularly in documenting the causes and the extent of anemia and the development and evaluation of innovative programs to control anemia, as well as the greater connections between basic scientific knowledge and ongoing country programs.

Dr. Davidson emphasized that the focus of the symposium was on integrating programs of iron deficiency and anemia control into larger health care programs, such as programs for controlling malaria, helminthic infections, and vitamin A deficiency, in order to create synergies. She contrasted, on the one hand, the ease, at both the policy and community levels, of delivering vitamin A supplementation and the recognized benefits of correcting vitamin A deficiency with, on the other hand, the difficulties of controlling anemia because of its complexity and its opaque impact on populations. However, she was encouraged by the recent development of innovative intervention programs and new data on the potential of food fortification, which could have a significant impact on efforts to correct iron deficiency.

In closing, Dr. Davidson cited INACG's mission statement: "The purpose of INACG is to guide international activities aimed at reducing nutritional anemia in the world. INACG offers consultation and guidance to various operating and donor agencies that are seeking to reduce the prevalence of IDA and other nutritionally preventable anemias." She reminded attendees that this INACG symposium was an important part of ongoing INACG activities related to its mandate, which includes sponsoring international meetings to analyze issues related to the etiology, treatment, and prevention of nutritional anemias in order to aid in the establishment of public policy and action programs.

All contents and ideas 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.

Infectious Disease, Iron Deficiency, and Anemia Control

Keynote Address: The Killer Cycle of Infectious Anemias in Developing Countries: Hookworm, HIV-AIDS, and Malaria

Dr. Peter Hotez, of George Washington University and the Sabin Vaccine Institute, in Washington, D.C. (USA), noted that anemia has an important global impact on worker productivity, child mortality, maternal mortality, and child development but that the role of infectious agents in these processes is largely underappreciated. Three major infectious diseases, he said — hookworm, malaria, and HIV-AIDS — stand out for their important link to anemia-related disease burdens. These infections induce anemia by different mechanisms: hookworm causes IDA (Stoltzfus et al. 1997), malaria causes hemolytic anemia (Guyatt and Snow 2001, Steketee et al. 2001), and HIV-AIDS causes dyserythropoiesis (Moore et al. 2000). New evidence suggests that hookworm may promote susceptibility to HIV-AIDS and that HIV-AIDS promotes susceptibility to malaria. In many parts of the developing world, individuals may have all three types of infection-related anemia.

Anemia is now considered an independent risk factor for early death from HIV-AIDS. For patients whose hemoglobin concentration is below 9 g/dL, the likelihood of death is five times greater than that for patients with higher concentrations (Cox proportional hazards analysis), and recovery from anemia is associated with a 40% reduction in the likelihood of death (Moore et al. 2000). Similarly, *Plasmodium falciparum* malaria–related anemia in childhood is increasingly recognized for its contribution to pediatric mortality; it kills more children than cerebral malaria does, and twice as many as IDA does. An estimated 50 million pregnancies in malaria-endemic areas are associated with 75,000 to 200,000 infant deaths, primarily the result of intrauterine growth retardation (IUGR) and low birth weight. New evidence suggests that the hemolytic anemia from malaria during pregnancy may result in folate deficiency caused by compensatory erythropoiesis, eventually leading to IUGR.

Hookworm-induced IDA is the direct result of blood loss caused by the blood-feeding behavior of adult hookworms in the intestine. At their intestinal attachment site, adult hookworms produce a battery of pharmacologically active mediators that allows them to feed on host blood, including factor Xa and VIIa/TF inhibitors, hemoglobinases, and platelet anti-aggregating agents. However, whether anemia develops in patients infected with hookworm is related to their iron intake and iron stores as well as the intensity of the infection and the species of the hookworm (either *Necator americanus* or *Ancylostoma duodenale*). Studies conducted in regions with iron-poor diets in East Africa and in Nepal demonstrate a linear relationship between anemia and hookworm burden, which is typically measured by quantitative fecal egg counts (Stoltzfus et al. 1997). Hemoglobin concentration decreases by 5 g/L for every 2,000 eggs per gram in women and children, and 8 g/L for every 2,000 eggs per gram in men. Hookworm infection in these regions accounts for up to 57% of moderate to severe anemia among schoolchildren and 41% among pregnant women. Thus hookworm is a significant maternal and child health problem.

The important effect of hookworm infection on IDA among schoolchildren and the potential impact of IDA on cognitive and intellectual potential have stimulated a great deal of interest in focusing control program interventions on this age group. Such programs frequently rely on periodic deworming in the schools, using benzimidazole anthelminthics (albendazole or mebendazole). However, studies conducted by Dr. Hotez's group in 1998 in China and Brazil indicate that, unlike other soil-transmitted helminthic infections, such as those caused by *Ascaris* and *Trichuris,* hookworm burdens are highest among adult populations. In Hainan, Sichuan, and elsewhere in southern China, for example, the highest prevalence and intensity of hookworm infection were found among the elderly (Gandhi et al. 2001, Bethony et al. 2002). The mechanisms underlying susceptibility to hookworm infection in adulthood are under investigation. The data also suggest an active immunosuppression mechanism caused directly by hookworms, which may increase susceptibility to HIV-AIDS and other intercurrent viral infections. Hookworms release substances that may promote immunosuppression, including molecules that block host natural killer cell and granulocyte function. Studies are needed to examine the impact of hookworm on susceptibility to HIV and malaria as well as to evaluate whether hookworm infection might block the effect of anti-HIV or antimalaria vaccines.

Dr. Hotez discussed current attempts to develop a hookworm vaccine. Natural infection with hookworm does not appear to elicit protective immunity against the parasite. Thus, individuals treated for hookworm infection are susceptible to reinfection, and it is difficult to sustain hookworm control through widespread use of anthelminthic drugs. Even though studies indicate that anthelminthic treatment can increase hemoglobin concentration, in many parts of the world reinfection occurs so quickly that the beneficial effect is transient. As an alternative approach to hookworm control, an initiative is under way to genetically engineer a recombinant vaccine for hookworm (Hotez et al. 2003a,b). Experiments with laboratory animals indicate that vaccine immunity can be produced either with attenuated larval vaccines and their associated secreted antigens or with antigens derived from the alimentary canal of adult blood-feeding parasites. Among the antigens discovered, cloned, and expressed from the third-stage infective larvae of *Ancylostoma duodenale* and *Necator americanus* are the macromolecules secreted by the parasite when it enters the host. These include *Ancylostoma*-secreted protein 1 (ASP-1) and

ASP-2, two cysteine-rich secretory proteins belonging to the pathogenesis-related protein superfamily (Hotez et al. 2003a,b), a zinc metalloprotease of the astacin family (Zhan et al. 2002), and a transthyretin. Among the adult hookworm antigens are hemoglobinases of the aspartic, cysteinyl, and metalloprotease families. The proteases immunolocalize (bind specifically) to the alimentary canal of the adult hookworms, where they may function as hidden antigens.

Attempting to prepare a vaccine has required a reengineering of the hookworm vaccine antigens in yeast. One hurdle in this effort has been the relatively poor immunogenicity (capacity to promote an immune response) of some of these antigens using usual adjuvants (substance added to enhance the antibody response to the antigen). However, reformulation of the lead candidate hookworm antigens using new-generation adjuvants offers some hope of eliciting immune responses that can reduce hookworm load or hookworm-associated blood loss.

The development of an antihookworm vaccine, Dr. Hotez concluded, would help reduce the requirement for periodic deworming with benzimidazole anthelminthics and might also help in reconstituting host immunity against intercurrent infectious diseases such as HIV-AIDS and malaria. A hookworm vaccine might also reduce rates of IDA in tropical developing countries.

Effect of Iron Supplementation on the Incidence of Infections in Children: A Systematic Review

Dr. Tarun Gera, of Sunder Lal Jain Hospital, in New Delhi, India, discussed the effect of iron supplementation on pediatric infection rates. Given the current interest in enhancing iron intake early in life, the safety of such interventions needs to be established, and in this context the role of iron in resistance to infectious morbidity is controversial.

Objective data on the effects of iron supplementation from longitudinal studies is mixed; trials have demonstrated either reduced infectious morbidity, no effect, or an increase in infectious morbidity. Because children — particularly infants and those residing in developing countries — are vulnerable to infectious diseases, it is important to establish the safety of iron supplementation in this population on a public health scale. Dr. Gera and coauthor Dr. H.P.S. Sachdev conducted a systematic review and meta-analysis to determine the effect of iron supplementation on infectious morbidity (Gera and Sachdev 2002).

The criteria for inclusion in the review were threefold. First, studies had to be randomized placebo-controlled trials, with the exception of studies in which iron supplementation was administered parenterally, in which case randomized non-placebo-controlled trials were eligible because of the difficulty of using a similar placebo. Second, iron supplementation for the intervention group had to be given orally or parenterally, or in the form of iron-fortified formulas or cereals. Third, morbidity with one or more infectious diseases had to be an evaluated outcome measure of the study. Studies in which other micronutrients and drugs were administered simultaneously were included if the only difference between the study and control groups was iron supplementation.

Medical databases were searched to identify eligible studies, including MEDLINE, the Cochrane controlled trials register, EMBASE, IBIDS, and HealthSTAR. In addition, the reference lists of identified articles were reviewed along with manual searches of reviews, bibliographies in books, and abstracts and proceedings of international conferences and meetings. Donor agencies, known specialists, and authors of recent iron supplementation trial reports were contacted and queried about their knowledge of any additional or ongoing trials. To avoid publication bias, both published and unpublished trials were included. Quality assessment of the trials was performed with standard criteria.

Subset analyses, specified in advance, were conducted for methodological quality, case detection (active field based or passive facility based), case definition specificity, route of administration (parenteral or oral supplement, or food fortification), duration of supplementation, type of morbidity (gastrointestinal, respiratory, malaria, non-diarrheal, or others), and hemoglobin concentration at the beginning of the study in the group that received supplementation. (Subset analysis of the supplementation dose was planned but could not be performed because dosages could not be extracted for all studies.)

Twenty-eight studies were included in the review (22 published and six unpublished),

providing data on 7,892 subjects followed up for 5,651 child-years — 4,027 children and 2,802 child-years in the group that received iron supplementation and 3,865 children and 2,849 child-years in the placebo group. The pooled estimate of the incidence rate ratio (IRR) (iron versus placebo) for all the recorded morbidities was 1.02 (95% confidence interval [CI], 0.96 to 1.08), which was not statistically significant (p=0.54). This means that the relative risk of the iron-supplemented group getting an infection when compared with the control group was 1.02. From the public health perspective, the incidence rate difference (IRD) is considered more informative. The IRD (iron minus placebo) for all the recorded morbidities was 0.06 episodes per child-year (95% CI, –0.06 to 0.18, p=0.34). Incidence rate difference reflects the difference in the incidence of infectious morbidities per child year between the two groups, i.e., iron minus placebo.

Stratified analysis for the effect on individual infectious morbidities revealed that the risk (IRR) of contracting diarrhea was 11% higher for the iron supplementation group (95% CI, 1% to 23%, p=0.04). The effect on other individual morbidities was not statistically significant. However, the IRD for diarrhea was 0.05 episodes per child-year (95% CI, –0.03 to 0.13, p=0.21). The studies did not evaluate the microbiological profile of diarrhea to determine an infectious etiology. Dysentery can be equated with severe infectious diarrhea, but only two studies provided information on dysentery, and these revealed no difference in the incidence between the two groups. Future research should use microbiological evidence to examine the effect of iron supplementation on diarrheal disease.

In the trials that reported the prevalence of smear-positive malarial parasitemia, the pooled odds ratio of smear-positive malarial parasitemia at the end of the supplementation period (using the random effects model) was 1.43 (95% CI, 1.08 to 1.91, p=0.014). A meta–regression analysis of the trials that provided relevant data indicated that this treatment effect was significantly associated with the baseline smear positivity (for a unit increase in log odds ratio of baseline smear positivity, the treatment effect increased by 2.89; 95% CI, 1.37 to 6.10, p=0.005) but not with iron supplementation (1.24; 95% CI, 0.98 to 1.57, p=0.076).

Thus the results of the study indicate that, on average, iron supplementation did not significantly increase the overall risk of infection (IRR=1.02, p=0.54; IRD=0.06 episodes per child-year, p=0.34). An increase in the risk of developing diarrhea was observed (IRR=1.11; 95% CI, 1.01 to 1.23; p=0.04), but it did not translate into a significant public health problem (IRD=0.05 episodes per child-year; p=0.21). The occurrence of other morbidities and malarial smear positivity (adjusted for baseline smear positivity) was not significantly affected by iron supplementation.

Although it was not possible to analyze the dose effect of iron supplementation on the incidence of infections, the near absence of any significant adverse effects, particularly diarrhea, among children who received iron-fortified foods raises the possibility of a dose-related effect. Interestingly, this stratified analysis also suggested a significant protective effect against respiratory tract infections (four studies; IRR= 0.92; 95% CI, 0.86 to 0.98). Low-dose iron fortification is closest to the physiological situation and could be considered the safest public health intervention.

Malaria, Iron Deficiency, and Anemia Control: An Update

Dr. Jane Crawley, of Roll Back Malaria, World Health Organization (WHO), in Geneva, Switzerland, began by reminding attendees that in tropical and subtropical regions of the world, anemia is almost always multifactorial in origin. Although malaria plays a key etiological role in endemic countries, it is clear that nutritional deficiencies, intestinal helminths, HIV infection, and hemoglobinopathies also make important contributions. It is essential, therefore, for anemia control programs to use integrated, broad-based approaches.

Over 40% of the world's population, mostly those living in the world's poorest countries, are at risk of malaria. Each year, some 300 to 500 million clinical cases of malaria lead to more than 1 million deaths, of which over 75% are African children under age five infected with *Plasmodium falciparum* (Snow et al. 1999). Malaria accounts for one of every five childhood deaths in Africa, and at least half of these deaths are caused by severe malarial anemia. Pregnant women are also at high risk of severe anemia in malaria-endemic regions of Africa, and placental parasitemia is an important cause of low birth weight.

The clinical pattern of malaria varies according to transmission intensity. In areas of stable malaria transmission, infection occurs throughout the year, but with peaks following the rainy seasons. Infants are vulnerable to malaria from the age of about 4 months, when acquired immunity from the mother has worn off, and in these regions severe disease and almost all deaths are seen in children between the ages of 6 months and 3 years. With the development of acquired immunity, most individuals over age five will no longer be at risk of severe disease or death. Infected adults may present with mild symptoms such as headache and fever, or remain asymptomatic and provide a reservoir of infection for subsequent transmission to non-immune individuals. Immunity to malaria is impaired in pregnancy, particularly in first-time pregnancies, and pregnant women in areas of stable transmission frequently have asymptomatic infections that go untreated, leading to severe anemia and placental parasitemia. This pattern is seen throughout many parts of sub-Saharan Africa and accounts for the great majority of deaths from malaria.

In areas of unstable, seasonal transmission, as occurs in some parts of Africa and much of Southeast Asia, malaria transmission occurs intermittently. Consequently, adults as well as children can have severe disease. In these settings, pregnant women are not immune and thus are prone to severe disease and death, and the risks of abortion, premature delivery, and stillbirth are elevated.

The pathogenesis of malarial anemia is complex, involving both increased destruction and decreased production of red blood cells (RBCs). Increased RBC destruction is caused by hemolysis and splenic clearance of both infected and uninfected RBCs, and decreased RBC production results from cytokine-induced suppression of erythropoeitin production (Menendez et al. 2000). Repeated episodes of malaria (either from reinfection or from inadequate clearance of parasitemia because of antimalarial drug resistance) exacerbate anemia caused by nutritional deficiencies or hookworm infection, causing a progressive fall in hemoglobin concentration and leading eventually to life-threatening anemia and severe metabolic acidosis (English et al. 1996). In this situation, blood transfusion can be life saving, but it is also associated with an increased risk of HIV and other blood-borne diseases (Lackritz 1998).

Clearly, it is important to intervene before this situation arises.

Insecticide-treated bed nets (ITNs) and intermittent preventive treatment (IPT) for pregnant women have been shown to reduce the risk of both malaria and anemia, and they now form part of the malaria control strategy of many African countries. Antimalarial drug resistance is spreading rapidly in Africa, a factor that exacerbates anemia (Bloland et al. 1993); it is essential to ensure that all episodes of clinical malaria are promptly treated with an adequate dose of an effective antimalarial drug. ITNs have been shown in controlled trials to reduce mortality by all causes in children under age five by 17%, which translates to the saving of six lives per year for every 1,000 children protected by ITNs (Lengeler 2000). A social marketing program for ITNs in southern Tanzania demonstrated a protective efficacy of 62% on the prevalence of parasitemia in children under age two, and of 63% on hemoglobin levels below 8 g/dL (Abdulla et al. 2001). Use of ITNs by pregnant women reduced episodes of hemoglobin levels below 8 g/dL by 47%, placental malaria by 23%, and low birth weight by 28% in a controlled trial in a high-transmission setting in western Kenya (ter Kuile et al. 2003).

IPT in pregnancy involves the administration of a curative dose of an effective antimalarial drug at predefined intervals. The drug is given presumptively, not on the basis of clinical symptoms, since asymptomatic placental parasitemia is common in areas of stable malaria transmission. The administration of a single dose of sulfadoxine-pyrimethamine in the second and third trimesters of pregnancy was shown in two controlled studies in Kenya to reduce maternal anemia (defined as a hemoglobin level below 8 g/dL at 34 weeks) by 39% (Shulman et al. 1999), placental malaria by 56%, and low birth weight by 43% (Parise et al. 1998). In both studies, sulfadoxine-pyrimethamine appeared safe and well tolerated.

Might a similar approach benefit infants? Dr. Crawley described a randomized controlled trial in southern Tanzania in which malaria chemoprophylaxis with once-weekly administration of Deltaprim (3.125 mg pyrimethamine plus 25 mg dapsone) to infants aged 2–10 months reduced episodes of malaria by 60% and episodes of anemia (defined as a packed cell volume below 25%) by 57% (Menendez et al. 1997).

However, a rebound increase in the number of episodes of malaria and anemia was observed in the 11-month period after chemoprophylaxis was discontinued, which raised the question of whether intermittent preventive treatment could have a beneficial effect on malaria and anemia without the rebound effect. The same investigators went on to demonstrate that a single dose of sulfadoxine-pyrimethamine given to infants at 2, 3, and 9 months of age, in conjunction with routine Expanded Programme on Immunization (EPI) vaccinations, reduced episodes of clinical malaria by 60% and episodes of anemia (packed cell volume below 25%) by 50% during the first year of life (Schellenberg et al. 2001). Similar results were obtained in a study in northern Tanzania using the antimalarial drug amodiaquine (Massaga et al. 2003). Dr. Crawley cautioned that although these are promising findings, a number of important questions remained unanswered: Will infant IPT work in other epidemiological settings? Is it safe? Might it have an adverse impact on serological responses to EPI vaccines or on the development of malarial immunity? Is it operationally feasible and cost-effective? Such questions need to be answered before IPT in infants can form part of national malaria control policies.

Dr. Crawley spoke briefly about iron supplementation in infancy. In areas of intense malaria transmission, the prevalence of anemia is particularly high in infants under 12 months of age. A community-based study from southeastern Tanzania revealed that 40% of infants between the ages of 1 and 5 months and 59% of infants aged 6 to 11 months had hemoglobin levels below 8 g/dl (Schellenberg et al. in press). The efficacy and safety of providing targeted iron supplementation (2 mg/kg/day between 2 and 6 months) was assessed as part of a randomized controlled trial that used a 2 by 2 factorial design to assess the impact of iron, malaria chemoprophylaxis, both, or neither on the incidence of malaria and anemia in infants (Menendez et al. 1997). The prevalence of iron deficiency in this group was below 1% at 2 months and rose above 30% by 12 months (Menendez C, Schellenberg D, Quinto LL, et al., unpublished data, 1995). Iron supplementation reduced anemia (packed cell volume below 25%) by 32% and was not associated with an increase in episodes of malaria. Compliance, as judged by the proportion of infants finishing the full course of iron supplementation, appeared good. The follow-up of this study group has proved particularly interesting, since a consistently lower proportion of those who received iron supplementation in infancy subsequently developed episodes of anemia in the three-year period following supplementation. This has important programmatic implications, since it introduces the possibility of providing a period of targeted iron supplementation in infancy, which could provide sustained benefit.

Dr. Crawley then discussed the targeted delivery of interventions against anemia. Full advantage should be taken of routine points of contact with health services, such as antenatal clinics and EPI. Antenatal clinic attendance exceeded 70% in 20 of 28 African countries that recently underwent a Demographic and Health Survey (DHS), and EPI coverage, although variable, reaches 60% in the majority of African countries. Although it is important to avoid overloading the system, both facilities could be used for the delivery of IPT, ITNs, prepackaged antimalarial drugs for emergency use at home, micronutrient supplementation, and dietary advice. This combined approach might have the additional advantage of increasing attendance at these routine points of contact with health services.

Antimalarial strategies have been shown to reduce episodes of malaria and anemia in infants, young children, and pregnant women. The challenge now, Dr. Crawley said, is to ensure that they are delivered through sustainable systems and as part of integrated control programs that address the wide range of additional factors that cause anemia in especially vulnerable groups.

Panel Discussion

Dr. Lena Davidsson, leading the panel discussion, began by asking Dr. Hotez to comment on the time frame for the development of the hookworm and malaria vaccines. Dr. Hotez said he was 18 to 24 months from launching human phase 1 trials with a candidate antigen from the larval stage. The trials will probably be conducted in Brazil or China. Malaria vaccine trials are already under way, using a vaccine antigen that corresponds to sporozooite antigens, and the results thus far are promising. A consistent problem in vaccine development, he said, is that infections with HIV, malaria, and hookworm generate little acquired resistance, and this low immunogenicity necessitates the development and use of a new generation of adjuvants.

Dr. Gera was asked whether oral iron supplementation given during malarial infection could provide a source of iron for the parasites, and whether there is any risk in giving oral iron to HIV-positive children. He said that the review he conducted did not include studies with sick children, and none of the study groups included subjects with HIV-AIDS, so the meta-analysis did not provide any information on these issues. Dr. Clive West, of Wageningen University, commented that a recent placebo-controlled trial of iron together with antimalarials had produced a good hemoglobin response without an increase in the risk of malaria, so he felt that the evidence is leaning towards the safety of these regimens in children with malaria.

Dr. Sean Lynch, of Eastern Virginia Medical School, wondered if there is any reason to believe that iron deficiency is protective against malaria, to which Dr. Gera replied that there is no clear evidence at this time. Dr. Lynch also asked whether an increase in baseline parasitemia with iron supplementation would have any clinical significance. Dr. Gera said that eight of the studies in his review looked at malarial parasitemia at the end of the supplementation period, and they did find an increase after supplementation, but after baseline malarial positivity was adjusted for, there was no longer a significant increase.

In response to a question from the audience, Dr. Hotez said that it is unknown whether treatment of hookworm can reduce the risk of HIV transmission, although a study in Ethiopia has suggested that in persons co-infected with hookworm and HIV, the reduction in CD4 cells progresses more rapidly than in those who do not have hookworm.

A member of the audience wondered about integrated management of childhood illness (IMCI), which had not been mentioned in the presentations. Dr. Crawley noted that, indeed, IMCI programs have been adopted in many sub-Saharan countries and could be a key platform for promoting anemia control for children and infants.

Another member of the audience remarked that hunger has been described as a weapon of mass destruction and asked if malaria, which kills a large number of children each year in Africa, can be similarly characterized. Dr. Hotez agreed that the current situation is a moral outrage, considering that we live in a period of great global prosperity. He expressed concern that expensive new vaccines may not be affordable in the poorest, most affected countries. But many children still die from diseases for which vaccines are inexpensive and readily available, such as those for pertussis and measles, because of limited access. We are living in a time when our technology has outpaced our social, economic, and political institutions, he said, and rectifying this will be a major challenge in the 21st century.

Update on Issues Related to Iron Deficiency and Anemia Control

Iron Deficiency and the Global Burden of Disease

Dr. Rebecca Stoltzfus, of Cornell University, in Ithaca, New York (USA), discussed the burden of disease caused by iron deficiency. Although iron deficiency is considered one of most prevalent forms of malnutrition, no consensus has been reached about the nature and magnitude of the health consequences of iron deficiency in populations. Dr. Stoltzfus presented new estimates of the public health importance of IDA, which were made as part of the Global Burden of Disease (GBD) 2000 project (Stoltzfus et al. 2003, Ezzati et al. 2002).

Iron deficiency contributes to death and disability as a risk factor for maternal and perinatal mortality as well as through its contributions to cognitive impairment, decreased work productivity, and death from severe anemia. Based on meta-analysis of observational studies, mortality risk estimates for maternal and perinatal mortality were calculated as the decreased risk in mortality for each 1 g/dL increase in mean hemoglobin concentration during pregnancy. On average, globally, 50% of the anemia was assumed to be attributable to iron deficiency.

Population figures and anemia prevalence data, provided by WHO, are presented in Table 1 for the world and selected developing regions of the world. Anemia prevalence is highest in young children, and second highest in women. Mortality risk estimates associated with hemoglobin levels during

Table 1. Population, anemia prevalence in risk groups, and death and disability attributable to iron deficiency anemia (IDA) in the world and in selected developing regions of the world

Region	Population (thousands)	Anemia Prevalence (%)		Burden Attributable to IDA (thousands)	
		Women	Children	Deaths	DALYs
Africa[1]	639,593	41	60	271	10,140
Latin America[2]	502,162	23	46	33	1,249
Eastern Mediterranean–D[3]	481,635	44	63	80	3,195
Southeast Asia–B[4]	293,819	49	49	34	1,528
Southeast Asia–D[5]	1,241,806	60	66	324	12,497
North America[6]	325,183	8	7	5	478
World	6,045,017			841	35,057

Sources: Stoltzfus et al. 2003, Ezzati et al. 2002
[1]Excluding Egypt, Morocco, Somalia, Sudan, and Tunisia
[2]Excluding Cuba
[3]Afghanistan, Djibouti, Egypt, Iraq, Morocco, Pakistan, Somalia, Sudan, and Yemen
[4]Indonesia, Sri Lanka, and Thailand
[5]Bangladesh, Bhutan, Democratic People's Republic of Korea, India, Maldives, Myanmar, and Nepal
[6]Including Cuba

pregnancy were derived from a meta-analysis of six published studies of maternal mortality and ten published studies of perinatal mortality. For both outcomes, the studies included in the analysis varied in their geographical location and included populations with and without endemic malaria. For perinatal mortality, there was evidence that the risk relationship was stronger in studies conducted in Africa than in those from other locations, and therefore an Africa-specific risk estimate was used. Data from two recent studies were used to estimate the likely magnitude of bias in the summary estimates due to unmeasured factors. Based on this analysis, the risk estimates were attenuated by 20%. The final risk estimates are presented in Table 2.

The GBD 2000 uses the disability adjusted life year (DALY) as the summary measure of death and disability. The DALY measures years of life spent in less than full health. In the case of premature mortality, a full DALY is lost for each year of expected life lost. For other disease states, a fraction of a DALY — a disability weight — is assigned to each year lived with the disease, with the weight

Table 2. PROFILES simulations of lives saved if iron deficiency anemia were eliminated by 2010 in four countries

Country	Maternal Mortality Ratio[1]	Perinatal Mortality[2]	Pregnancy Anemia Prevalence (%)	Cumulative Lives Saved from 2003 to 2010[3]	
				Maternal Deaths Averted	Perinatal Deaths Averted
Malawi	1100	46	88	9,160	52,139
Mozambique	1100	90	37	4,775	56,309
Indonesia	380	40	74	18,209	268,866
India	540	85	88	180,630	3,903,540

[1]Per 100,000 live births
[2]Per 1,000 live births
[3]Assumes a linear decline in anemia from the current prevalence to 50% of that level

corresponding to the severity of the disease. Globally, 841,000 deaths and 35,057,000 DALYs are attributable to IDA (see Table 1).

The relationship between maternal pregnancy anemia and perinatal mortality is responsible for the largest contribution to both deaths and DALYs, representing 56% of the total. The global distribution of the disease burden of IDA is heavily concentrated in Africa and parts of Asia, especially in the WHO region Southeast Asia–D (see Table 1). These regions bear 71% of the global mortality burden and 65% of the DALYs lost. By contrast, the DALYs lost to iron deficiency in North America and Cuba amount to 0.4% of the global total.

Dr. Stoltzfus discussed the PROFILES tool,[1] which can be used to demonstrate through simulation features how certain assumptions made by the GBD 2000 can allow health planners to use local or national data to obtain local or national estimates of the mortality burden of IDA. It can also be used to project the number of deaths averted under various program scenarios. For example, Table 2 provides estimates of deaths averted for four countries if IDA were eliminated (thereby reducing total anemia rates by 50%) gradually over the course of eight years.

Dr. Stoltzfus suggested that the GBD 2000 estimates provide a new basis for advocating for the control of iron deficiency. Compared with other forms of malnutrition included among the 26 risk factors in GBD 2000 (Ezzati et al. 2002), iron deficiency ranks ninth overall in terms of DALYs lost, falling lower than underweight (which ranks first), and slightly higher than zinc deficiency (eleventh place) and vitamin A deficiency (thirteenth place). There is no excuse, Dr. Stoltzfus said, for the scientific and public health community to be complacent about iron deficiency.

At the same time, the GBD 2000 further defines important gaps in our knowledge about the consequences of iron deficiency. Evidence for the relationships between IDA and maternal and perinatal mortality needs to be strengthened by well-controlled prospective observational studies. Randomized trials would add greatly to the evidence base, but for ethical reasons they would not likely be placebo controlled. There is also an urgent need for more evidence on the relationship between IDA and mortality in young children.

Recent Advances in Iron Fortification

Dr. Richard Hurrell, of the Swiss Federal Institute of Technology Zurich, in Zurich, Switzerland, provided an update on the past two years in iron fortification. Iron fortification is "on the move," he said. The successes are due at least in part to the agencies that have been involved, including ILSI's Iron Deficiency Elimination Action (Project IDEA), Sharing United States Technology to Aid in the Improvement of Nutrition (SUSTAIN), the Pan American Health Organization (PAHO), WHO, INACG, the Iron Deficiency Project Advisory Service (IDPAS), and the Global Alliance for Improved Nutrition (GAIN). He was encouraged by the new GAIN initiative to provide funding for national food fortification programs and found that this initiative had given iron fortification a new impetus.

Since the previous INACG meeting, new guidelines on iron fortification of foods have been published and major new technical developments have been made. SUSTAIN first raised concern about the usefulness of elemental iron compounds for food fortification (Hurrell et al. 2002) and published guidelines for the fortification of cereal food staples (wheat and maize flours) (SUSTAIN 2001). PAHO guidelines were published recently (PAHO 2002), and the comprehensive WHO guidelines for food fortification, to be published 2003, will include information about major food vehicles, fortification levels, monitoring, and cost-benefit evaluation. Recommendations on which compounds should be used are comparable in all the guidelines. Thus far, however, published guidelines have not given a clear indication of how much iron to add to foods. This is the focus of an ongoing INACG task force.

The PAHO guidelines state that for low-phytic-acid flours (such as white wheat flour and degermed maize flour) the first choice of iron fortificant is ferrous sulfate or encapsulated ferrous sulfate, followed by ferrous fumarate or encapsulated ferrous fumarate, and finally, electrolytic iron powder at twice the concentration of sulfate. For nixtamalized maize flour, sodium iron

[1] For more information about the PROFILES Project of the Academy for Educational Development, contact Helen Stiefel at hsteifel@smtp.aed.org.

EDTA (NaFeEDTA) is the recommended iron compound, in order to overcome the high phytic acid level. Second choices are ferrous sulfate or fumarate or their encapsulates at twice the concentration of NaFeEDTA. For complementary foods, PAHO recommends sulfate or fumarate together with ascorbic acid at a 2:1 molar ratio to enhance iron bioavailability. The other elemental iron compounds, including hydrogen reduced, carbon monoxide reduced, atomized, and carbonyl iron, are not currently recommended. Recent results from ongoing evaluation trials of elemental iron powders, initiated by SUSTAIN and presented in a poster at this meeting, provided new data on relative bioavailability (RBV) in rats: carbonyl iron, 64%, electrolytic iron, 54%, and hydrogen-reduced iron, 42% relative to ferrous sulfate (Th70).[2] In earlier human studies, electrolytic iron was absorbed at 75% the level of sulfate (Forbes et al. 1989), and carbonyl iron was absorbed at only 5–20% (Hallberg et al. 1986). The current recommendation to use electrolytic iron is based on these earlier human studies. Several additional human studies are planned to further evaluate the efficacy of elemental iron compounds.

An efficacy study using fortified fish sauce in Vietnam showed that NaFeEDTA is a highly efficacious fortificant (Thuy et al. 2003). In a recent double-blind study conducted in northern Morocco, salt was dual-fortified with 25 μg iodine per gram salt and 1 mg iron per gram salt as ferrous sulfate encapsulated in hydrogenated soybean oil. A total of 377 children were randomized into two groups, both consuming 7–12 g salt per day; one group was given the dual-fortified salt, and the other was given salt fortified with iodine only. The prevalence of IDA fell from 35% to 8% after nine months among the children who received the salt containing iron. The study suggested that salt may be a good vehicle for iron as well as iodine (Zimmermann et al. 2003). Dr. Hurrell suggested that these recent fortification trials were successful because high amounts of iron (approximately 10 mg/day) were provided in highly bioavailable forms, and because IDA was rigorously defined, using multiple criteria models. Because not all anemia is due to iron deficiency, it is important to measure response to iron fortification in groups with well-defined IDA.

Encapsulated iron salts are commercially available with many different encapsulation materials, including hydrogenated fats, cellulose, and edible waxes. In animal studies, there is no indication of reduced bioavailability with encapsulation, and in the Moroccan salt study, the encapsulated iron was highly efficacious. Encapsulated ferrous sulfate offers the possibility of replacing elemental iron in cereal fortification programs without provoking unacceptable sensory changes, and higher levels of fortification should be possible. The extra cost of encapsulated compounds —three to four times higher than ferrous sulfate per mg iron — is a consideration, however. Another consideration is that encapsulation technology will still need improvement if low-grade salt, as currently used in many developing countries, is to be fortified without change in color and without iodine losses. Also, the capsules melt at about 65 degrees centigrade and thus would be removed during cooking.

Recent research findings have shown that micronization of insoluble compounds can greatly improve their bioavailability. By decreasing the particle size of ferric pyrophosphate from 5–10 μm to less than 0.5 μm, the absorption was increased nearly threefold, from 34% to 89%, relative to sulfate (Th69). This micronized ferric pyrophosphate is mixed with emulsifiers (marketed under the brand name SunActive Fe). It should be explored in this form as a potential food fortificant for use in cereals, salt, extruded rice grains, and bouillon cubes.

In making recommendations on iron fortification, one important question that remains to be answered is whether iron absorption data obtained from healthy, well-nourished adults in the United States or Europe can be assumed to apply to persons of all ages in developing countries, where infections and micronutrient deficiencies are common. These issues have been raised in recent studies in Bangladesh and Switzerland that were presented in posters at the symposium. The RBV of ferrous fumarate was found to be only about 35% in Bangladeshi children (both with and without *Helicobacter pylori* infection) (Th30), whereas it was 100% in healthy Swiss adults (Th68).

[2] Readers can use the codes in parentheses throughout the report to locate abstracts of the presentations beginning on page 35. Abstracts are not available for all presentations.

Dr. Hurrell concluded by saying that recent data on water-soluble iron compounds added to condiments clearly show that iron fortification can have a significant role in reducing the prevalence of IDA. At present, however, there are no data on the efficacy of non–water soluble iron compounds added to cereal flour. More research is needed to evaluate the usefulness of non–water soluble iron compounds in different settings.

Complementary Food Supplements

Dr. André Briend, of the Institut de Recherche pour le Développement, in Paris, France, discussed complementary food supplements to achieve micronutrient adequacy for infants and young children. His presentation was based on the proceedings of a July 2002 meeting in Paris organized jointly by the U.S. Agency for International Development (USAID), WHO, and the Institut National Français de Recherche Médicale (INSERM) on new approaches to achieving nutritional adequacy during the complementary feeding period (Nestel et al. 2003).

Micronutrient deficiencies are common during the complementary feeding period. Currently proposed solutions are to provide nutritional education with optimal use of local foods and to use centrally processed, cereal-based, fortified complementary foods. These two approaches have had limited success as micronutrient requirements, especially for iron but also for zinc and retinol, are so high that they are often difficult to provide without the use of large amounts of expensive animal source foods, such as liver. Centrally processed fortified foods are also often too expensive for the poor. Therefore, to move forward, new food-based approaches have been proposed that are based on adding micronutrient supplements to complementary foods (prepared with local foods) by using tablets, sprinkles, or spreads. All these approaches aim to reduce the cost of a balanced diet based on macronutrients from the local diet by providing the missing nutrients in inexpensive chemical forms using an adapted vehicle — a complementary food supplement (CFS) — during the complementary feeding period. All CFSs use high levels of vitamins and minerals packed in a small volume. They are at the borderline between food and pharmaceutical industries. These approaches are still at the development stage, and optimal solutions may vary according to cost constraints, distribution channels, and other considerations.

Tablets

In 1999, a meeting organized by the United Nations Children's Fund (UNICEF) recommended that a micronutrient supplement containing one or two times the recommended dietary allowance of ten vitamins and four minerals be developed and field tested (UNICEF 2000). The low-cost, stable, readily crushable, and water-dispersible tablets developed after the 1999 meeting can be mixed with food or chewed directly. The advantage of this formulation is that consumers may perceive adding the crushed tablet to food as a food-based rather than a medical intervention. Side effects, in particular stomach irritation, are also likely to be lower if the supplements are mixed with food. However, administration of these supplements with food may reduce iron and zinc absorption. The developed tablet was used in a multicenter supplementation trial in infants and young children in Peru, Indonesia, Vietnam, and South Africa. Preliminary results from three of the sites were presented as posters at the symposium (Th15, Th22, Th18). Three of the four studies, however, administered the tablet as a stand-alone product rather than as a CFS. Another dispersible tablet containing iron, zinc, and folate was developed for the ongoing WHO/USAID multicenter study in India, Nepal, and Zanzibar. These tablets, which dissolve in water or breast milk in 30 seconds, were developed for administration as stand-alone products rather than as CFSs. Tablets rely on well-established pharmaceutical technology and are at an advanced stage of development. For example, production of the iron, zinc, and folate dispersible WHO/USAID tablet is now being transferred to Bangladesh. A major question is whether these tablets will be perceived as food supplements, and thus used on a day-to-day basis, and not as medicines.

Sprinkles

Sprinkles are vitamin and mineral mixes designed to be added to foods. They are distributed in small sachets and can be regarded as "uncompressed tablets." The technology is well known and is even simpler than that for tablets, as the compression stage is not needed. Sprinkles containing iron with vitamin C (as an iron absorption enhancer rather than for nutritional purposes) were shown in a study in Ghana

to be efficacious in treating anemia (Zlotkin et al. 2001). Several micronutrients can be included in a sprinkle formulation. The unpalatable nutrients, especially iron, can be encapsulated to minimize taste problems and to ensure good consumer acceptability. Posters presented at the symposium suggest that sprinkles are well accepted among preschool children and that iron is well absorbed when sprinkles are mixed with maize porridge (Th75, Th76). The sprinkle sachets contain bland-tasting fillers (edible carbohydrates), which add volume to the micronutrients so that they can be easily handled by caretakers. Instructions are to sprinkle the entire contents of a sachet on the infant's gruel or porridge just before feeding. Sprinkles could potentially be produced in many developing countries with minimal industrial infrastructure. Their use raises the same questions as that of tablets: How will sprinkles be perceived by families? Will they be perceived as a food to be used on a day-to-day basis for several months, or as a medicine to be given when the child is not well?

Spreads

Spreads are not traditionally used for infant feeding. The concept emerged after failed attempts to develop a bar to be used instead of a liquid feed (such as the WHO F100 rehabilitation diet) for severely malnourished children. The bars melted at high ambient temperatures, and the decision was made to use a spread instead, which could be distributed in sachets. Acceptability of the spread was excellent, despite high fortification levels with multiple unpalatable micronutrients. Fortified spreads are now used in therapeutic feeding to treat severely undernourished children in relief operations (Collins 2001). Later an attempt was made to produce a more concentrated version that could be used as a CFS by mixing dry powdered ingredients (e.g., dried milk products, precooked soy flour, sugars, maltodextrin, minerals, and vitamins) with a vegetable fat such as peanut butter. The viscosity and melting point of the fat must be such that the resulting product is easy to store and to swallow. Spreads are made without water and can therefore be safely stored without any risk of pathogenic bacterial proliferation. Because a strong-flavored fat base — such as peanut butter — is used, the metallic taste of soluble minerals can be masked more easily than in other products. For infants, spreads can be mixed with local complementary foods, and children can eat spreads as a snack. In therapeutic settings, older children usually eat the spread as a snack, but because infants may have difficulty swallowing a thick paste, mixing it into traditional porridges just before serving may be more appropriate. The preparation of spreads is based on simple technology, and the therapeutic version is now produced in Malawi without apparent difficulty. The technology can be used to prepare foods at a cost in relation to nutrient content (iron, zinc, retinol, water-soluble vitamins) lower than most locally available foods. The formulation of spreads used as CFSs has not yet been optimized — in particular the optimal ratio between the spread itself (which is a useful source of energy) and added micronutrients. Also, its acceptability needs to be assessed in different cultures.

Dr. Briend concluded by noting that although CFSs represent a promising new approach to preventing micronutrient deficiencies in children, several important issues need to be resolved before large-scale programs can be developed. Operational issues include identifying the market positioning of the CFSs, cost positioning of the different CFSs, regulatory requirements, CFS production and technology transfer, quality assurance, and partnerships and coordination between the public and private sectors. Intervention trials are needed to determine the efficacy of CFSs in preventing micronutrient deficiencies. Other important knowledge gaps in technical and operational issues also need to be addressed. Sprinkles and tablets are produced with well-known technologies, but further research is needed on modifying them for use as CFSs. The development of spreads is not as advanced as that of sprinkles and tablets, and further research is needed to improve the technology and to optimize formulations. Although none of the products is ready for widespread use, enough information is available to set research priorities and accelerate product development and implementation.

Report from the IDPAS Working Group on Strategies to Prevent and Control Iron Deficiency in Children Less Than Two Years of Age

Dr. Gary Gleason, of the Iron Deficiency Project Advisory Service (IDPAS), in Boston, Massachusetts (USA), described the activities of IDPAS's technical working group on eliminating iron deficiency in

children under age two by 2008. He noted that the UN General Assembly's goal of reducing anemia, including IDA, by 30% in all populations by 2010 focuses on the full life cycle and total national populations. Children under two are at particularly high risk of IDA, and new research findings confirm that IDA causes poor brain development, weakens the young child's immune defenses, and has a negative impact on physical, social, and cognitive performance. Children aged 6–18 months grow rapidly, and in developing countries they often do not receive sufficient iron after six months. Complementary foods do not provide it unless they are fortified with iron. However, such foods are rarely available to poor families in developing countries. Infants born with low birth weight exhaust their iron stores even earlier, at 2–4 months of age, and need iron supplementation. Despite these facts, and despite the focus on early childhood development and care in many countries, few developing countries have national programs that focus on preventing IDA in this age group.

The Micronutrient Working Group of the UN Standing Committee on Nutrition requested that this issue be a focus of the Subgroup on Iron Deficiency. In response, the International Nutrition Foundation and the United Nations University set up a technical Working Group to Develop Strategies to Eliminate Deficiency in Children Less Than Two Years of Age by 2008. This group, with support from the U.S. Centers for Disease Control and Prevention and the Micronutrient Initiative in Canada, was formed in April 2002. The Working Group's goals are to identify and share information about the most feasible methods developing countries can use to reduce the prevalence of IDA in children under age two. It also seeks to identify gaps in knowledge and program strategies and to recommend a more focused research agenda and operational strategies to address these. In 2002 the Working Group reviewed published research and unpublished reports of experiences and initiated an electronic discussion among members from agencies, nongovernmental organizations (NGOs), researchers, and private-sector officials that led to a meeting in Ottawa, Canada, in September 2002.

Dr. Gleason then presented a set of modeling experiments in 6- and 9-month-old infants using different combinations of human milk and complementary foods to illustrate the difficulties involved in providing adequate iron intake in this age group. Another problem he pointed out was that although supplementation guidelines exist, very often they are not actively promoted or widely supported. In addition, access and demand for safe pediatric iron supplements is a problem in many countries. "In-home fortificants" (complementary food supplements — CFSs) provide innovative approaches that might allow a food-based approach to increasing iron intake in this age group.

Another barrier to adequate iron nutrition in this age group is low access and demand for fortified complementary cereals at the family and community levels in many countries, at least partly because of cost. Moreover, health promotion activities in developing countries seldom include activities aimed at developing demand within families for pediatric iron supplements or for fortified complementary foods.

Dr. Gleason pointed out some perceived negative images of fortified foods. In addition to the high cost and frequent lack of access to these products, fortified infant formulas and fortified infant cereals, even those advocated for infants and young children older than 6 months, wrongly tend to be perceived as a threat to exclusive breast-feeding. Because of these concerns, not enough work has been done to create positive alliances with the private sector in developing countries.

Dr. Gleason summarized the overall conclusions of the Working Group in order to achieve the goals of providing iron for this age group as follows:

- Rapid development of effective strategies
- Systems providing safe affordable oral supplementation (syrups to every child 6–24 months old) or systems allowing effective in-home fortification (sprinkles, spreads, and complementary foods)
- Community involvement in the purchase and distribution of oral supplements
- Effective strategies promoting better iron nutrition in complementary diets
- Linkage with other programs, for example, reproductive health, malaria and helminth control, IMCI, and others

- Well-defined collaboration among government agencies and the private sector, NGOs, and international donors

A progress report from the Working Group is being prepared, and a plenary presentation based on the group's work was given at the 2003 UN Standing Committee on Nutrition meeting in India in March.

Panel Discussion

Dr. Anna Verster, of the WHO Eastern Mediterranean Regional Office (EMRO), commented that WHO regional EMRO guidelines are available and are in agreement with the PAHO guidelines presented by Dr. Hurrell. The EMRO guidelines recommend 30 ppm iron from ferrous sulfate or 60 ppm from electrolytic iron powder in wheat flour. Dr. Verster also expressed concern that dual fortification of salt would involve a dry mix, which would mean a changeover from the current wet spraying methods of iodizing salt.

Dr. Tahmeed Ahmed, of the Centre for Health and Population Research of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B), raised the question of whether performing placebo-controlled trials is ethical in the iron fortification or supplementation field. Dr. Hurrell agreed that this is an important issue, particularly in infants and young children, for whom IDA has a negative influence on brain development. For clarification, Dr. Hurrell stressed that the studies he discussed in his presentation included schoolchildren and adults. On resolving the ethical dilemma, Dr. Lynch suggested a parallel in oncology research, where one alternative is to add new treatment regimens to existing therapy to see if it can be improved, which could be a way to proceed without a placebo control in the iron field.

Dr. Clive West, of Wageningen University, commented that underweight was defined by the GBD project as an important risk factor for childhood and maternal mortality and wondered how much of that underweight could be due to lack of micronutrients, such as zinc, iron, and vitamin A. For example, Dr. West said, his studies in Ethiopia suggested that zinc deficiency could contribute to up to one-third of the underweight in children. Dr. Stoltzfus responded that there is potential for overlap in many of the categories included in the GBD estimates, particularly with regard to underweight and zinc deficiency. She cautioned that the DALYs cannot simply be added up, that they are not mutually exclusive and that there is significant overlap.

A comment by a participant from Iran suggested that there may be low compliance with sprinkles or spreads and that passive fortification, such as salt with iodine, might be preferable. Dr. Briend agreed that the greatest challenge is acceptability, and that although CFSs may work on a small scale, their usefulness on a national scale needs still to be shown.

Reducing the Prevalence of Anemia: Planning and Implementing a Strategic Communication Approach: Report from INACG Workshop, Cape Town

In opening the afternoon session, Ms. Pauline Kuzwayo, of the Medical University of Southern Africa, in Pretoria, South Africa, emphasized that addressing the enormous challenges of anemia requires an integrated approach that is multifactorial and multisectoral. She described the workshop, "Reducing the Prevalence of Anemia: Planning and Implementing a Strategic Communication Approach," to which 21 participants from Eritrea, Ghana, and South Africa came. The workshop format involved plenary and small-group meetings over a two-day period. Participants included representatives of the public and private sectors as well as individuals from outside the nutrition field, including specialists in communications, media, and education. The goal of the workshop was to provide participants a targeted approach for planning a strategic framework for communication to control anemia and to develop a set of realistic and measurable goals for each of the three countries.

Moving from Theory to Practice: The Role of Strategic Communication

Mr. James Hyde, of Tufts University School of Medicine, in Boston, Massachusetts

(USA), began by introducing some basic concepts from behavioral theory. He said that a common fallacy of behavioral change models is the idea that there is a chain of logic that moves from improved knowledge to changes in attitudes and beliefs to changes in behaviors to improved health outcomes. He emphasized that there is little empirical evidence to support this simplistic theory. Increasing knowledge may be useful but, it is rarely, if ever, sufficient.

One may think of the determinants of health status as falling into four major domains: biological, behavioral, environmental, and services. Health status can be seen as resulting from the intersection of these four categories of determinants. Determinants of behavior can be further divided broadly into personal or individual factors and external factors. Personal factors include knowledge and understanding the consequences of behavior; attitudes, particularly dissatisfaction with the status quo; beliefs; coping skills and psychological resiliency; and a sense of personal control. External factors, which are broader, include housing and employment, social and economic sanctioning, peer-to-peer encouragement (especially important in adopting behaviors such as use of bed nets against malaria), organizational or institutional support (including in the private sector), social support networks, and religious and cultural norms.

Mr. Hyde then turned to a discussion of the "ecology of health." All behaviors that we try to influence occur in the context of the communities in which we live, organizations and institutions, and the broader policy environment. The policy culture that exists in any given region or country varies widely. Concentric layers of these factors constitute the ecology of health. Too often in public health practice we send messages to the individual consumer without considering the context in which he or she lives.

Communication must be used effectively to achieve change. The role of communication in behavior change for anemia is to motivate, educate, teach skills, empower, and reward and reinforce appropriate actions.

Thinking strategically, Mr. Hyde said, means abandoning single-factor solutions. It means committing to changing the organizational, institutional, community, and policy environments in which people live. This involves a sustained, coordinated, and concerted effort and requires the adoption of multiple communication strategies to achieve goals.

Strategic planning of communication campaigns requires a series of steps, the first of which is problem analysis. Next are selection of strategies, targeting the audiences, specifying behavioral objectives, and identifying strategic collaborators — very important in anemia control. In parallel, decisions must be made about what messages to craft, what channels to use to disseminate them, and how outcomes will be measured.

Mr. Hyde pointed out that there is an important distinction between strategy and tactics. Strategy entails identifying "what" needs to change, whereas tactics involve "how" you will change it. People often prefer to discuss tactics when they should be thinking about strategy. Too much time is spent on the "how," and rarely enough on the "what."

Crafting an intervention strategy involves deciding what needs to change. Three factors are involved:

1) Locality, that is, at what level of the ecological model one wishes to intervene

2) What needs to change, for example, knowledge, attitudes, awareness, skills, or policy

3) How communication will be used to create the change—for example, mass media or personal communication efforts

In general, factors 2 and 3 need to be considered at each level of the ecological framework. That is, at the population/policy level, the community level, the organizational/institutional level, the interpersonal level, and finally, the intrapersonal level. Mr. Hyde suggested using the ten-box matrix on the next page (Table 3), filling in the empty cells with concrete ideas.

Mr. Hyde then gave examples of applying these concepts to anemia control:

- First one should consider the population/policy level, and decide what needs to be changed. Usually this involves modifying the attitudes, beliefs, and awareness of policy makers in both the public and private sectors. For anemia control programs, examples of potential areas can be in vaccine policy or IMCI policy.
- At the community level, again one must decide what needs to be changed. Examples include development of

Table 3. Identifying and applying the strategies for a comprehensive anemial control program

Level at which change is directed	What needs to change?	How will communication be used to create the change?
Population/policy		
Community		
Organizational/institutional		
Interpersonal		
Intrapersonal		

more direct services and better access, but one must decide how change can be initiated and how demand can be created. This usually involves forming coalitions and educating local leaders and workers.

- At the organizational/institutional level, community-based or school-based interventions can be used; here communication is especially important to teach skills or deliver services.
- At the interpersonal level, the attitudes and beliefs of families and health care providers must be changed.
- And, finally, at the intrapersonal level (where most of the effort is spent in public health), one must determine how best to get people to change their thinking and behavior.

The workshop in Cape Town was built around this approach.

In summary, Mr. Hyde said, health behaviors have multiple determinants. To be successful, intervention strategies must be multifactorial and multisectoral. Using this approach and thinking strategically about how to use health communication will be effective in producing behavioral change.

Cape Town Model

Mrs. Rosanna Agble, of the Ghana Health Service, in Accra, Ghana, described how the strategic process outlined at the INACG Workshop in Cape Town was implemented in Ghana to develop a strategic plan for anemia control. The team from Ghana was composed of nine members: the Head of the Nutrition Unit of the Ghana Health Services (GHS); the Anemia Program Coordinator, GHS; the Roll Back Malaria Program Manager, GHS; the IMCI Coordinator, GHS; the School Health Coordinator, Ghana Education Services; a pediatrician from a teaching hospital; a pharmacist from a teaching hospital; the Development Planning Officer from the Ministry of Local Government and Rural Development (the participation of a representative from the local government was important because of the current decentralization process in Ghana); and a private-sector health journalist.

A short-term plan was developed, to be implemented within the first six months. Its aim was to improve political and public awareness.

To improve political awareness, the behavioral changes and objectives were to commit resources to anemia control, to include anemia issues in government propaganda, and to include anemia control in programs in other ministries, departments, and agencies in the government. The targeted message was that anemia not only affects the health of women and children, it also has serious repercussions on the educational achievement of children and worker productivity, and thus on the economic development of the country.

To improve public awareness, two behavioral objectives were identified. The first was to create demand for the required services and facilities for anemia control. The second was to get the organizers of beauty pageants to convince pageant winners to help educate the public on anemia. Thus pageant winners could travel around Ghana promoting anemia control and disseminating information at the district and community levels. The targeted messages were that the public can be engaged in

reducing the prevalence of anemia if they appreciate the magnitude of the problem, its consequences, and what they can do by themselves to control it. The media can be an important factor in creating awareness about anemia and its control among the public.

To achieve communication of these messages, short-term activities were:

- Convening consensus-building meetings on national anemia control strategy
- Convening sensitization meetings with ministers and Members of Parliament (MPs)
- Producing information packets, including press briefs
- Meeting with the media and getting at least two reports in newspapers (this has already occurred)
- Arranging for the Minister of Public Health to make a statement about anemia and refer to what the country is doing
- Broadcasting anemia control messages as part of the Safe Motherhood Campaign
- Broadcasting radio programs on anemia and deworming with anemia control messages
- Convening sensitization meetings with the Ghana Medical Council
- Convening curriculum review meetings with the Nurses and Midwives Council and the Pharmacy Council

The goal of the medium-term plan (6–12 months) is to improve the knowledge, attitudes, and skills of health care providers and extension agents at the organizational level. The plan's behavioral objective is to ensure that information about anemia control is incorporated into the curricula and in training materials. The targeted message is that health care workers and extension agents must have adequate knowledge and skills in anemia control.

The medium-term activities therefore were:

- Convening a consensus-building meeting on including anemia control in school health policy
- Disseminating a finalized anemia control strategy
- Continuing Safe Motherhood Campaigns with anemia messages
- Continuing radio programs on anemia and its control
- Meeting with program managers to harmonize standards for common indicators of anemia
- Developing a plan for continuous media activities
- Reviewing and developing protocols, information, education, and communication (IEC) materials, job aids, training manuals, and curricula to strengthen components of anemia control

Finally, the planned long-term (12–18 months) activities include:

- Convening sensitization meetings for curricula development (teacher training colleges, agricultural extension training, community development training institutions, etc.)
- Convening media review meetings
- Training health workers on new protocols and job aids
- Advocating to MPs, District Chief Executives (DCEs), and District Assemblies (DAs) in Roll Back Malaria districts on the need to provide supplements to schoolchildren
- Advocating to MPs, DCEs, and DAs in three selected districts on supplementation using complementary food supplements for children aged 6–24 months
- Orienting chiefs (key regional authority figures) and community-based and faith-based organizations on village-level fortification
- Convening media review meetings
- Continuing to advocate to MPs, DCEs, and DAs about village-level fortification and supplementation for schoolchildren
- Continuing to advocate to chiefs on village-level fortification
- Integrating training on anemia into ongoing in-service training of extension agents

Iron Supplementation Programs in Morocco

Dr. Abdelwahab Zerrari, of the Maternal and Child Health Division of the Ministry of Health, in Rabat, Morocco, discussed iron supplementation programs in Morocco. Iron deficiency and anemia are major problems in Morocco, he noted, particularly among pregnant and lactating women and young children, and existing preventive services do not yet cover all of these vulnerable groups. He said that his division's decisions on how to control anemia were made on the basis of political commitment and of information about effective actions.

The targeted messages directed toward health professionals were:

- To identify target groups for intervention
- To train health aides on the importance of iron supplements and to provide training in communication
- To increase access to iron supplements through the use of fixed and mobile units for distribution and a multisectoral approach
- To focus on improving the quality of antenatal care consultations, that is, providing adequate equipment, drugs, treatment, and management as well as counseling for mothers-to-be
- To increase monitoring of individual cases and evaluation of progress

The communication strategies directed toward women of childbearing age were aimed at increasing knowledge about anemia and its adverse effects and the benefits of iron supplementation. Also, counseling about the potential adverse effects of iron supplementation, including gastrointestinal distress and black stools, was given.

Communication Strategy on Integrating Anemia Control into Child Survival Programs in Ghana

Mrs. Agble described the current attempts in Ghana to integrate anemia control into existing child survival programs, particularly into two programs, IMCI and the child growth promotion program.

The child growth promotion program is implemented at two levels: at the health facility level and at the community level. It aims to promote appropriate complementary feeding practices; its four areas of focus are frequency, quality, quantity, and timeliness of the introduction of complementary foods. The program also emphasizes increasing the promotion of deworming as well as of improved hygiene and sanitation. In the malaria programs, insecticide-treated materials, such as bed nets, are also considered part of anemia control. There is a plan to implement a communication strategy through radio programs that will focus on the importance of home-based care, including teaching mothers to seek appropriate and timely help for their anemic children.

The challenges of integrating anemia control programs into these services include:

- Improving education and quality of care at the referral health facility
- Improving access to health facilities, both financial and geographical. For example, sale and retreatment of insecticide-treated bed nets should be at the community level.
- Increasing and promoting service points in the community
- Integrating services and making them affordable. As an example, Mrs. Agble discussed the current situation in Ghana, in which mothers have the choice of buying bed nets (about US$7 for a single bed) or using the available free care for the children if they become infected with malaria. There is a clear need to reconcile this type of conflicting policy among the programs.

Communication Strategy for Anemia Control in Mali

Dr. Amenatou Cisse, of Helen Keller International, in Bamako, Mali, discussed the anemia control program in Mali. The program's overall ten-year goal is to reduce anemia among pregnant women by 30%. Current estimates of anemia prevalence in Mali are 63% among women aged 15–49 years, 73% among pregnant women, and 82% among children under age five. National policy is to provide iron and folate supplements to pregnant women from their first prenatal visit and continue supplementation through the second month after delivery.

Dr. Cisse identified several barriers to program success. At the health facility level, they include the availability of iron/folate tablets, the quality of the care provided, and the program coverage (it is estimated that only 45% of the population live within 15 km of a health facility). At the community level, barriers include access, which is limited by geographical, economical, and sociocultural constraints; and low demand for and utilization of supplementation.

The communication strategy Helen Keller International devised in Mali for advocacy with health authorities and partners entails:

- Including iron/folate supplements in the price of prenatal service packages
- Improving the supply of iron/folate tablets
- Introducing iron/folate supplementation into the preservice training curricula of health workers
- Distributing iron/folate supplements to pregnant women during mass vitamin A capsule distribution campaigns for children

The main communication channels used are rural and community radio as well as traditional community communication channels such as public criers, songs, and theater.

Progress evaluation through 2002 showed that 93% of surveyed health centers had adequate stocks of iron/folate tablets and that the cost of the supplements is now included in the antenatal package, which is paid for at the first consultation. In-service training modules are in place in many regions. During three years of experience of Regional Micronutrient Days, the coverage of pregnant women with at least 90 iron/folate tablets consumed was 57% in the first year, 94% in the second year, and 55% in the third year.

Dr. Cisse listed the program's strong points as follows:

- Political will at the national level (Ministry of Health/Division of Nutrition)
- Strong implementation partners — for example, the Ministry of Health/ Division of Nutrition, regional health authorities, and NGOs
- Good social mobilization
- Use of rural community radio for communication

Challenges that remain for Mali's program are the high cost and the sustainability of mass distribution. In addition, health worker compliance with the national policy for iron/folate supplementation needs to be strengthened.

Malawi Micronutrient and Health Program

Ms. Rose Namarika, of World Vision International, in Lilongwe, Malawi, discussed Malawi's Micronutrient and Health Program (MICAH). A national anemia task force has been formed, and significant progress has been made on the integrated objectives of the MICAH anemia program.

At the national policy level, MICAH's integrated approaches include:

- Water and sanitation programs
- Iron/folate supplementation
- Disease prevention and treatment (especially malaria and HIV-AIDS)
- Dietary diversification and modification (including animal source foods)
- Capacity building and advocacy
- Fortification of maize flour with multiple micronutrients

MICAH's communication strategy includes the use of health surveillance assistants, traditional trained birth attendants, MICAH village committees, and MICAH project staff and is supported by policies of the Ministry of Health.

Ms. Namarika noted that on the local level, strategic communication with consistent messages, using culturally appropriate forms of communication (for example, drummers and songs are well accepted in the community) is important for the integrated approach.

Several lessons can be drawn from the experience with MICAH. The first is that working closely with the Ministry of Health resulted in the formulation of a national action plan on anemia. Second, integrated implementation and collaboration with partners resulted in a measurable impact, namely, a reduction of anemia among pregnant women. Finally, it is clear that the communities should own the projects and feel empowered to operate the program.

Some of the challenges that must be addressed in phase 2 (2002–2005) of MICAH Malawi are to continue implementing the integrated strategies; to continue monitoring to evaluate the program's impact; to continue working with the Ministry of Health to ensure consistency and sustainability; to scale up HIV-AIDS and malaria interventions; and to promote iron/folate supplementation using village volunteers to ensure compliance.

Panel Discussion

An attendee commented on the importance of local research in developing communication strategies and of monitoring and evaluation in sustaining and refining these strategies. Mr. Hyde added that formative research can be very important in helping to avoid unanticipated consequences of interventions. Dr. Verster noted that in Morocco, Bahrain, Egypt, Jordan, and other EMRO countries, local research had been done on how the population would respond to iron fortification of bread, as this food is seen as the "the staff of life" and should not be adulterated. In Egypt, people were more responsive to the idea of vitamins added to the bread than iron, and so a new term, "fetaminized," was developed.

The motivation of local health care workers was identified as a challenge, and Dr. Cisse suggested that the problem is partly due to inadequate training. An attendee suggested that consumer knowledge has an important role in getting pregnant women to take iron/folate supplements. Mr. Hyde noted in response that in public policy there are very few examples of where imparting knowledge to individuals alone has resulted in long-term behavior change, and he cited the Back to Sleep campaign in the United States against sudden infant death syndrome as an example. He emphasized that knowledge is important in precipitating short-term changes in behavior, but sustainability depends on a more integrated strategic approach.

Dr. John Beard, of Pennsylvania State University, asked, "What are the outcome variables, and what are the objectives used to measure success of strategies against anemia?" In response, Dr. Cisse provided a concrete example from the program in Mali: the evaluation of a radio program, aired in conjunction with the mass distribution of 90 tablets of iron/folate to all pregnant women, urging them to take the tablets. A population-based survey done 45 days afterward showed that two-thirds of women had taken at least half of the tablets, suggesting that the radio message had an impact.

Ms. Kuzwayo emphasized that monitoring and evaluation are very important aspects of anemia control programs: strategies against anemia need to be able to stand up to rigorous evaluation. Moreover, communication strategies, like other aspects of anemia control programs, must be carefully and scientifically evaluated. The aims and the target groups must be specifically identified. Change must occur at all levels in order to make a difference, but training of program implementers at the community level is a key component. She reemphasized that integration of all aspects of health care is important and that programs need to consider components of evaluation and monitoring at an early stage, during planning. Effective communication must be integrated with other community and policy approaches to controlling anemia.

Concluding Remarks

Dr. Lena Davidsson, chair of the INACG Steering Committee, summarized the presentations and highlighted the importance of integrated approaches in controlling iron deficiency and anemia.

The first session focused on the central importance of controlling infectious disease in reducing anemia. Dr. Peter Hotez's keynote address provided new insights into vaccine development and their potential for controlling infectious disease. Although promising results have been obtained in recent years, the development of malaria and hookworm vaccines has been hindered by the minimal development of acquired resistance and the pathogens' low immunogenicity. The cost and availability of vaccines is also a critical issue; expensive new vaccines may not be affordable for the poorest, most affected countries.

Malaria is a major factor in the etiology of anemia, particularly in Africa, and as Dr. Jane Crawley's presentation clearly illustrated, effective malaria control is critically important in reducing anemia, particularly in vulnerable groups such as pregnant women and young children. A strategy using targeted delivery of antimalarials can

be used, and Dr. Crawley emphasized the possibility of taking advantage of well-established routine points of contact with health services, such as antenatal clinics and the Expanded Programme on Immunization. However, the challenge now is to ensure delivery of intermittent preventive treatment, insecticide-treated bed nets, and antimalarial drugs as well as iron supplementation through sustainable systems.

The important question of the possibility that supplementation and food fortification with iron might increase the risk of infectious disease was discussed by Dr. Gera. In a recently published meta-analysis, Gera and Sachdev (2002) evaluated the effect of iron supplementation on the incidence of infections in children. The results reassuringly indicated that, on average, iron supplementation did not significantly increase the overall risk of infection. Although an increase in the risk of developing diarrhea was noted, the increase is small and is unlikely to have a significant public health impact. Unfortunately, the available data were not sufficiently detailed for an analysis of the dose effect of iron on the incidence of infections. However, the near absence of any significant adverse effects, particularly diarrhea, among children consuming iron-fortified foods emphasizes the need to further evaluate food fortification as the safest means of increasing iron intake.

The presentations in the second session of the morning provided updates on several issues related to iron deficiency and anemia control. Dr. Stoltzfus presented estimates on IDA from the Global Burden of Disease (GBD) 2000 project. Of the 26 risk factors included in the project, IDA was ranked ninth for DALYs lost. These estimates provide a basis for advocacy for the control of iron deficiency and IDA. At the same time, however, the GBD estimates clearly indicate important gaps in our knowledge about the consequences of iron deficiency and IDA. For example, more information on the relationships between IDA and maternal and perinatal mortality as well as between IDA and mortality in young children is urgently needed.

The presentation of the GBD estimates was followed by an update by Dr. Richard Hurrell on food fortification, one of the major strategies for combating iron deficiency. Food fortification has received renewed interest, and guidelines have been published recently by SUSTAIN and PAHO. In addition, a comprehensive WHO document on food fortification will be published later this year, and an INACG task force is working on guidelines for appropriate levels for iron fortification. Dr. Hurrell discussed the importance of demonstrating the usefulness of food fortification, and he cited encouraging recent data demonstrating that iron fortification of condiments such as fish sauce and salt is efficacious. It is important to bear in mind that these studies have all been conducted with water-soluble iron compounds at relatively high fortification levels. At present, we have no information on the usefulness of non–water soluble iron compounds for fortification of cereal flours. This issue may be clarified by several planned and ongoing studies.

Traditionally, iron fortification has been focused on industrially produced and centrally processed foods. However, because many people in developing countries do not have access to such foods, innovative solutions are needed to increase the intake of bioavailable iron. Because infants and young children are particularly vulnerable to iron deficiency, the recently developed approach of using complementary food supplements or "in-home fortification," as presented by Dr. André Briend, offers exciting prospects. It is hoped that the approaches discussed at the meeting will be further developed and evaluated in different settings. These approaches are of special relevance to the IDPAS Working Group, which focuses on children under two years of age. As Dr. Gary Gleason emphasized in his presentation, this age group deserves more attention than it has been given.

Finally, the importance of cross-sectoral collaborative efforts and strategic communication was further highlighted in the last session of the day, which focused on the planning and implementing of a strategic communication approach for reducing the prevalence of anemia. As Mr. James Hyde pointed out, there is an important distinction between strategy and tactics; strategy is "what needs to change," and tactics refer to "how you will change it." To think strategically, one must abandon single-factor solutions and focus instead on changing the overall environment in which people live. Thus, intervention strategies must be multifactorial and multisectoral, and multiple communication strategies are needed to produce behavioral change. We clearly need to spend more time on strategy, and perhaps less on tactics, to integrate programs to move anemia control forward.

Presenting an example of strategic communication in an anemia control program, Mrs. Rosanna Agble described how the strategic process outlined at the INACG Workshop in Cape Town was implemented in Ghana. The multisectoral team in Ghana defined their short-term and medium-term strategies in terms of enhancing political and public awareness about anemia and improving knowledge, attitudes, and skills. Their long-term strategy was defined in terms of committing resources and improving service delivery. Mrs. Agble's presentation illustrated how strategic communication can be implemented, but it also emphasized the importance of a strong commitment and of defining realistic time frames in the planning stages. The panel discussion and presentations from Morocco, Ghana, Mali, and Malawi included examples of how communication strategies to integrate anemia control are built into existing programs. These presentations stressed the importance of cross-sectoral collaborative efforts and strategic communication to move the agenda forward. It is hoped that they will stimulate discussions on how to implement strategic communication to combat anemia and iron deficiency in other countries.

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ABSTRACTS
morocco

Th1 EFFECTIVE IRON SUPPLEMENTATION CONDUCTED BY *BRIGADISTAS* IN RURAL NICARAGUA. J. Bonilla, M. Bosche, M. Zapata, J. Barbas, I. Gonzalez, A. Parajon, J. Mora. MOST, USAID, MINSA, PROSALUD, BASICS II. Managua, Nicaragua.

Background: In Nicaragua, more than half of children between 6 and 23 months of age are anemic (Ministry of Health, MOH, 2000). Limited access to iron supplements by the target population, and poor counseling and follow-up by health care providers were identified as major barriers in the supplementation program. **Aims**: To demonstrate the feasibility of increasing access to iron supplements, counseling and follow-up through "*brigadistas*" (community health volunteers). **Methods**: A community-based program was designed, combining several strategies (AIN-C/IMCI/IRON). Health technicians from U.S. private voluntary organizations provided assistance to local health staff (MOH) to implement the program. AIN-C/IMCI/IRON was implemented in four rural communities in El Cuá where the census revealed a total of 117 children 6-23 months of age. Monthly community meetings were held with mothers and their children under two years old. Trained brigadistas weighed each child, talked with mothers about the child's health status, distributed a liquid iron supplement to provide 12 mg daily, referred children to health units and provided counseling on infant feeding and iron absorption inhibiting/facilitating practices. More than 90% of the children participated in the program. Availability of iron supplements was ensured through the regular MOH procurement system. **Results**: In its pilot phase, the program succeeded in improving the knowledge and skills of health personnel and *brigadistas* about anemia and iron supplementation, increased coverage, created demand and acceptance by mothers of iron supplementation via *brigadistas*, and reduced the prevalence rate of anemia in children from 54% to 26% in four months. **Conclusion**: Trained community health volunteers can effectively distribute iron supplements and provide counseling and follow up to their mothers thus significantly reducing anemia in young children. The MOH is now regularly incorporating trained *brigadistas* into the regular supplementation program.

Th2 TRADITIONAL BIRTH ATTENDANTS CAN SUCCESFULY ENSURE COMMUNITY-BASED SUPPLEMENTATION OF PREGNANT WOMEN WITH IRON/FOLATE.. H Hamani, X Crespin, A Mamadoultaibou, MB Tidjani, SK Baker, and VM Aguayo. HKI NIGER, MOPH, and HKI-Africa Region.

Background: In Niger, the prevalence of anemia in pregnant women is around 60%, and less than 40% of them have access to prenatal services and that, less than 12% of women receive iron/folate supplements during pregnancy. Alternative approaches need to be explored to ensure adequate iron/folate supplementation of women during pregnancy. Aims: To assess the feasibility and effectiveness of a community-based distribution system. Helen Keller International implements the project in nine health districts. Methods: The main components of the project are: baseline assessment, community sensitization and mobilization, recruitment and training of traditional birth attendants as community-based supplementation agents, training of health workers as supervisors, routine quality assurance and monitoring, periodic supply of iron/folate supplements, and evaluation. Results: Preliminary results for two districts are available. Baseline data show that 43% of pregnant women in Tahoua district and 78% in Tera district are anemic. Before intervention, only 19% of pregnant women in Tera district and 25% in Tahoua district had access to iron/folate supplements. Monitoring data show a significant improvement in iron/folate coverage rates: 86% in Tahoua and 92% in Tera. Moreover, adherence to supplementation regime shows a significant improvement from baseline: 77% in Tahoua and 92% in Tera. Conclusion: Community-based distribution of iron/folate supplements using traditional birth attendants seems to be a feasible and cost-effective approach to ensure adequate iron/folate supplementation of women during pregnancy. Appropriate training and supervision seem to be key elements to the success of the project. the approach is being expanded to 220 villages based on the pilot program success. A full report of the project will be presented at the 2003-INACG Symposium.

Th3 **COMMUNITY-BASED INTEGRATED APPROACH REDUCES ANEMIA IN CHILDREN AND WOMEN IN GHANA.** M Neequaye, K Siekmans, S Blaney. World Vision Ghana and World Vision Canada.

Problem: Iron deficiency anemia is of public health importance in Ghana. In Kwahu South district (Eastern Region) in 1997, 75% of children under five (U5) and 43% of women of childbearing age (WCBA) were anemic. Nationally, anemia prevalence is 71% among schoolchildren. **Objective**: To evaluate the effectiveness of community-based iron supplementation in reducing the prevalence of anemia in children and WCBA. **Design**: The MICronutrient And Health (MICAH) program in Ghana targets 150,000 beneficiaries with multiple integrated strategies. In collaboration with key stakeholders (Ministry of Health, Ghana Education Service, District Assembly and community leaders), iron and vitamin A supplementation was integrated with public health interventions (treatment/prevention of parasites, water and sanitation, immunization), nutrition education and capacity building. Trained community volunteers distributed weekly iron/folate supplements to WCBA and U5; teachers gave weekly iron/folate supplements to schoolchildren. **Evaluation**: Cross-sectional surveys conducted at baseline (1997) and follow-up (2000) assessed program impact. Iron status was assessed using Hb (Hemocue). **Results**: Iron supplement coverage increased from 7% (n=966) to 85% (n=831) for WCBA ($p<0.001$) and was 79% (n=932) for U5 in 2000. Prevalence of anemia (Hb<12.0 g/dL) decreased from 43% (n=160) to 29% (n=490) among WCBA ($p<0.05$). Anemia among U5 (Hb<11.0 g/dL) decreased from 75% (n=301) to 65% (n=455; $p<0.05$). Prevalence of schisto among school children decreased from 19% to 8% ($p<0.001$) but hookworm remained similar (4% vs. 3%). Women's knowledge of cause of anemia increased from 71% to 100% ($p<0.001$). **Conclusion**: Results demonstrate effectiveness of community-based weekly iron supplementation, together with parasitic disease control and nutrition education in reducing the prevalence of anemia in women and children. Successful integration within district MOH strategy increases sustainability of anemia prevention.

Th4 A RAPID ASSESSMENT OF IRON FOLATE SUPPLEMENTATION FOR PREGNANT WOMEN IN GHANA. K Quarshie, R Agble, A Nyaku, P Harvey, Nutrition Unit, Ministry of Health, Ghana; MOST, The USAID Micronutrient Program, Ghana and USA.

Background: The Ministry of Health, Ghana, instituted an anaemia control program, under which pregnant women receiving antenatal care are given iron and folate supplements (IFS) as well as malaria prophylaxis and deworming treatment. Although this programme has run for several years, anaemia prevalence continues to be high. A recent national survey gave a prevalence value of 65%. Aim: A rapid assessment of the program was carried out to identify its strengths and weaknesses with a view to improve on it. Methods: Data was collected on; availability of policy guidelines and protocols; availability of IFS, antimalarials and deworming medication; existence of facilitative supervision; training; provider-client interaction; perceived barriers and enablers related to compliance with supplements. Results: Shortages of supplements had occurred in one third of the facilities 6 months preceding the assessment. Training was inadequate at regional and district levels. Overall 88% of women interviewed in households received some Antenatal Care, 82% had received iron and 93% folate supplements. However the number of visits made were too few and concentrated in the third trimester. Malaria prophylaxis was given to only 25% of women. Counselling on benefits of IFS was provided to 50% of clients – but information on potential side effects was given to only 21% of them. Conclusion: Inadequate training and supervision, at regional and district levels resulted in non-adherence to policies on IFS and malaria prophylaxis. Poor counselling on IFS, delayed and infrequent ANC visits are barriers to an effective IFS program. Procurement, distribution and stock monitoring systems need strengthening if shortages of supplies are to be prevented. There is the need to carry out an intensive behavior change campaign to step up ANC attendance and compliance to IFS.

Th5 **COMBINED PRIMARY HEALTH CARE INTERVENTIONS FOR CONTROLLING IRON DEFICIENCY ANEMIA IN SENEGAL**. G Sall, B Ndiaye, K Siekmans. MICAH project in Senegal, World Vision/ Ministry of Health, Kaolack.

Problem: Iron deficiency anemia is still one of the major public health problems in Senegal where it is estimated to affect about 50% of pregnant women and more than 80% of children under five. Effective iron deficiency anemia control programs are one of the greatest challenges for developing countries. **Objective**: To highlight how primary health care interventions contribute to the control of iron deficiency anemia in rural Senegalese communities. **Conceptual framework**: Addressing community and family practices as well as direct environmental underlying causes of iron deficiency anemia is expected to have an effect on this large scale public health problem. **Program design**: Program identified family and community factors that are underlying causes of iron deficiency and anemia. A package of primary health care services was defined. This included the promotion of latrine construction and appropriate human waste management at the household level. Communities and households were also encouraged to adopt appropriate cleaning and storage practices for drinking water. **Outcomes**: Results from a randomized sample survey of 1876 households showed that women of childbearing age living in households that have adopted appropriate waste management and drinking water storage are less likely to be anemic (Hb<120g/L) than those who live in households that have not adopted these practices. **Program implication**: Appropriate primary health care interventions, focused on addressing household and community practices that contribute to increase iron deficiency anemia risk factors such as water communicable parasite diseases, have to be incorporated into any iron deficiency anemia control program in countries characterized by poor education and health systems.

Th6 **REACHING YOUNG CHILDREN WITH DEWORMING MEDICINE –COST-EFFECTIVE AND SUSTAINABLE DISTRIBUTION THROUGH BIANNUALVITAMIN A SUPPLEMENTATION IN NEPAL**

Ram Shrestha, Sanjay Rijal (NTAG), Kyoko Okamura, P.O. Blomquist, Pragyan Mathema (UNICEF Nepal)

Background: Deworming of young children has recently drawn great attention in relation to its possible impact on anemia, growth and other aspects that contribute to child development. In Nepal, although prevalence data among pre-school children is not available, an unacceptably high proportion of children are presumably suffering from worm infestation (75% in school children; WHO-WFP Survey, 1996). In addition, prevalence of anemia in young children is extremely high (78% in 6-59 months old; Nepal Micronutrient Status Survey 1998). The magnitude of the problem advocates the need to establish a system that can reach all eligible pre-school children with deworming medicine at least twice a year.

Programme: Nepal has established a mechanism to provide deworming tablets for pre-school children through National Vitamin A Programme (NVAP) which covers 73 out of 75 districts. Various surveys have found that over 80% of the pre-school children aged 6-60 months (more than 3 million children in this age group) are reached through NVAP with more than 40,000 female community health volunteers (FCHVs) who distribute the vitamin A capsules twice a year with. Based on the finding, deworming of children aged 2-5 years has been integrated with NVAP since 1999, in which FCHVs are also trained on dosing of deworming tablets (Albendazole 400mg) by Ministry of Health (MoH) with initial one-year intensive support from Nepali Technical Assistance Group. The deworming component has been expanded to 48 districts, reaching more than 1 million children, and will cover the whole nation in 2004. Coverage of the deworming tablets is now monitored as part of the Mini-survey system which was originally designed to estimate vitamin A coverage in 10-15 selected districts after each distribution round. The Mini-surveys have found consistently high coverage of deworming, ranging from 88% to 91%, with minimal additional training cost. Additionally, the fact that the vitamin A coverage rate has been maintained above 90% in both deworming and non-deworming districts indicates that adding deworming has not distributed the achievement of vitamin A supplementation.

Conclustion: The Nepal's model of integrated vitamin A-deworming programme, as VITAMIN A 'PLUS', is a cost-effective and sustainable approach to universal deworming of preschool children, while maintaining high coverage in biannual vitamin A supplementation.

Th7 **USING DATA TO ADVOCATE FOR ANEMIA CONTROL IN CAMEROON.** D. Sibetcheu, M. Nankap, A.A. Ntonga, B. Kollo, A. Toko, F. Nissack, N.J. Haselow and V.M. Aguayo. Ministry of Health/Cameroon, UNICEF/Cameroon, WHO/Cameroon, Helen Keller International/Cameroon and Regional Office.
Background: The 2000-National Anemia Survey showed that 57% of Cameroonian children 1-5 years old and 53% of pregnant women 15-45 years old are anemic (hemoglobin levels < 11 g/dl). The current policy recommends iron/folate supplementation of all pregnant women for 6 months or more, yet the survey found that although 75% of pregnant women had taken an iron supplement at least once, only 19% had taken supplements through the recommended 6 months. There are no anemia control efforts targeted at children. **Objectives**: 1) To assess the health, educational, and economic consequences of anemia and 2) to develop an advocacy tool to motivate decision makers to support anemia control interventions. **Methodology**: The hemocue method was used to measure hemoglobin levels in children and women. The HKI Food Frequency Method was used to collect women's iron supplementation data. During a 10-day multi-sectoral workshop, the PROFILES analytical tools were used to estimate the consequences of anemia on the heath, education, and productivity of Cameroonians over a period of ten years. An advocacy presentation was developed based on the findings. **Results**: 4338 interviews were conducted and hemoglobin samples were collected on 2516 children and 2508 women, of which 12.3% were pregnant. The PROFILES analysis showed that if nothing more is done, 5,000 Cameroonian women will die after childbirth over the next ten years because they were anemic. The benefit from supplementing all pregnant women with iron/folate will be more than six times the cost of the interventions required. Moreover, considering that 27% of women 15-45 years are anemic, if nothing is done anemia will cause a productivity loss of US$338 million from agriculture activity alone. Anemia among 57% of pre-school children constitutes a major educational handicap. **Conclusions**: Credible survey data and multiple advocacy presentations linking improvement in anemia status to poverty reduction were effective in convincing government decision-makers to elevate the Ministry of Health Nutrition Service to a Sub-Direction in their new reorganization plan and to include more funds for anemia control activities in their poverty reduction budget. Partner organizations have used the data to solicit funding to improve and increase anemia control efforts.

Th8 **INTEGRATED MICRONUTRIENT PROGRAM REDUCES ANEMIA IN MALAWI**. K Siekmans, C MacDonald, S Blaney, R Namarika. World Vision Canada and World Vision Malawi.
Problem: Few programs have demonstrated impact on anemia levels in women and children in developing countries. Iron deficiency is Malawi's most prevalent micronutrient deficiency. **Objectives**: To determine the effectiveness of an integrated nutrition program in reducing high levels of anemia in children under five (U5) and pregnant women (PW). **Program description**: Due to the complex etiology of anemia in Malawi, a holistic approach is needed to address iron deficiency and other causes of anemia (malaria, hookworm). The MICronutrient And Health (MICAH) program in Malawi, with 1.8 million beneficiaries, addresses anemia in U5 and PW through multiple strategies: iron/folate supplementation, dietary diversification (increased access to animal protein), primary health care (malaria control, deworming) and education. **Methods**: Data was collected in 2 cross-sectional household surveys (baseline 1996, follow-up 2000), using cluster sampling. Non-MICAH comparison areas were surveyed in 2000. Hb and malaria were assessed for U5 and PW; hookworm by stool analysis among schoolchildren served as a proxy indicator. **Results**: Mean Hb levels in U5 increased from 9.2±1.8g/dL (n=644) to 10.2±1.9g/dL (n=1140) and in PW from 10.4±1.7g/dL (n=385) to 11.0±1.5g/dL (n=147) (all cases p<0.05). Moreover, the proportion of U5 and PW classified as anemic (Hb<11.0g/dL) decreased from 83.7% to 65.9% and 59.0% to 42.2%, respectively (all cases p<0.05). Hookworm prevalence decreased from 17.7% to 3.4% (p<0.05). Malaria prevalence remained unchanged in U5 and PW. Non-MICAH anemia prevalence was higher for U5 (76.5%, n=1111, p<0.05) but non-significant for PW (46.2%, n=173). **Implications**: An integrated program can reduce anemia among women and children by increasing dietary intake of iron and addressing non-dietary causes of anemia. Decreasing malaria is likely to further reduce anemia levels. Community-level food fortification, initiated in 2001, is expected to sustainably increase program impact.

Th9 HEMOGLOBIN CONCENTRATIONS ARE INCREASED IN INDONESIAN CHILDREN WITH VITAMIN A AND DEWORMING INTERVENTIONS. S.A. Tanumihardjo, D. Permaesih and Muhilal. Dept. Nutritional Sciences, UW-Madison, Madison, WI and Research and Development Center, Bogor, Indonesia.

Background: Iron deficiency anemia is a major public health problem caused by multiple factors. Vitamin A status does affect hemoglobin concentrations (Hb). Aims: We investigated the improvement in Hb in preschool Indonesian children by looking at the change in vitamin A status and Hb after supplementation with 200,000 IU vitamin A and deworming with albendazole. Methods: Indonesian preschool children were screened for the presence of Ascaris lumbricoides and Trichuris trichiura. If a positive stool test was obtained (n = 130) they were enrolled. The children were grouped by length of time since administration of 200,000 IU vitamin A by the local health post. Group 1 (no vitamin A in the past >4 months) consisted of 51 children with Ascaris and 28 children with T. trichiura. After baseline Hb and vitamin A status assessment with the modified relative dose response (MRDR) test, they were given 200,000 IU vitamin A and albendazole. Follow up assessment was at 1 month. Group 2 (n = 51, vitamin A <1 month) were dewormed either before, during or after baseline MRDR and Hb measures. Results: Vitamin A status of group 1 was significantly improved by intervention in children with either Ascaris (P < 0.0001) or T. trichiura (P = 0.028) but one month post-dosing was not enough to see a significant improvement in Hb (P = 0.26). However in group 2, improved vitamin A status had been maintained for longer than one month and Hb was improved (P = 0.004). This improvement seemed to be enhanced by the length of time of deworming before follow-up assessments. Conclusions: Public health programs to improve vitamin A status may also improve Hb especially when linked to deworming regimens.

Th10 IMPACT OF AN INTEGRATED SCHOOL-HEALTH PROGRAM ON THE PREVALENCE OF ANEMIA AMONG SCHOOL CHILDREN IN RURAL BURKINA FASO. A Tarini, M Saka-Kaboré, Z Sifri, M Ag Bendech, EM Ilboudo and SK Baker. Catholic Relief Services (MSK), Helen Keller International-Burkina Faso (AT, ZS, MB), Centre national pour la nutrition, Burkina Faso (EMI), Helen Keller International-Africa Region (SKB).

Background: In Burkina Faso, an estimated 50% of school-age children are anemic. From 1999 to 2001, Helen Keller International and CATHWEL supported the Ministry of Basic Education in the design, implementation, and evaluation of an integrated school-health program in the province of Kourweogo (central Burkina Faso). **Objective**: To assess the impact of an integrated school-health package on anemia prevalence among school-age children. **Methods**: The intervention package included micronutrient supplementation (vitamin A and iron/folate), parasite control (mebendazole administration), and hygiene and nutrition education. The program covered 70 schools and enrolled a total of 9,745 schoolchildren less than 14 years old. Schoolteachers administered the iron/folate supplements (60 mg of elemental iron and 0.4 mg of folate) to children once weekly for 16 weeks. Hemoglobin concentration was assessed with HemoCue™ portable hemoglobinometer before and after the intervention. **Results**: The end-line survey after the 16-week intervention period showed high adherence levels to the supplementation regime; 89% of school children received the 16 required tablets. The prevalence of anemia among the children included in the project declined from 50% before intervention to 21% after intervention. This represents a reduction of about 57% in the prevalence of anemia; reduction was similar in boys and girls. **Conclusion**: Our findings show that an integrated school-based program that takes into account the multiple etiology of anemia can translate into significant reductions in anemia prevalence. Moreover, teachers when well prepared can play a fundamental role in obtaining and maintaining a high adherence levels to micronutrient supplementation regimes. These findings, together with those from the global research agenda on school-based anemia control strategies will inform policy and program development for the effective control of anemia in Burkinabe school-age children.

Supplementation

Th11 EFFECT OF IRON SUPPLEMENTATION ON GROWTH OF IRON-DEPLETE AND REPLETE BANGALDESHI CHILDREN. Tahmeed Ahmed, GJ Fuchs[1], MA Islam[2], A Dowla, T Islam, ME Haque, MA Wahed, Pat Crofton[3], T Ranke[4] , Chris Kelnar[3], William Cutting[3]. ICDDR,B: Centre for Health and Population Research, Dhaka, Bangladesh; [1]University of Arkansas, USA; [2]University of Alabama, USA; [3]University of Edinburgh, UK; [4]Tubingen, Germany

Objective: Investigate the effect of iron supplementation on growth of iron-deplete and replete Bangladeshi children. **Methods**: Iron-deplete and replete children aged 1-5 years, not suffering from malnutrition or any illness, were selected from a peri-urban community of Dhaka, Bangladesh. Iron-deplete children had a hemoglobin level <10.5 g/dl, serum ferritin <12 microgram/l, and serum transferrin receptor >8 mg/l. Cutoffs for these markers of iron status iron-replete children were >12 g/dl,>20 microgram/l, and <8 mg/l respectively. After the children were dewormed on enrolment, supervised iron supplementation was started at a dose of 3 mg/kg body weight per day for 3 months. Anthropometry was done on enrolment and then monthly for 3 months. Metabolic bone markers of growth were also measured at enrolment and after one month. **Results**: The mean enrolment age of the children in iron-deplete and replete groups were 35 and 48 months respectively. The mean weights were 10.8 and 12.7 kg respectively. The Z scores for weight for age, weight for height and height for age were similar between the groups. The mean weight gains over 3 months were 44.6 and 11.3 g/kg body weight in the 2 groups with difference persisting after adjusting for age. Result of bone metabolic markers will be presented. **Conclusion**: Iron supplementation to children with depleted iron stores not only replenishes iron stores but also promotes growth.

Th12 **IRON SUPPLEMENTATION DURING PREGNANCY IN THE ESTATE SECTOR OF SRI LANKA: IS IT EFFECTIVE?**
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Background: In the national strategy formulated by the Government of Sri Lanka all pregnant mothers should be given iron-folate supplements and ascorbic acid (to be taken once daily at night) and one course of anthelminthic therapy (after the first trimester of pregnancy) and supplementation continued for 12 weeks post partum. **Aims**: To study the effectiveness of the iron supplementation programme in a selected area in the estate sector. **Methods**: A cross sectional study was carried out in a cluster of upcountry estates (n=5) and low country estates (n=5). All pregnant mothers with a period of gestation <32 weeks (n=181) and 100 mothers at 10 to 24 weeks post partum resident in the same states were also studied. Interviewer-administered questionnaires were used to obtain information regarding interventions received during pregnancy and post partum. A venous blood sample was collected and haemoglobin and serum ferritin concentration was measured. Information on implementation of the iron supplementation programme was obtained by means of a questionnaire completed by health workers in respective estates. **Results**: 84% of pregnant mothers had received iron supplements, while only 6% of mothers had received supplements during the post partum period. Adequate stocks of iron supplements were available in 9 of 10 estates. Iron supplements were distributed in paper packages to 45.3% of subjects and advice regarding iron supplement intake was given to <50% of subjects. The prevalence of anaemia during pregnancy (Hb <110 g/L) and postpartum (Hb <120 g/L) was 25.1% and 35.0% respectively. Forty one percent of pregnant mothers and 44% of post partum mothers had serum ferritin <12 µg/L. A significant positive association was noted between haemoglobin concentration and serum ferritin concentration (p=0.000) intake of iron supplements the previous day (p=0.014) and anthelminthic therapy (p=0.001) among pregnant women. **Conclusions**: Unsupervised iron supplementation during pregnancy was effective in reducing the prevalence of anaemia, but it did not have a significant effect on iron stores, or on prevalence of anaemia at post partum. Iron supplementation should be continued up to 12 weeks post partum. Education of mothers regarding storage, intake and benefits vs. side effects of iron supplements is likely to increase the effectiveness of the supplementation programme.

Th13 IRON STATUS ALTERS COGNITIVE AND BEHAVIORAL FUNCTIONING IN WOMEN DURING REPRODUCTIVE YEARS. JL Beard[2], LE Murray-Kolb[2], E Perez[1], A Berg[1], M Tomlinson[2], J Irlam[1], W Isaacs[1], T Njengele[2], A Sive[1], M Hendricks[1]. [1]School of Child and Adolescent Health and Child Guidance Clinic, University of Cape Town, South Africa; [2]Dept Nutrition, Penn State University, USA

Background: Strong evidence exists that young children are at significant risk for effects of iron deficiency on behavior and cognition. Recently we began to question whether or not iron deficient adults have cognitive or behavioral dysfunctions as a result of this nutrient deficiency and whether young mothers might have different mother-child interactions as a result. **Aims**: To determine the relationship between iron status and cognitive and behavior in young women and mothers. In mothers, we also wanted to assess the impact of maternal iron deficiency on mother-infant interaction and infants' development. **Methods**: Two separate prospective intervention studies are reported: In the *first study* of 4-months duration we enrolled nearly 160 women between the ages of 18-35 assigned to iron supplements or placebo in either iron deficient anemic (IDA), iron deficient non-anemic (ID), or iron sufficient (CN) groups. We measured behavioral domains (anxiety and depression) and cognitive functioning at baseline and then again after 4 months. The *second study* was done with three groups of mothers (Cape Town, South Africa): a non-anaemic control group (C n=31) and two anemic groups on placebo (A, n=34) and iron therapy (B, n=30). Mothers of full term infants were recruited at 6-weeks post-partum and followed up until their infants were 9-months old. Maternal iron, socio-economic, intelligence, cognitive and emotional status; mother -infant interaction and infants' development were assessed at baseline and follow-up. **Results: Study 1**: Iron status was significantly associated with memory, learning, and attention with women in the lowest quintile of plasma ferritin requiring more trials to learn, displayed poorer memory, and were less attentive than women in the higher quintiles. They also had more anger, anxiety, and depression than women in the higher quintiles. **Study 2**: *At baseline*, anemic mothers had significant decrements in Digit Symbol and Ravens Matrices, more depression and anxiety than control mothers. *At follow-up*, significant effects of iron status on depression scores, perceived stress, Digit Symbol, and Ravens Matrices persisted in placebo treated mothers while iron treatment resulted in "better" scores on these 4 measures of functioning. Mother-child interactions were also related to maternal iron status. **Conclusion**: These studies demonstrate a significant relationship between iron status and cognitive functioning, depression, anxiety, and anger in adult women. In the USA and South Africa, women in vastly different social-economic, cultural, and social settings showed significant relationships between iron status, depression, and anxiety. This robust finding is quite significant given the estimates of iron deficiency in the world's young women.

Th14 EVALUATION OF ANAEMIA AMONG PREGNANT WOMEN IN DOUKKALA REGION IN MOROCCO. S Belgnaoui and R Belahsen. Training and Research Unit on Food Sciences, School of Science, El Jadida Morocco.

Background: Anaemia in pregnant women generates in the monther a great tiredness, a low resistance to infections as well as a decreased tolerance to haemorrhage and to surgical intervention at birth. Pronounced anaemia can have prejudicial effects on pregnancy and increases the risks of prematurity and low-weight at birth. A strategy of iron supplementation is systematically applied to pregnant women in Moroccan health centres. Aims: The purpose of this study is to determine the parameters of iron status among pregnant women in a region of Morocco: Doukkala, in order to evaluate the impact of iron supplementation strategy on anaemia. Methods: The study was carried out on 230 women at various ages of pregnancy, sampled from rural and urban areas. Data on socio-demographic, health, reproduction and dietary habits were examined. Blood samples were collected to determine biochemical and haematological parameters. Results: The results show that there isn't a systematic pregnancy follow up in the population studied, mainly in the rural area and that only about 40% of pregnant women have an iron supplementation. Anaemia persists, especially during the second and the third quarter of the pregnancy. The anaemia prevalence is higher in rural than urban area where it can reach 50%. The results show also that 30% of the women studied have haemoglobin rates which can harm a good gestation. Conclusion: The results are discussed according to biochemical parameters of iron metabolism, dietary habits and socio-economic data.

Th15 **MULTI-MICRONUTRIENT SUPPLEMENTATION IN VIETNAMESE INFANTS.** LT Hop*, J Berger#, DT Quyen*, TT Lua*, R Vallo#. *National Institute of Nutrition (NIN), Hanoi, Vietnam; #The Institute of Research for Development (IRD), Montpellier, France.

Background: In Vietnam, infants suffer from simultaneous micronutrient deficiencies. Multi-micronutrient supplementation aims to increase cost-effectiveness of interventions. **Aims**: To assess the efficacy of daily and weekly multi-micronutrient supplementation (MM) on nutritional status and morbidity in infants. **Methods**: A randomized, double blind controlled trial in 306 infants aged 6-12 months, in Soc Son district of Vietnam. Supplements were given for 6 months under supervision: group 1 received daily MM (1RDA of vitamin A, B-1, B-2, B-6, B-12, C, D, E, folic acid, niacin, Fe, Zn, Cu, I), group 2 daily a placebo, group 3 weekly MM (2 RDA) and group 4 daily iron (10 mg). Hemoglobin (Hb) and serum ferritin (SF), zinc (SZn), copper (SCu), retinol (SR), tocopherol (ST), homocysteine (SH), riboflavin (SB2) were measured at baseline and at end of intervention (T6). Anthropometry was measured monthly and morbidity daily. **Results**: 301 infants completed the study. Length-for-age (LAZ) and weight-for-length worsened during intervention in all groups but LAZ decreased significantly less in group 1 (-0.32±0.05 z-score) than in groups 2 (–0.49±0.05) and 3 (-0.51±0.05, p=0.001). Hb increased significantly more in groups 1 (15.9±1.8 g/L), 3 (14.1±1.8 g/L) and 4 (13.5±1.8 g/L) than in group 2 (8.9±1.8 g/L, p=0.04). SF changes were significantly higher in groups 1 (+11.7 µg/L) and 4 (+9.4 7 µg / L) than in groups 2 (-15 7 µg /L) and 3 (-9.9 7 µg /L, p<0.001). At T6, no children in groups 1 and 4 had SF<10 7 µg/L but 50% in group 2 and 29% in group 3 (p<0.0001). ST and SH changes were significantly higher in group 1 than in other groups except for SH compared with group 3. SR, SZn, SCu, SB2 changes did not differ significantly between groups. Morbidity data will be presented. **Conclusion**: 6-month daily MM had a significant positive effect on growth, Hb, SF, ST and SH whereas weekly MM improved Hb and daily iron supplementation improved iron status. In the framework of *"International Research on Infant Supplementation" (IRIS). Funded by UNICEF.*

Th16 SCHOOL PARTICIPATORY APPROACH FOR IRON SUPPLEMENTATION DISTRIBUTION PROGRAM: USING A SOCIAL MARKETING STRATEGY. N Eid, A Gohar, I Ismail, A Darwish. Nutrition Institute, Cairo, Egypt

Background: In Egypt the prevalence of IDA among school children (aged 11-18 years) reached about (29%). An iron supplement distribution program has been going on through School Health Insurance sector/MOHP for preparatory and secondary schools in upper Egyptian governorates. However a more convenient feasible and effective method of delivery is needed. **Aim**: To implement and evaluate a non-traditional school-based participatory method of iron tablet distribution. **Methods**: Twelve schools were chosen from two lower Egyptian governorates. A weekly dose (one tablet of 60 mg iron and 300 µ folic acid) was scheduled for 8 weeks following a broad spectrum anti-helmenthic treatment. Advocacy and partnership meetings were carried out to motivate school staff to share in the program. A school committee of (3-4) school staff members was formed in each school and trained to be responsible for supplement distribution, recording student compliance and conducting communication/education activities. Monitoring and Evaluation was made both qualitatively; and quantitatively as well as with pre /post screening for anemia prevalence. **Results**: school committees were able to distribute iron in short time (5-10 minutes/class) with minor obstacles. There was a high coverage (97%) of children participating in the program. Compliance to the weekly supplement reached (83%) of intended amounts, with higher compliance of rural schools than urban (89% vs73%), females more than males (86% vs. 80%) and younger more than older students (87.6% vs. 74%). Health impact of the program showed decrease of anemia prevalence from (12.96% to 9.01%), and was found highly associated with compliance of students to the regimen of scheduled tablets. **Conclusion**: School-based participatory approach for iron supplement distribution with social marketing activities is an effective feasible method for distribution.

Th17 IMPROVING COMPLIANCE TO IRON PILL OF PREGNANT WOMEN: THE IMPORTANCE OF HUSBAND ROLE. H Hadi, MD Jamil, D Susetyo, and Wahyuni.

Background: Low compliance to iron pill was reported to be the major constrain to reduce anemia in Indonesian pregnant women. Being forgot and undesirable side effects of daily iron pill were observed to be associated with low compliance. Aims: To examine the importance of husband role in increasing compliance to iron pill. Methods: Pregnant women with gestation age of 16-20 weeks from 4 zones of Jogjakarta Province were followed up until delivery and their compliance to iron pill was recorded. Pregnant women from the 1st zone (n=68) received daily iron pill under their husband observation; those from the 2nd zone (n=56) received the same iron pill under village midwifes observation; those from the 3rd zone (n=55) received two iron pills every Monday; one in the morning and another one in the night without observation; and those from the 4th zone (n=65) received daily iron pill as usual (stayed as control group). After receiving health education on the importance of iron pill for pregnancy outcome, husbands were instructed to monitor and remind their wife to always take iron pill while village midwifes were asked to monitor and remind pregnant women any time they had contacts to take iron pill. Results: On average, the compliance to iron pill in the control group was 71.9%. The compliance in the 1st zone was 16% higher ($p<0.001$) than that in the control group. In the 2nd zone it was only 8.3% higher ($p>0.05$), while in the 3rd zone it was 13.2% higher $p<0.01$) than that in the control group. Pregnant women in the 1st and the 3rd zones were 8.5 times and 4 times (respectively) more likely to have compliance >= 80% than those from the control group. Conclusions: Husband role is the strongest potential factor to improve compliance to iron pill of Indonesian pregnant women.

Th18 **EFFICACY OF MULTI-MICRONUTRIENT AND SINGLE IRON SUPPLEMENTATION ON NUTRITIONAL STATUS & MORBIDITY OF INDONESIAN INFANTS.** J Untoro*, E Karyadi, Lindawati, and M Wijaya. SEAMEO-TROPMED Regional Center for Community Nutrition, University of Indonesia, Jakarta, Indonesia. *Present address: World Bank, Jakarta, Indonesia

Background: Deficiencies of micronutrient are commonly prevalent in developing countries, affecting vulnerable group such as infants. However, the existence of concurrent deficiencies among infants has received little attention. Intervention focus on single micronutrient often lack of effectiveness. Weekly instead of daily supplementation may improve effectiveness. **Aims**: To investigate the efficacy of multi-micronutrient and single iron supplementation in improving micronutrient status, growth and morbidity of Indonesian infants. **Results**: In this double-blind, placebo-controlled trial, 260 infants aged 6-12 mo were randomly allocated into 4 different treatments. First group received daily 1 RDA multi-micronutrient supplementation (n= 66), group 2: daily placebo (n=65), group 3: weekly 2 RDA multi-micronutrient with another 6 days of daily placebo (n=60), group 4: daily iron 10 mg (n=69). Venous blood samples were collected at the baseline and post-treatment for assessing the concentrations of iron, vitamin A and zinc. Anthropometric measurement were taken monthly, and morbidity were recorded daily during 6 mo of supplementation. At baseline, 58.7% of subjects were iron deficiency anemia, 11.2% zinc deficiency and 25.1% marginally vitamin A deficiency. All treatment groups were able to significantly increase the iron stores of the infants ($P<0.001$) but not the hemoglobin ncentration. The 1 RDA multi-micronutrient supplementation was able to increase the hemoglobin concentration of anemic infants and improve zinc concentration of zinc deficient infants. There was no significant difference in growth and morbidity between groups. **Conclusions**: Daily 1 RDA multi-micronutrient supplementation for 6 months among micronutient-deficient infants was more efficacious than those of weekly 2 RDA multi-micronutrient supplementation and daily iron supplementation in improving iron and zinc status. There was no intervention affected the growth and morbidity of the infants.

Th19 WEEKLY PREVENTATIVE IRON-FOLATE SUPPLEMENTATION FOR WOMEN AND SCHOOL GIRLS OF REPRODUCTIVE AGE IN CAMBODIA. K Ou 1, D Touch 1, P Ouk 1, S Or 1, M Sau Sokun 1, J Busch-Hallen 2, M Dunbar 2, T Cavalli-Sforza 3, S Smitasiri 4, E Kenefick 5. 1 Ministry of Health, Cambodia, 2 WHO Phnom Penh, Cambodia, 3 WHO Western Pacific Regional Office, Manila, The Philippines, 4 Mahidol University, Bangkok, Thailand, 5 WFP, Rome, Italy.

Background: In Cambodia the prevalence of anemia is 58% in women of reproductive age (WRA) and 65% in pregnant women despite a national iron-folate supplementation program for expectant mothers. Aim:To evaluate the effectiveness of weekly iron–folate supplementation and six-monthly mebendazole, combined and separate, for improving haemoglobin levels in WRA attending secondary schools and living in rural communities in Cambodia. Method: Schoolgirls of reproductive age attending five secondary schools (N=640) and WRA living in 139 villages (N=12000) in Kampong Speu province were included in the project. The Cambodian MOH collaborated with six other ministries and UNICEF through the Seth Koma integrated community development program in Kampong Speu province. Preventative iron–folate supplements (60mg iron + 3.5mg folate) were sold by teachers and village health volunteers to WRA and schoolgirls for 7 months. Deworming was also provided free of charge with six-monthly administration of mebendazole (500mg) to girls at three schools and women in 5 villages. At the beginning a social marketing and training campaign was initiated to inform women about the importance of dietary diversification and preventative iron-folate supplementation. Knowledge, attitude, behavior and practice (KABP) and haemoglobin (anaemia) were independently evaluated in about 85% of the secondary school girls and approximately 10% of the village women at baseline and 7 months. The prevalence and intensity of intestinal parasites were also evaluated for those participants receiving mebendazole. Results: There were highly significant increases ($p < 0.001$) in knowledge, attitudes, behaviors and practices in both groups, with 90-100% of women giving correct responses to KAP questions. The final impact results are still being analysed and will be reported here.

Th20 **Maternal Iron Deficiency Anaemia alters Mother-Infant Interaction and Infant Development**. E Perez[1], M Hendricks[1], A Berg[1], M Tomlinson[2], J Irlam[1], W Isaacs[1], T Njengele[2], A Sive[1], L Feagans[2], L Murray[2], J Beard[2]. [1]School of Child and Adolescent Health and 2Child Guidance Clinic, University of Cape Town, South Africa; [2]Dept Nutrition, Penn State University, USA.

Background: While the impact of iron deficiency in infancy has been examined many times, few studies examined the impact of *maternal* iron deficiency anaemia on mothering "characteristics" **Aim**: To assess the impact of maternal iron deficiency anaemia (IDA) on mother-infant interaction and infants' development. **Methods**: A prospective randomized controlled intervention trial was done with three groups of mothers: a non-anaemic control group (C) and two anemic groups on placebo (A) and iron therapy (B). Mothers of full term infants were recruited at 6-weeks post-partum and followed up until their infants were 9-months old. Maternal iron, socio-economic, intelligence, cognitive and emotional status; mother -infant interaction and infants' development were assessed at baseline and follow-up. Anaemic mothers were given either daily iron supplements or placebo and other causes of anaemia identified.

Results. ***At baseline*** there were 95 mother-infant pairs: [control=31, iron treated=34 and placebo treated=30]. Infants in all 3 groups had similar birth weights and anthropometric status. Infants of anaemic mothers (A and B) compared to infants of control mothers (C) performed worse in the Griffith's developmental test (mean GQ 100.3 vs. 109.7; $p<0.05$). There were no significant differences between groups in mother-infant interaction at this time. ***At follow-up***, there were 81 mother-infant pairs [A=21, B=30 and C= 30]. Infants of control mothers performed significantly better in the Locomotor scale ($p<0.05$) and overall General Quotient scales ($p<0.07$) of the Griffith's developmental test than infants of the anaemic mothers. In mother-child interaction scales, anaemic mothers receiving placebo were significantly different than iron treated mothers and control mothers in Goal Setting, Responsiveness and Negative statements scales. Goal setting and Directives were positively correlated with iron status. **Conclusions**: Iron deficiency anaemia during the post-partum period and through the first 9 months of lactation significantly alters the mother-child relationship at 9-months of age. The infants of these anaemic mothers also develop differently than infants of non-anaemic mothers as evaluated by a common developmental scale. The long-term consequences of this altered mother-child interaction due to iron deficiency on infant development is unknown though other studies of high-risk mothers suggest permanent alterations do occur.

Th21 **AN ACTION RESEARCH TO CONTROL AND PREVENT IRON DEFICIENCY AND IRON DEFICIENCY ANEMIA IN WOMEN OF REPRODUCTIVE AGE IN A FACTORY IN THAILAND.**

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Background: In Thailand, a national survey in 1995 showed that 16.8% of women of reproductive age (WRA) suffered from anemia. In 2000, the Department of Health set up a "Healthy Workplace Campaign" by promoting weekly iron intake of ferrous sulfate (60 mg elemental iron) among WRA. **Aims**: To decrease iron deficiency (ID) and iron deficiency anemia (IDA) through iron supplementation and increase knowledge and practice (KP) among WRA. **Methods**: An action research was conducted among 118 WRA in a factory. Pre and post data collection included Hemoglobin (Hb), Serum Ferritin (SF) and KP on ID and IDA. A focus group discussion, in-depth interview and observation were employed for evaluation. The intervention was weekly iron supplementation and an information, education and communication (IEC) program operated by two "Change Agents" in the factory for 20 weeks after a 400 mg single dose of Albendazole was administered to each WRA for hookworm eradication under direct observation. Results: The pre and post mean (SD) Hb were 112 (11) and 112 (10) g/dL, SF (SD) were 80.7 (66) and 110.0 (92) mcg/L ($p<0.001$). The prevalence of ID (SF < 30 mcg/L) and IDA (SF < 30 mcg/L + Hb < 120 g/dL) before the intervention were 5.1 and 8.5 then it was decreased to 0 and 3.4% respectively after the intervention. The pre and post mean (SD) scores of knowledge on iron-rich food were 4.7 (2.2) and 6.1 (1.9) ($p<0.001$), iron-rich food consumption were 3.0 (1.7) and 3.1 (1.7), knowledge on ID and IDA were 13.4 (4.0) and 14.7 (3.6) ($p<0.01$). Compliance on iron tablet consumption was 89.8%. Reasons for compliance among WRA were: Feeling the benefit of iron tablet intake and close supervision. Sustainability if affected by factory's management perceiving benefit for the factory at low cost. **Conclusion**: Weekly iron tablet supplementation along with IEC can prevent and control ID and IDA. Advocating the benefit of this program to workplace management is crucial and "change Agents" played an important role in this study.

Th22 MULTI-CENTRE STUDY ON MULTI-MICRONUTRIENT SUPPLEMENTATION IN SMALL CHILDREN: SOUTH AFRICAN EXPERIENCE. CM Smuts, M Faber, MA Dhansay, ME van Stuijvenberg, R Gross and AJS Benadé. Nutritional Intervention Research Unit, MRC, Tygerberg 7505, South Africa.

Background: Infants in developing countries are at risk of suffering from more than one micronutrient deficiency, because the same causative factors may lead to a deficiency of different micronutrients. IRIS (International Research on Infant Supplementation) was a multi-centre study that aimed to examine the efficacy of a multi-micronutrient supplement in 6-12-month-old infants from four different countries. The study was carried out in Indonesia, Vietnam, South Africa and Peru. This paper reports on the South African data. Design: The study had a randomized, double blind placebo controlled design. Infants (n=263) were randomly allocated to one of four treatment groups, namely, (i) placebo daily; (ii) 1 RDA iron only daily; (iii) 1 RDA multi-micronutrients (MM) daily; and (iv) 2 RDA MM once per week. Results: At baseline the prevalence of anaemia (Hb < 11 g/dL), iron deficiency (ferritin < 12 µg/L), vitamin A deficiency (plasma retinol < 0.70 µmol/L) and zinc deficiency (plasma zinc < 10.7 µmol/L) were 40%, 19%, 18% and 46%, respectively. After 6 months of intervention there was an improvement in Hb status in all three iron treatments; however, the treatment effect was significant for the 1 RDA daily MM supplement only. Significant treatment effects for ferritin were seen in both the 1 RDA MM daily and 1 RDA iron daily groups. For retinol, zinc, riboflavin and folate the treatment effects were greater in the 1 RDA MM daily group than in the 2 RDA MM weekly group.

Conclusion: According to the IRIS results from South Africa it appears that daily supplementation with 1 RDA was more effective than weekly supplementation with twice the RDA. It also appears that iron given together with other micronutrients was more effective in raising Hb levels than iron on its own. However, only the statistical analysis on the collated data from the four participating countries will have enough power to measure the final outcome to make objective recommendations.

Th23 WEEKLY PREVENTATIVE IRON-FOLATE SUPPLEMENTATION IN WOMEN OF REPRODUCTIVE AGE WORKING IN CAMBODIA.

D Touch [1], P Ouk [1], S Or[1], M Sau Sokun [1], J Busch-Hallen [2], M Dunbar [2], T Cavalli- Sforza [3], S Smitasiri [4], E Kenefick [5]. [1] Ministry of Health, Cambodia, [2] WHO Phnom Penh, Cambodia, [3]WHO Western Pacific Regional Office, Manila, The Philippines, [4]Mahidol University, Bangkok, Thailand, [5]WFP, Rome, Italy.

Background: In Cambodia the prevalence of anaemia is 58% in women of reproductive (WRA) age and 65% in pregnant women. WRA (non pregnant) are difficult to access within existing government programs in Cambodia. Between 70 and 99% of Cambodian garment factory workers are under 29 years of age and most are women. The garment industry generates about 90% of all Cambodian exports. A reduction in the prevalence of anaemia in garment factory workers would not only contribute substantially to their health, but also to their productivity and to the economic development of Cambodia. Aim: To evaluate the effectiveness of weekly iron–folate supplementation and six-monthly mebendazole, combined and separate, for improving haemoglobin levels in women of reproductive age working in garment factories. Method: WRA (non pregnant) working in 8 factories (N= 9000) in Phnom Penh were included in the project. The Cambodian government, including collaboration from several ministries and departments, offered weekly iron–folate supplements (60mg iron + 3.5mg folate) to all women within existing factory structures for 12 months. Deworming was also provided with six-monthly administration of mebendazole to women at three of the factories. At the beginning a social marketing and training campaign was initiated to educate the women about the importance of dietary diversification and preventative iron-folate supplementation. Knowledge, attitude, behavior and practice (KABP), haemoglobin (anaemia) and intestinal parasites were independently evaluated in a randomly selected sample of approximately 10% of the study population at baseline, 3 and 12 months. Results: Compliance in the factories was high, with 83% of women taking the supplements at follow up. There were significant increases ($p<0.001$) in knowledge, attitudes, behaviours and practices regarding iron supplements, iron and vitamin C rich foods, and anaemia. The final impact results are still being analysed and will be reported here.

Th24 **COST-EFFECTIVENESS OF AN IRON SUPPLEMENTATION PROGRAM FOR WOMEN AND CHILDREN IN A RURAL DISTRICT OF VIETNAM.**

VTM Dung, T Tuan, TD Thach, NX Ninh, E Boy, J Cervinskas. Center for Research and Training on Community Development, Hanoi, National Institute of Nutrition, Hanoi, Viet Nam, and Micronutrient Initiative, Canada.

Background: Notwithstanding the existence of a national policy for anemia control, as of the year 2000 less than 15% of the population had access to iron supplementation in Vietnam. Integrating iron supplement delivery with other ongoing community health activities was considered an appropriate alternative to accelerate the control of anemia in women and children. **Aims**: To determine the cost-effectiveness of daily supplementation to pregnant women and of weekly supplementation to children 6-23 months of age and non-pregnant women of 15-34 years old through a community-based model of iron administration integrated with EPI and vitamin A supplementation. **Methods**: A community-based quasi-experimental study was conducted in a district in which there had been no previous interventions to control anemia among children or women. In line with the national policy, pregnant women received one tablet with 60mg iron and 0.4 mg folic acid per day from diagnosis of pregnancy to one month postpartum. Non-pregnant women received weekly doses of 60mg iron + 0.4 mg folic during 4 consecutive months. Children 6-23 months of age, were given 1 mL of ferrous sulphate syrup (25 mg iron/mL) weekly. This intervention was provided in 10 communes for 7 months. A further 10 comparable communes without intervention were used as control. Before- and after- intervention surveys were carried out with representative samples to measure hemoglobin levels in all the targeted groups in both intervention and control communes. Hemoglobin concentration was determined using the Corning™spectrophotometer at a fixed wave-length of 540 nm. Coverage rate (%) and women's compliance with iron tablet intake were measured through household surveys. **Results**: The prevalence of anemia in pregnant women adjusted for gestational age was reduced from 25.4% to 12.5% ($P<0.001$), and in children adjusting for age from 68% to 31.7% ($P<0.001$). Changes in mean hemoglobin concentration in the non-pregnant women groups were not statistically significant. Compliance with iron supplement intake remained high at 70%, 74% and 80% in the pregnant women group, but varied in the child-bearing women group, from 58.5%, to 80% and 38% at baseline, mid-term and final evaluation, respectively. The average cost per pregnant woman in whom anemia was prevented was US$2.18. The cost of delivering the iron supplement to a child-bearing age woman monthly was $0.28 compared with $0.24 for pregnant women. The average cost of the intervention per child in whom anemia was prevented after 6 project-months was $4.73. To have a child supplemented with 4 doses of iron syrup in the project month, cost is $0.40, reduced to $0.11/ month once the iron supplementation became a routine task. **Conclusions**: When implemented, the current policy of iron supplementation had a significant impact on the prevalence of anemia among pregnant women and children 6-23 months at costs acceptable and affordable to a poor socio-economic community, but did not show significant impact among non-pregnant women.

Th25 ZINC AND ß-CAROTENE ADDED TO IRON SUPPLEMENTATION DURING PREGNANCY IMPROVES BIRTHWEIGHT AND MORBIDITY OF INFANTS. FT Wieringa, MA Dijkhuizen, CE West, J Van der Ven, Muhilal, JMW Van der Meer. Division of Human Nutrition and Epidemiology, Wageningen University, Netherlands; Nutrition Research and Development Centre, Bogor, Indonesia; Department of Internal Medicine, Catholic University Nijmegen, Netherlands.

Background: Micronutrient deficiencies are prevalent in pregnant women, adversely affecting pregnancy outcome, including increased delivery complications and lower birthweight. Maternal micronutrient nutrition could be an important determinant of the newborn's nutritional status and immunocompetence. Aims: To investigate whether supplementation of pregnant women with ß-carotene and/or zinc in addition to standard iron+folate can reduce pregnancy complications, increase birthweight, and improve morbidity of newborns during the first 6 months of life. Methods: In a randomized double-blind trial, pregnant women (229), <20 weeks pregnant, were supplemented daily until delivery with iron+folate, in combination with zinc (30 mg) and/or ß-carotene (4.8 mg) or neither. Mothers and newborns were followed for 6 months. Results: Supplementation with ß-carotene+zinc in addition to iron+folate increased birthweight in boys, but not in girls. However, women supplemented with only zinc added to iron+folate had more complications during delivery (12 vs. 3 in the zinc vs. control group, P<0.05). Although overall morbidity of the infants during the first 6 months of life was not different among the groups, diarrhoeal episodes tended to be less frequent after zinc supplementation during pregnancy (P=0.06). This was especially apparent in low birthweight (<3 kg) infants for which both the number of diarrhoeal episodes was less (mean 0.019 vs 0.077, P<0.01), as well as the episode duration(0.5 vs 1.8, P<0.01). Infants in the zinc only group tended towards more episodes of coughing (P=0.094). ß-Carotene supplementation did not significantly affect morbidity patterns. Conclusion: Zinc and ß-carotene supplementation can be useful additions to the standard iron+folate supplements for pregnant women, improving pregnancy outcome and morbidity during the first 6 months of life. The increased incidence of pregnancy complications after zinc supplementation warrants further research.

Infectious Diseases

Th26 PREVALENCE OF SUBCLINICAL INFLAMMATION AS INDICATED BY ELEVATED SERUM ALPHA-1 ACID GLYCOPROTEIN (AGP) AND IMPLICATIONS FOR IRON STATUS ASSESSMENT IN NICARAGUAN CHILDREN. **N Ahluwalia**, E Boy, J Bulux, Y Medrano, CB Wallace, and N Solomons. Penn State University, University Park, PA, USA; Micronutrient Initiative, Ottawa, Canada; CeSSIAM, Guatemala City, Guatemala; and Universidad Nacional Autónoma de Nicaragua, Managua, Nicaragua.

Background: Recent studies in malarial areas of Kenya and Ivory Coast have illustrated the impact that infection and inflammation can have on the valid interpretation of iron-status indicators, notably serum ferritin.
Aims: Our interest was to determine the prevalence of subclinical inflammation (INF) and its impact on assessing iron status in young children in a tropical region in absence of malaria. **Methods**: Serial measurements of AGP, dried serum spot (DSS) ferritin, and hemoglobin (Hb) were made in young children (3 – 9 y) in rural communities in Nicaragua, at baseline and 6 and 12 mo following intervention with vitamin A-fortified sugar. Completed data on 147 children (age: 6.3 ± 1.4 y; 79 M and 68 F) at baseline examination were used for the present analyses. **Results**: The prevalence of subclinical INF (AGP > 1.1 g/L) was high (16%). Children with high AGP had significantly greater serum ferritin than those with normal AGP levels; geometric mean and range were 28 (20 – 40) and 20 (12 – 33) µg/L, respectively (p< 0.05). Serum AGP levels correlated significantly with serum ferritin (r = 0.22, p < 0.001). Prevalence of anemia was 8% and not affected by INF or gender (p > 0.10). Using serum ferritin < 12 µg/L, 14% children (17% children without and 0% children with INF) were considered iron-deficient. With a higher cut-off of 16 µg/L, prevalence of iron deficiency was 33% and 4% in children without and with INF, respectively. These data suggest that a cutoff > 16 ¼g/L is indicated for children with elevated AGP. **Conclusions**: In this low-income tropical country, subclinical INF, reflected by elevation of Serum AGP, was common, presumably due to the poor hygienic conditions. The implications for iron status assessment include that: some fraction of low Hb may be secondary to INF, and the diagnosis of iron deficiency based on serum ferritin is affected by presence of INF. Revised cut-offs for serum ferritin, to suitably adjust for the effect of coexisting INF, are needed to reliably assess iron status in presence of infection.

Th27 **IRON STATUS OF MALARIA PATIENTS IN DOUALA TOWN. I.** **Gouado**, N.M. Djuidjé, Department of Biochemistry, Faculty of Science, University of Douala. Po Box: 24157 Douala, Cameroon.H.K. Fotso, Laboratory of biology, Laquintinie Hospital, Douala, Cameroon. **Background**: In Africa, anaemia associated with plasmodium falciparum infection is a major cause of childhood morbidity and mortality. Problem of severe anaemia linked to malaria is increasing as antimalarial drugs resistant parasites widespread throughout Africa. In Cameroon, it turn out to be the dominant parasitosis with the higher number of annual decease, especially among young and pregnant women. Aim: This work was carry out to find out the relationship between iron status and malaria among cameroonian. **Methods**: Iron status of malarial was evaluated using three biochemical (Serum Iron: SI, Total Iron Binding capacity: TIBC, and Transferin Saturation:TS) and five haematological (Haemoglobin: HGB, Haematocrit: HTC, Mean Cell Volume: MCV, Mean Cell Haemoglobin: MCH and Mean Corpuscular Haemoglobin Concentration: MCHC) parameters. Blood samples came from 163 subjects with malaria (aged between 0-60 years) and 98 uninfected subjects (aged between 0-65) in Douala town, where malaria is endemic. **Results** showed that 41.7% and 63.19% of malarial are serum iron and haemoglobin deficient respectively. Moreover, the rates of SI, TS, HGB, HTC, MCV and MCH are significantly lesser in malarial than controls (p<0.01). Therefore, the TIBC rate is significantly higher among the malarial than in the uninfected subjects (P<0.01). This rate decreases with age while HGB, HTC and MCV percentages increase with age. It was also observed that parasitic density is higher in patients age between 0-3 years (3365.71 ± 432.85 TPF/mm3) than those between 4-25 years (1483.05±293.02 TPF/mm3) and between 26-60 years of age (602.94 ±108.75 TPF/mm3). We noticed significant (P<0.01) increase of SI with moderate parasitaemia. Significant (P<0.001) correlations between SI and TS (r=0.63), HGB and HTC (r= 0.865), age and parasitaemia (r>-0.3) were observed among malarial.**Conclusion**: This result suggested that malaria negatively affects iron status, but we need further research on iron metabolism for the better comprehension of the mechanism by which Plasmodium falciparum interact with iron status.

Th28 ANEMIA AMONG HIV INFECTED AND UNINFECTED POST PARTUM WOMEN: PREVALENCE AND HEALTH IMPLICATIONS. The ZVITAMBO Study Group. The University of Zimbabwe (Harare), Harare City Health Dept, Ctr for Human Nutr, Johns Hopkins Bloomberg School of Public Health (Baltimore, MD, USA), Montreal General Hospital Research Institute (Canada).

Anemia affects 1/3-1/2 of all African women, increases risk of poor pregancy outcome, and is usually correctable with iron-folate supplementation. Anemia also affects half to nearly all HIV infected people, is associated with earlier death, and (in industrialized countries) is usually correctable with recombinant erythropoietin (rHuEPO). Pregnant HIV+ African women are therefore at very great risk of anemia due to multiple etiologies, though their anemia and HIV infection are often undiagnosed and rHuEPO is financially out of reach. Concern has been raised regarding risk (possibility of iron overload) and benefit (possibility of correcting anemia) of iron supplementation for anemic HIV+ women. **OBJECTIVE**: To examine the prevalence and severity of anemia among post partum women enrolled in the ZVITAMBO trial, to determine if anemia is a risk factor for early death among HIV+ women, and to examine Hb response among anemic HIV+ women given iron supplements. **METHODS**: Hb was measured in 8187 women within 96 hours of delivery using Hemacue. HIV status was determined from the same blood sample by ELISA. CD4 count was measured by FACsCount from HIV+ samples. Anemic women were referred to the study physician. Women were followed at 6 wk, 3 mo, and then 3 monthly to 12 mo. **RESULTS**: 3020 women were HIV+ and 5167 were HIV neg at delivery. Mean Hb was 11.27 (SD=1.96) g/dl and 12.08 (SD=1.88) g/dl for HIV+ and HIV neg women, respectively ($p<0.01$). Having a Hb <10 g/dl was nearly twice as common among HIV+ compared to HIV neg women. Using Cox proportional hazards model to adjust for baseline CD4, HIV+ women with Hb between 7-11 g/dl and Hb <7 g/dl were 1.6 and 6.0 times more likely, respectively, to die by 6 months post partum compared to HIV+ non-anemic women. Analysis is underway to examine Hb response to prescribed iron supplementation and to identify other covariates. Funded by Nestle Foundation, CIDA, and USAID.

Th29 DETERMINANTS OF ANEMIA AMONG MOTHERS AND CHILDREN IN A LOW-INCOME POPULATION OF THE BOLIVIAN LOWLANDS AS GUIDES TO DEVELOPING COMMUNITY INTERVENTIONS. G O'Donnell, J Barrows, V Sheffield, and W Abastoflor. International Eye Foundation, Bethesda MD, and Centro de Promoción Agropecuaria Campesina, Santa Cruz, Boliva.

Background: Recent evidence suggests that iron status is not the sole determinant of endemic anemia in poor communities. Hence, other interventions along with iron delivery may by required to maximize hematological status and its related physical and cognitive performances. **Aims**: To determine the prevalence of maternal and preschooler anemia in a lowland Bolivian population and to assess potential non-nutritional determinants of hematological status. **Methods**: In 600 children of both sexes, aged 0 to 60 mo, and 600 corresponding mothers (or female caretakers), aged 15 to 74 years, from a stratified cluster sample in the Ichilo Province, Santa Cruz, Bolivia, hemoglobin concentrations were determined by Hemocue. Extensive questionnaire information on education and economic status, household infrastructure, child health and feeding practices was also obtained. Fecal samples for protozoa and helminth ova were collected in 20% of the child subjects and 20% of women. **Results**: Based on cutoff criteria of <105 g/L (0 – 11 mo) and <110 g/L (12-60 mo) 41.7% (95% CI 37.7 – 45.6%) of children were anemic. Rates were lowest in the first 6 months of life (11.9%) and highest from 6 to 24 months (65.3%), tapering down to 22% by the 5th year. Using a <120 g/L criterion, 40.0% (95% CI 36.1-44.0%) of women were anemic. In adjusted analyses, being male, presence of fever, defecating in a field having animals for sale or consumption, and lower maternal age and education were significant risk factors for childhood anemia. With respect to maternal risk, only defecation in the field ($p = 0.07$) approached significance among adjusted predictive variables. Overall prevalence of parasite was 62% in children and 75% in women. Among blood-feeding species, the respective child/maternal amebiasis rates were 6.9%/24.4%; for whipworm, 6.1%/7.3%; and for hookworm, 16.0%/26.8%. **Conclusion**: Although reversing the predictors of risk is not necessarily a key to achieving benefits, any determinants of risk for anemia which are amenable to community interventions, such as lack of indoor plumbing, early pregnancies, maternal illiteracy, and poor antenatal care, are of public health interest in the expanding global campaign to reduce endemic anemia rates.

Th30 HELICOBACTER PYLORI INFECTION, GASTRIC ACID SECRETION, AND IRON ABSORPTION IN BANGLADESHI CHILDREN. SA Sarker, L Davidsson, H Mahmud, T Walczyk, RF Hurrel, N Gyr and GJ Fuchs. ICDDR,B:Centre for Health & Population Research, Dhaka, Bangladesh, Swiss federal Institute of Technology,Zurich, and Univerity of Basel, Switzerland and University of Arkansas for Medical Sciences, Arkansas, USA.

Background & Aim: Gastric acid secretion is an essential luminal factor for iron absorption. Reduced gastric acid output (GAO) as a consequence of Helicobacter pylori (Hp) infection could be an important limiting factor for Fe bioavailibility.
Methods: Children 2 to 5 years old with iron deficiency anemia, with or without Hp infection (determined by 13C-urea breath test), were enrolled. GAO was quantified before (basal acid output, BAO) and after pentagastrin stimulation (stimulated acid output, SAO). Iron absorption from a non water-soluble iron compound (ferrous fumarate) was compared with that of a water-soluble iron compound (ferrous sulfate) by a double stable isotope technique. Hp-infected children were studied before and after treatment of the infection.
Results: BAO and SAO were significantly lower in the Hp infected compared to non infected children. Eradication therapy in the Hp-infected children was associated with a significant increase of both BAO and SAO, attaining values comparable to those of the Hp-non infected children. Iron absorption from ferrous sulfate was significantly greater than from ferrous fumarate before (19.7% vs. 5.3%; $p<0.0001$) and after treatment (22.5% vs. 6.4%; $p<0.0001$) in 12 Hp-infected children. Corresponding values for non-infected children were 15.6% vs. 5.4% ($p<0.001$; $n=12$). Eradication therapy in Hp-infected children was associated with increased hemoglobin concentration ($p<0.005$) although there was no concomitant improvement in absorption of either iron compound.
Conclusions: In contrast to earlier observations in healthy Western adults, iron absorption from ferrous fumarate was significantly lower than from ferrous sulfate in both Hp-infected and non-infected Bangladeshi children. Although Hp infection was associated with impaired gastric acid secretion, infection did not significantly influence iron absorption from the two iron compounds. Treatment of H. pylori infection improved gastric acid output and hemoglobin concentration, but had no effect on iron absorption. These latter results indicate that the efficay of ferrous fumarate as currently used in iron fortification programs to prevent iron deficiency in young children needs to be defined.

Th31 PARASITIC INFECTION AND ANEMIA IN SCHOOL AGED CHILDREN IN MACEIÓ, BRAZIL. CMD Santos, LMP Santos, JN Figueiroa, PMG Nmarroquim, MAO Oliveira

Anemia is a problem of public health significance in Brazil due to its high prevalence and widespread occurrence. Anemia in school children is particularly worrysome due to its effects on cognitive development and school achievement. A cross-sectional survey was conducted in the period of May to June 2000 on a representitive sample of 383 first graders (aged 8 to 10 years) from public schools in Maceió, state of Alagoas, Brazil. Multiple stage sampling was done by random selection of schools, classes and pupils within each class. Anthropometric data was collected by trained nutritionists and analyzed by the software Epi-Nut, with the NCHS growth curves as a standard. Blood was collected by venipuncture and measurements were done by an automatic Coulter STKS Counter. Stools were collected in appropriate vials and examined under a microscope for the presence of protozoa and helminths. Blood and stool examinations were performed by professionals at the State of Alagoas Central Laboratory (LACEN). The prevalence of anemia (hemoglobin < 12.0 g/dl) was 26.7% among these first graders. Growth retardation was present in a small proportion of children: 6.2% as far as height-for-age, 4.0% when considering weight-for-age and 3.0% for weight-for-height, considering inadequate indices below –2.0 standard deviations. Ascaris lumbricoides was the most common parasitic infection, present in 89 (23.2%) of the chidren. Only seven students (1.8%) were infected by Ancylostoma duodenale, the worm most directly implicated as a risk factor for anemia. In this study, no statistical correlation was found between the ocurrence of anemia and parasitic infection, when tested as single or multiple infestations. As a conclusion, anemia was very frequent in this population, and risk factors other than parasitism should be investigated.

Th32 IRON NUTRITION IN MOROCCO:INTAKES,SOURCES AND BIOAVAILABILITY. L.Alaoui.Dept.Sciences Alimentaires et Nutritionnelles,IAV HassanII,Rabat,Morocco.

Iron deficiency is a major nutritional problem in Morocco.Iron deficiency anemia is prevalent among children,pregnant women,and those at reproductive age.The present work is aimed at presenting available data on dietary iron intakes,sources,and availability,in order to understand the cause(es)of deficiency.A national survey on food consumption,conducted in 1984/85,showed that the mean dietary iron intake was 13.7mg/p/d,mostly from plant origin.In four regions of Morocco,a study conducted in 1987,showed that the total dietary iron supply ranged from 14.5 to 22.5mg/p/d;more than 80% of that supply was non-heme iron from cereals and vegetables.In Chefchaouen (north of Morocco) a study conducted in 1989,involving 28 families,reported iron intakes from 15.3 to 17.7mg/p/d,with an estimated availability of 6%.In other regions,total dietary iron supply ranged from 7 to 26 mg/p/d, in a study conducted in 1998.In 1999,an in vitro iron bioavailability study,showed that in flour and fortified flour,the availability of iron was less than 6%.A more recent study,conducted in 2001,showed that in 24 families,mean dietary iron intakes were 17.2 mg/p/d,with a very low availability estimated using algorithms.In coclusion,iron deficiency in Morocco,is most likely caused by low bioavailability of dietary iron rather than low intake per se.

Th33 A FOOD-BASED APPROACH TO IMPROVE IRON STATUS IN EGYPTIAN CHILDREN.. M. Elguindi, M. Rashed, O. Galal and A. Stormer. Liver Institute, Menoufiya University, Menoufia, Egypt; National Nutrition Institute, Cairo, Egypt; UCLA School of Public Health, Los Angeles, CA, USA.

Background: Non-heme iron is present in the Egyptian diet in amounts exceeding daily allowances; low intake of bioavailability enhancers contributes to the prevalence of anemia. Aims: To study dietary factors contributing to iron deficiency anemia and evaluate the efficacy of providing a Vitamin C source to school children's lunch. Methods: We evaluated dietary intake for 60 anemic and 50 non-anemic children using repeated 24-hour recalls. An intervention study followed that included 363 school children and 82 control children ages 10-12 years. For three-months, children in the intervention group received the usual iron-fortified school meal plus an orange every school day (6 days/ week). The control children, in a similar school, received only the iron-fortified meal. Hemoglobin and serum ferritin were measured for both groups at baseline and after three months. Results: In the observational study children with low available iron intake were 3.4 times more likely to be anemic and those with low vitamin C intake were 3.5 times more likely to be anemic than children with higher levels of vitamin C and available iron intake ($p<.05$). In the intervention study, the mean hemoglobin in the intervention group was 11.8 gm% at baseline, with 55.1% of children below 12 gm%. After three months of intervention with an orange a day, mean hemoglobin rose to 12.4 gm% ($p<.001$) and 29.8% were below 12 gm%. The control group experienced no change in hemoglobin (mean 11.7 g% at baseline and 11.7% at followup. The same results were seen for serum ferritin. Conclusion: In the context of the Egyptian diet, low vitamin C intake is a strong predictor for iron deficiency anemia. The addition of an orange a day to the school meal resulted in significant improvement in iron status for school children. (Supported by the Thrasher Research Fund)

Th34 DIETARY INTAKE OF BIOAVAILABLE IRON IN MEXICAN CHILDREN 12 TO 59 MONTHS OF AGE. S Rodríguez-Ramírez, J Rivera-Dommarco, C Hotz , A García-Guerra. Centro de Investigación en Nutrición y Salud, Instituto Nacional de Salud Pública, Cuernavaca, Morelos, México.

The estimation of bioavailable iron is important to assess whether iron requirements are met, particulary in children <5 yrs, who have high demands for Fe. In Mexico, the prevalence of Fe deficiency is 48.1%(transferrin saturation <16%), and anemia is 27.2%, (Hb<11 g/dL) among children <5 yrs. Objective: To estimate the dietary intake of total Fe and bioavailable iron (FeBIO) in Mexican children <5 yrs. Methods: A National probabilistic sample of 919 children 12 to 59 months was studied (Oct 98-March 99). A 24-h recall was applied to each participant and the heme, nonheme and total Fe intake was calculated. The nonheme iron bioavailability was estimated using equations to adjust for the presence of vitamin C, phytates, and meat, fish and poultry. The estimations were based on 3 different levels of iron body stores (500, 250, and 0 mg). Anemia was determined as Hb<11 g/dL at sea level, adjusting for altitude as necessary. Results: Children had a mean intake of 6.2±4.4 mg Fe. After accounting for enhancing and inhibiting factors of Fe absorption, the amount of FeBIO was extremely low: 0.17±0.32, 0.25±0.48, and 0.35±0.68 mg assuming 500, 250 y 0 mg Fe stores, respectively, only representing 2.8 to 5.5% of the total iron intake. The amount of FeBIO(250 mg body store) represented only 42% of the physiological requirement for absorbed Fe. The amount of FeBIO in relation to the physiological requirement was less in children 12 to 24 months (37%) than in those >24 months (43%), and they also had a higher prevalence of anemia: 41.4% vs. 19.5% ($p<0.05$). Conclusions: The mean estimated level of Fe absorption was even lower than the lower level suggested by WHO (5%). These estimates of bioavailability may be useful in the development of recommended dietary Fe intake for Mexican children. Interventions to improve Fe status of Mexican children must include methods to improve the bioavailability of Fe.

Th35 IRON BIOAVAILABILITY FROM ROOT NODULES OF SOYBEAN (GLYCINE MAX) - EVALUATION IN A RAT HEMOGLOBIN REGENERATION BIOASSAY. AK Proulx, Y Kakuda, G Bassel.

Sources of iron in nutrition have typically been classified as either heme iron or non-heme iron. Heme iron has always historically been associated with meat based foods. Legumes and particularly soybean create nodular root structures which are capable of creating a heme iron containing protein, leghemoglobin, comprising about 26% of the total iron store in the nodule, and storing total iron at levels of up to 2.5mg/g dry weight basis. Using a rat hemoglobin repletion model animals were fed diets containing iron almost exclusively from one of 3 sources, soy root nodules, bovine hemoglobin, or ferrous sulphate (control) each at three predicted levels of iron, 5, 15 or 25ppm. Slope ratio analysis (SRA) as modified from the AOAC model indicated that soy root nodules and bovine hemoglobin exhibited Relative Biological Value (RBV) 63% and 55% for soy nodule and bovine hemoglobin respectively when analysed in the dose response curve in comparison to ferrous sulphate. This difference was not statistically significant at the $p<0.05$ level. Hemoglobin repletion efficiency (HRE) at the presumptive dose rate 25ppm indicated that bovine hemoglobin supported a similar repletion efficiency to soy root nodules at 45.8 and 44.5 respectively and relative biological value based on HRE at 60% versus 59% respectively. These values are not statistically significant at the $p<0.05$ level. This indicates that soy root nodule as a fortificant respond similarly to bovine hemoglobin in terms of hemoglobin repletion efficiency. By displaying a hemoglobin repletion efficiency similar to many iron fortified foods, and a repletion efficiency as high or higher than typical plant foods, this indicates the potential use of soy or legume nodules as a bioavailable and concentrated source of plant iron pending further research.

Th36 HOME-BASED DIVERSIFIED COMPLEMENTARY FOODS AS A MEANS TO ADDRESS ANAEMIA AND GROWTH FALTERING IN A DEVELOPING COUNTRIY. N Sultana, M Rashid. Institute of Public Health Nutrition, Dhaka, Bangladesh.

Repeated nutrition surveys in Bangladesh showed that the prevalence of anemia in the population is more than 70%. Unacceptable weaning practices in infants and children have been blamed as predisposing factors to concomitant infections, anemia and growth faltering.

An intervention trial was conducted to test the hypothesis that infants receiving home-based complementary food do not have a higher incidence of anemia and infection (primary outcome) and growth failure (secondary outcome) than infants on culture dependent traditional complementary feeding practices.

The intervention study was conducted in a rural setting to evaluate the acceptance of different (8 varieties) home based complementary foods among infants aged 4 to 6 months for a period of 180 days. They were divided into cases (n=69) and controls (n=46). The cases were grouped into 3 each being placed under the guidance of a community field worker and supervisor. On average the foods ensured 145 kcal/100ml. All the three groups initially received two basic mixes alternately for two weeks followed by two multi-mixes which were different in each group. By conducting non-parametric tests for acceptance and t-test for consumption of 8 different recipes, 4 recipes were found to be very well accepted by the infants. After completion of intervention, uniform increment in weight and height was observed. Compared to that of controls, the percentage increase in the study group for weight was 9.3 ($p<0.001$) and for height it was 2.1 ($p<0.08$). Growth faltering was not seen in infants receiving diversified food. Clinically they were found not to be anemic and there was evidence of fewer infections.

Complementary foods offer an affordable opportunity to provide a diet which is not only acceptable to the infants but at the same time provide adequate growth and prevent anemia too if iron rich foods are included in the mixes of complementary food.

Th37 **IRON AVAILABILITY FROM BROWN RICE AND IRON-FORTIFIED INSTANT NOODLES.** Trinidad TP[1]*, Valdez DH, Mallillin AC, Feliciano RRA[2], Askali FC[1], Castillo JC[1], Loyola AS, Nicolas MG[2]. [1]Food and Nutrition Research Institute, Department of Science and Technology, Bicutan, Taguig, Metro Manila 1631 Philippines; [2]University of the Philippines, Padre Faura St., Ermita, Manila, Philippines.

Background: Iron (Fe) and vitamin A deficiencies are nutritional problems in the Philippines. The International Rice Research Institute and the Philippine Rice Research Institute are conducting studies to further improve the nutrient content of different varieties of rice, e.g. mineral content. The Department of Health through its "Sangkap Pinoy Seal" Program introduced the use of single and multiple fortification of snack foods. **Aim**: This study determined iron availability from different varieties of rice and instant noodles fortified with different iron fortificants with and without vitamin A. **Method**: Four different varieties of rice were analyzed for phytic acid (PA), tannic acid (TA), and dietary fiber (DF). The instant noodles were fortified as follows: No addition, vitamin A, ferrous fumarate (FeF), FeF+vitA, FeF+EDTA, FeF+EDTA+vitA, ferrous sulfate (FeS), FeS+vitA, FeS+EDTA, FeS +EDTA+vitA, NaFeEDTA, and NaFeEDTA+vitA. Percent Fe availability was determined by measuring dialyzable Fe after pepsin-pancreatin-bile digestion and dialysis of the test foods. **Results**: Fe availability from the different varieties of rice are: PSB RC 34 (brown rice) 25.3±3.2 > PSB RC 54, 20.2±0.7; IR841, 19.4±0.6; and IR 65, 19.1±1.2 ($P<0.05$; n=6). Fe availability from instant noodles are: FeF+EDTA+vitA (39.1±1.2), NaFeEDTA+vitA (37.9±2.1), NaFeEDTA (35.9±2.8), FeF+EDTA (35.1±1.0) > FeS+EDTA (30.8±0.2) > FeS+EDTA+vitA (27.2±0.8) > FeF+vitA (20.6±1.7), FeF (20.4±1.8), FeS+vitA (13.7±0.7), FeS (13.3±0.7) > vitamin A (4.6±0.2) > no addition (2.8±1.7) ($P<0.05$; n=5). **Conclusion**: Fe availability from brown rice was significantly greater than the other rice varieties and is not affected by the presence of PA, TA and DF. The addition of EDTA to Fe sulfate and Fe fumarate, as well as of NaFeEDTA enhanced iron availability from instant noodles.

Reproductive Health

Th38 **ACCEPTABILITY OF DAILY IRON+FOLATE VS MULTIPLE MICRONUTRIENT SUPPLEMENTS BY MALIAN PREGNANT WOMEN.** VM Aguayo, D Kone, B Diallo, D Traore, P Signe, D Kagnassy, and SK Baker. Helen Keller International-Africa Region (VMA, SKB), Helen Keller International-Mali (DK), Ministry of Health-Mali (BD, DT, DK), and UNICEF-Mali (PS).

Background: The latest DHS in Mali (2001) shows that 73% of pregnant women are anemic. These high anemia prevalence in pregnant women is largely attributable to iron deficiency. Current national policy recommends that women take daily iron+folate supplements from first pre-natal contact until three months after delivery for the control of iron deficiency and iron deficiency anemia. However, there is increasing evidence that many pregnant women in Mali lack in their diets other micronutrients besides iron and folic acid. Such women and their newborns could benefit from multiple micronutrient supplements. The Ministry of Health in Mali is considering replacing current iron+folate supplements for pregnant women with multiple micronutrient supplements. **Aim**: 1) To assess pregnant women's acceptability of a daily multiple micronutrient supplementation scheme (UNICEF's multiple micronutrient supplement formulation) vs the current (standard) daily iron+folate supplementation scheme. **Methods**: 90 pregnant women have agreed to participate in the acceptability study and be allocated to either the daily multiple micronutrient supplementation scheme or the current (standard) iron+folate daily supplementation scheme. All women started receiving daily supplements at the end of the first trimester of pregnancy. They continued taking daily supplements until delivery and throughout the first trimester post-partum. Data on adherence to the supplementation scheme and on factual and/or perceived benefits and undesirable side effects have been collected at the end of the second and third trimesters of pregnancy and at the end of the first trimester post-partum. **Results and discussion**: Results will be available at the time of the INACG Symposium. These findings, together with those from the global research agenda on efficacy of multiple micronutrient supplements for pregnant women, will inform policy development in Mali for the effective control of iron deficiency and iron deficiency anemia in pregnant women.

Th39 MULTIPLE NUTRIENT SUPPLEMENTATION IN PREGNANT ANAEMIC WOMEN. S.AMEYAW, E.ADU-GYAMFI, HEALTH AND LIFE GHANA.

BACKGROUND:Whilst foetal growth and development is hampered by anaemia in Pregnancy, over 50% of pregnant women encountered at the Tamale Regional Hospital begin and go through the greater part of their pregnancy with a haemoglobin concentration of less than 10gram/dl. AIM: To identify and compare the effects and the importance of multiple nutrient supplementation on haemoglobin synthesis and intrauterine growth in pregnant women. METHOD: 969 pregnant anaemic women encountered at the Regional Hospital in Tamale from April 1999 to December 2000 were each supplemented with capsules containing: iron, histidine, lysine, glycine, vitamins B1, B2, B6, B12, folic acid, vitamin C, zinc and calcium throughout their pregnancies, and their average haemoglobin concentration, as well as the average weights of their newborns crosschecked against the average weight of 1321 others who did not receive this particular preparation, but who received iron, B-complex, folic acid and multivite. RESULTS: Birth weights were on the average 3.29kilogram in those who received the multiple nutrients containing iron, histidine, lysine, glycine, vitamins B1, B2, B6, B12, folic acid, vitamin C, zinc and calcium, but 2.58 in those who received only iron, B-complex, folic acid and multivite. Haemoglobin concentrations were on the average higher in the former (11.3g/dl) than the latter (9.1g/dl). CONCLUSION: Anaemia in this part of the world is due to multiple instead of single nutrient deficiencies. Pregnant women who received multiple nutrient supplementation had higher haemoglobin concentrations and better intrauterine foetal growth. Women in this, and similar parts of the world where poverty and ignorance contributes to poor diets, needs a broader range of micronutrient supplements throughout their pregnancy.

Th40 **HIGH PREVALENCE OF LOW HEMOGLOBIN CONCENTRATION AMONG INDONESIAN INFANTS AGED 3-5 MONTHS IS RELATED TO MATERNAL ANEMIA.** S de Pee, MW Bloem, M Sari, L Kiess, R Yip, S Kosen. Helen Keller International – Indonesia & Asia Pacific, Jakarta, Indonesia, UNICEF, Beijing, China, and National Institute for Health Research and Development, Jakarta, Indonesia

Background. Iron deficiency anemia among young children is a large health problem. However, there is little information about the prevalence of anemia among young infants, because it has been assumed that normal, breastfed, infants have adequate iron stores until 4-6 mo of age. **Methods**. We analysed cross-sectional data from the HKI/GOI Nutrition and Health Surveillance System in rural Java, Indonesia from Sept '99 – Feb '01 for Hb of 3-5 mo old breastfed infants (n=990) and related factors. **Results**. Prevalence of Hb<90 g/L was 13.4%, <100 g/L 37%, and <110 g/L 71%. Multiple logistic regression analysis revealed that normal birth weight infants (>2500 g) of anemic mothers (Hb<120 g/L) had an Odds Ratio (OR [95% CI]) of 1.81 [1.34-2.43] to have a low Hb (<100 g/L) as compared to infants with a normal birth weight of non-anemic mothers. Infants of non-anemic mothers but with low birth weight had an OR of 1.15 [0.61-2.16], and those with low birth weight and anemic mothers of 3.68 [1.69-8.02]. Other risk factors included stunting (OR 1.70 [0.97-2.95]), a young mother (<20 y, OR 1.54 [0.95-2.49]), lower maternal education and living in West Java or East Java. **Discussion**. Considering that maternal postpartum Hb reflects Hb during pregnancy, that anemia among mothers in this population is mainly due to iron deficiency, and that children born to anemic mothers are at higher risk of a low Hb, it is hypothesized that low infant Hb in this population is due to iron deficiency. Studies in iron deficient populations need to test this hypothesis.

Th41 **SELF-REPORTED MENSTRUAL LOSSES PREDICT IRON STATUS IN PREMENOPAUSAL U.S. WOMEN.** JR Hunt and LK Johnson. Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA

Background: In industrialized countries, dietary variables generally have been poor predictors of iron status. For premenopausal women in such countries, the magnitude of menstrual blood loss may be at least as important as dietary iron bioavailability in determining iron stores. **Aim**: To evaluate the relative strength of self-reported indices of iron status to predict iron stores (serum ferritin) in premenopausal women. Method: Healthy premenopausal women (n=262), with median (range) age of 31 (19 to 46) y, and serum ferritin of 27 (3 to 262) µg/L, were recruited by advertising to give a single fasting blood sample and complete a questionnaire plus a 7-day food record, which was reviewed with a dietitian. **Results**: Menstrual loss, estimated from menstrual period frequency, length, and number of pads/tampons used on days of heaviest menstruation, was the primary predictor of serum ferritin. Those in the upper quartile of menstrual loss (use of >14 products/mo) were nearly 5 times as likely to have low serum ferritin (<12 µg/L) as those in the lower quartile (<6 products/mo). Using stepwise multiple regression and dietary data from the 7-d food record, 26% (R2) of the variance in serum ferritin was predicted by 7 indices (included only if $p<0.05$): menstrual loss (15%, partial R-square); total meat, poultry and fish intake (3%); years of hormonal contraceptive use (2%); use of aspirin/antacids (2%); blood donations (1%); BMI (1%); and amount of supplemental iron (1%). Age, exercise, parity, dietary iron, vitamin C, calcium, phytic acid, coffee, tea or alcohol consumption did not contribute significantly to the model. Discussion: Among premenopausal women on Western diets, self-reported menstrual losses predict iron stores much more substantiallythan dietary variables. Hormonal contraceptive modification of menstrual iron loss may be a useful treatment option for Western women with chronic iron deficiency anemia.

Th42 THE RELATIONSHIP BETWEEN TIMING OF CLAMPING OF THE UMBILICAL CORD AT BIRTH AND IRON STATUS AT 6 AND 10 MONTHS OF AGE. J.Kilbride, A.Al Abed. Faculty of Nursing, Applied Science University, Amman, Jordan.

Background: Recent studies reported a high prevalence(65-72%) of iron-deficiency anaemia(IDA) in infants in Jordan. Cognitive and psychomotor delay associated with iron-deficiency in infancy is well-documented. Some authors suggest immediate cord-clamping at birth deprives the infant of a significant potential blood transfusion representing iron endowment. Aim: To assess whether delayed cord-clamping benefits iron status during infancy. Method: A prospective on-going study from October, 2001 in which 132 normal deliveries at term were attended by the authors at Al Bashir Government Hospital, Amman. Mothers who were of similar lower middle-class background were randomly allocated to one of two groups: the subject group where the Leboyer method of delivery on to the mothers abdomen was used and delayed cord-clamping(until pulsation ceased 1-3 minutes after birth)and the control group where immediate clamping was performed. Oxytocics were routinely given after clamping. Current follow-up of infants at home to 10 months of age includes data on nutrition, weight gain, infections and iron status through a venous sample at 6 and 10 months to assess Full Blood Count(FBC), Plasma Ferritin(PF) and Zinc Protoporphyrin(ZPP). Results to date: Subject group mean(SD) cord haemoglobin(Hb)14.5(1.2)g/dl(n=64) cf control Hb 15.0(1.4)g/dl (n=59($p = 0.03$);cord PF 146(79) and 168(80)mcg/l respectively(NS).Subject mean birthweight 3128(382)g(n=67)cf 3390(408)g in controls(n=64)($p = <0.005$). At 6 months the subject Hb11.0(0.8)(n= 61);control Hb10.8(0.8)g/dl(n=61)(NS); PF 20(12) cf 26(16) mcg/l respectively($p = 0.02$).IDA (defined as Hb<11gldl, MCV<72fl or MCH<24pg and PF 12mcg/l or <) affected 8% subject infants(n=61) at 6 months cf 25% controls(n=61)($p = 0.01$).Data for 10 months is in progress. Conclusion: The incidence of IDA is increased 3 times in controls at 6 months of age. All but 17 infants were breastfeeding at 6 months.

Th43 **DIETARY INTAKE AND IRON STATUS (USING SOLUBLE TRANSFERRIN RECEPTOR ASSAY) OF PREGNANT MOTHERS IN A FISHING COMMUNITY IN SRI LANKA.** Jaanaki Gooneratne, DM.Dissanayake, H Ueki and T Nagao. Agro and Food Technology Division, Industrial Technology Institute, Colombo, Department of Pathology, Faculty of Medicine, University of Peradeniya, Japan Overseas Cooperation Volunteer, JICA Sri Lanka and Dental Education Project (JICA Sri Lanka), University of Peradeniya.

Background: Iron deficiency anaemia (IDA) in pregnancy may increase maternal and fetal morbidity and mortality and lead to low birth weight infants. **Aim**: To study the dietary patterns of a fishing community and the prevalence of IDA among pregnant mothers. **Methods**: Pregnant mothers (n=58), aged 18-35 years, in the second trimester of pregnancy attending ante-natal clinics in Negombo area of Gampaha district, were selected as sample group. Controls were age matched, non-pregnant (n=28), non-lactating subjects. A three day, 24 h. recall dietary survey was conducted, with weighing of cooked food on one day. Socioeconomic data was collected and capillary blood was drawn to determine Haemoglobin (Hb), serum ferritin and soluble transferring receptor (sTfR) values. **Results**: All mothers were educated, only 19% had education < Grade 5. An income of <US$50/=per month was received by 67% and 73 % of the sample and control group, respectively. Both groups cooked at least two main meals at home. Both, sample and control groups had lower intake of energy (1679Kcal+ 397, 1771Kcal+ 292), protein (57.3g.+17.2, 59.8g.+10.1), calcium (636mg.+302, 515mg.+247), iron(19.5mg + 6.48, 19.2mg+ 6.27) and vitamin A (184µg+124, 76.5µg+90.4) than RDA. The significantly higher intake of calcium (p=0.05), vitamin A (p=0.00) and carotene (p=0.008) by the sample group resulted from an increase intake of milk and green leafy vegetables. The haem:non-haem iron ratio was 0.4:1, fish contributing 3.8mg.of dietary iron, for both groups. IDA was found in ten pregnant mothers and one non-pregnant subject as indicated by all three parameters. The mean values were: Hb (11.5g/dL+1.2 and 12.4g/dL+0.1); Serum ferritin (27.4µg/L+ 25.9 and 37.1µg/L+38.9 (p=0.24) and sTfR (2.65mg/L+2.1 and 1.71mg/L+ 0.5 (p= 0.0015), for the sample and control groups, respectively. Conclusions: sTfR was a better and sensitive indicator for determining the iron status during pregnancy. A community based food intervention to improve their dietary habits is recommended.

Th44 **ARE HAEMOGLOBIN AND HAEMATOCRIT INTERCHANGEABLE INDICATORS OF ANAEMIA PREVALENCE IN AUSTRALIAN ABORIGINAL ADOLESCENTS?** D Mackerras, GR Singh, Menzies School of Health Research, Darwin, NT, Australia

Introduction: Haemoglobin (Hb) and Haematocrit (Hct) are the most common methods for estimating anaemia, being inexpensive, rapid and easy to perform. Haemoglobin is the more direct measure, although both are relatively late indicators of iron deficiency anaemia. Either indicator can be used to describe population prevalence of anaemia.
Objective: To compare the prevalence of anaemia in an Aboriginal Birth Cohort based on Hb and Hct using both the WHO as well as US references.
Methods: An Aboriginal Birth Cohort was evaluated for growth and early markers of chronic disease at the ages of 10-12 years and had venous blood collected for the estimation of Hb, Hct, MCV, MCH, RCW and examination of blood films. No biochemical tests of iron deficiency were done. Puberty status, height, weight and presence of skin and ear infections were assessed.
Results: Blood samples were available for 521 children (278 M: 243 F) with an age range of 8.7-13.8. Puberty status was available for 482. The mean Hb was 12.8 g/dl (range 9.5-17.3) for boys and 12.6 (range 10.5-19.1) for girls. Using MCV, 115 (22.1%) were microcytic. Macrocytosis was not found on any film.
Table: Anaemia prevalence by different reference criteria – number (%)

WHO	Hb -	93 (13.1%):
WHO	Hct -	57 (6.0%):
US	Hb -	123 (24.2%):
US	Hct -	104 (19.4%).

Discussion: As the WHO references are lower, the prevalence of anaemia is less than that identified by the US references. As Hb and Hct measure different blood characteristics one would expect a slight difference when using the two as is seen. However, there is a more than 2-fold difference in the apparent prevalence of anaemia defined by Hb versus Hct when the WHO references are used. No differences in rates of infection, pubertal status or microcytosis (identified either by MCV or on film) were found by the use of Hb or Hct by either standard.
Conclusion: There is a marked difference in the identification of anaemia by using Hb or Hct. Especially when using WHO references, the difference may alter assessment of the size of the problem. Hence, the prevalence of anaemia from different locations may not be comparable if different indicators are used.

Th45 **AN IMPROVED METHOD FOR ASSESSING TRANSFERRIN RECEPTOR IN WHOLE BLOOD SPOTS.** T.W. McDade, B. Shell-Duncan. Department of Anthropology, Northwestern University, Evanston IL, USA; Department of Anthropology, University of Washington, Seattle WA, USA.

Background: Transferrin receptor (TfR) has been identified as an important measure of iron status that is not confounded by inflammation, and is therefore useful for community-based surveys where iron deficiency and infection commonly co-occur. Cook et al. (1998) have recently validated a method for measuring TfR in whole blood spots dried on filter paper, but constraints associated with sample processing and analysis limit its application. **Objective**: To validate an improved method for quantifying TfR in spots of whole blood collected from simple finger pricks. The method uses capillary blood that is applied directly from the finger to filter paper (eliminating the need for pre-measurement at the collection site), and commercially available reagents produced by Ramco Laboratories. **Methods**: 37 matched plasma-blood spot samples were used for assay development and validation. Blood spot assay performance was evaluated through an assessment of linearity, precision, reliability, sensitivity, stability, and blood spot-plasma correlation. In addition, blood spot TfR concentrations were compared for iron replete, iron-deficient, and iron-deficient anemic 5-10 year-olds from northern Kenya (N=275). **Results**: The blood spot TfR assay is linear, precise, reliable, and sensitive, and correlates highly with plasma TfR (Pearson R = 0.942; P < 0.001). Blood spot TfR concentrations are significantly elevated in Kenyan children who are iron-deficient compared to those who are iron replete (P<0.001). Blood spot TfR concentrations are significantly higher in children with iron-deficiency anemia compared to those with irondeficiency (P<0.001). **Conclusions**: Whole blood spots ovide a convenient and minimally-invasive means for collecting, transporting, and storing samples for analysis of TfR. Our blood spot TfR assay is a reliable and valid measure of iron status that should facilitate future field-based investigations of iron deficiency.

Th46 ASSOCIATIONS BETWEEN IRON (FE) AND ZINC (ZN) STATUS. H. Sandstead, K Yokoi, N Egger, V Ramanujam, N Alcock, H Dayal, J Penland. Univ Texas Medical Branch, Galveston, TX, the USDA ARS Grand Forks Human Nutr Rsch Ctr, Grand Forks, ND USA, and Seitoku Univ, Matsudo, Chiba, Japan.

Background: Fe & Zn are available from similar foods. Zn turnover is increased in 18 young women with serum ferritin <20 µg/L. Aims: Define associations of Fe & Zn status. Methods: Fe & Zn status, including Zn kinetics was measured in 50 healthy premenopausal women. Results: In 30 subjects with plasma Zn > 700 µg/L serum ferritin & Fe, & % saturation of Fe binding proteins were higher ($p < 0.03$) than in low Zn subjects. Food frequency correlated with serum ferritin & Zn kinetics in 33 subjects not on oral contraceptives. Beef predicted serum ferritin ($p = 0.002$), & bran cereal ($p = 0.097$) & bleeding through pads (BTP) ($p = 0.021$) were negative predictors ($n = 32$, $R2 = 0.326$, $p = 0.010$). Beef positively predicted ($p = 0.003$) & BTP negatively predicted ($p = 0.010$) the rapidly exchangeable Zn pool / fat free mass (FFM) ($n = 31$, $R2 = 0.322$, $p = 0.004$). Serum ferritin correlated with the central Zn pool (Q1, the plasma) / FFM ($n = 31$, $R2 = 0.394$, $p < 0.0001$), the lesser peripheral Zn pool (Q2, the rapidly turning over tissue Zn) / FFM (broken line equation, $n = 27$, $R2 = 0.756$, $p < 0.0001$), & the greater peripheral Zn pool (Q3, the slower turning over tissue Zn) / FFM ($n=32$, $R2 = 0.167$, $p = 0.020$). In the broken line model the breakpoint for Q2 was at serum ferritin 17.8 µg/L; below the break Q2 tended not to decrease; above the break Q2 increased proportionate to serum ferritin. Conclusions: 1) Fe & Zn statuses are highly related. 2) Food frequency correlated with Fe & Zn status. 3) Zn deficiency was associated with serum ferritin < 20 µg/L. Support: DAMD 17-95-C-5112 & USPHS M01-RR-00073.

Th47 MATHEMATICAL MODELING TO PREDICT POPULATION-BASED RESPONSE TO MICRONUTRIENT INTERVENTIONS

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One of the major criticisms of evidence-based medicine is that evidence obtained from one setting is inappropriately applied to other settings. To show that a given intervention would work in variable populations, clinical trials are repeated in several different settings. However, time and resources would be saved if the impact of a given intervention could be modeled to predict outcomes in variable settings. **Methods** We simulated a one year 4-cell clinical trial beginning with infants 6-24 months of age and longitudinally following them for one year. A fictitious infant population (N = 1,000,000) was created using Hemoglobin estimates taken from actual recent survey data from India. Infants were randomly allocated to four groups: There intervention groups received 15, 30 and 45mg of iron Sprinkles; and a control group received complementary foods only. Hemoglobin and ferritin levels were estimated at baseline, 6 months and one year. **Results** Predicted prevalence of anemia in the control group was 71.6% at 6 months and 75.8% at one year. These correspond very closely to the actual Indian prevalence rates of anemia (72%). In the intervention groups prevalence of anemia at 6 month and one year was 52.1% and 47.3% for the 15mg group, 37.4% and 16.9% for the 30mg group and 19.3% and 5.1% for the 45mg group. To predict toxicity from possible iron overload, we used a 350µg/L cut off level of ferritin. We did not find any evidence of toxicity even at the highest iron dose. **Conclusion** This methodology gives useful prior insight to clinical trials and might also be useful for generalizing results from studies done in one setting to another thereby, impacting evidence based decision making.
(Supported by HJ Heinz Company Foundation and the Canadian Institute of Health Research).

Th48 **USE OF CAPILLARY BLOOD TO ASSESS IRON STATUS IN RURAL KENYA: COMBINED MEASURES OF TFR, ZPP:H, HB, AND CRP.** B. Shell-Duncan, T. McDade.

Community-based surveys of iron deficiency (ID) require accurate methods that can be used in remote areas. Common indices – hemoglobin or hematocrit – do not detect pre-anemic forms of ID, and are not specific to ID. Improved accuracy is accomplished through the use of combined measures, which often require venipuncture, and facilities for blood sample processing and storage. Consequently, combined "field-friendly" assays using capillary blood are needed. **Objectives**: To assess iron status in rural Kenya using "field-friendly" methods for capillary blood, including an improved blood spot assay for transferrin receptor (TfR). **Methods**: A finger stick was used to obtain capillary blood from 275 children. Whole blood was applied directly to filter paper, dried, and later analyzed for TfR, as well as C-reactive protein (CRP), an acute phase protein that serves as a general marker of inflammation. Capillary blood was used to determine hemoglobin (Hb) and the ratio of zinc protoporphyrin to heme (ZPP:H). **Results**: Blood spot TfR values are highly correlated with other iron status indices ($p<.001$). Hb alone provides the lowest estimate of the prevalence of ID (6.2%). Because ZPP:H has previously been reported to be elevated in the presence of inflammation, we constructed a preliminary diagnostic model based on elevated ZPP:H (>80 µmol/mol) and normal CRP (< 1.5 mg/L), estimating the prevalence of ID at 26.2%. TfR (cutoff 6.7 mg/L) detects a lower prevalence of ID (18.5%) than ZPP:H, but higher than Hb alone. When TfR is added to a multiple criteria model (elevated ZPP:H in the absence of elevated CRP and/or elevated TfR) the prevalence of ID is estimated to be 31.3%. **Conclusions**: Combining TfR with other indices improves estimates by determining iron status in both the presence and absence of infection. Furthermore, this study is the first field application of TfR bloodspot methods, and demonstrates the utility and feasibility in a remote field setting.

Th49 **ASSESSMENT AND APPLICATION OF A SIMPLE TEST TO DETECT ANEMIA IN DEVELOPING COUNTRIES.** H Verhoef, R Hogervorst, CE West, NR van den Broek *, FJ Kok. Division of Human Nutrition and Epidemiology, Wageningen University, The Netherlands; *Wellcome Trust Centre for Research, Blantyre, Malawi/Department of Obstetrics and Gynaecology, University of Liverpool, United Kingdom

Background: A new and inexpensive color scale may facilitate anemia diagnosis in developing countries. Previous studies to assess its use had methodological shortcomings. We used data collected in various populations to determine sensitivity and specificity of the scale given hemoglobin concentration of any individual. These characteristics were used to predict test performance in two populations with different distributions of hemoglobin concentration.
Methods: Blood was collected from populations in Kenya, Malawi and Tanzania, and assessed by color scale and photometer. Logistic regression was used to estimate test characteristics of the scale in detecting anemia or severe anemia as a continuous function of hemoglobin concentration. These findings were applied to predict characteristics and performance of the scale in two representative samples of children aged 6-24 mo in areas with stable and seasonal malaria, respectively.
Results: Scores of the color scale >=10 indicated anemia (hemoglobin concentration <110 g/L) and severe anemia (hemoglobin concentration <70 g/L) with sensitivities >0.68 and >0.99, respectively. When used in populations with a heavy burden of anemia, sensitivity estimates were higher, and the scale could provide valid estimates of the prevalence of anemia.
Conclusions: The color scale is satisfactory and for many purposes superior to all other methods for detection of anemia at primary care level. Low scores of the scale may give unsatisfactory results when used to detect patients with severe anemia. The methodology presented in this report may facilitate development of strategies for its use in various target groups.

Th50 **A NOVEL STABLE ISOTOPE APPROACH TO MEASURE ERYTHROCYTE IRON MASS DURING PREGNANCY.** T Walczyk, L Davidsson, N van den Broek and RF Hurrell. Laboratory of Human Nutrition, ETH Zurich, Switzerland and Wellcome Trust Research Centre, Blantyre, Malawi.
Background: Assessment of iron status during pregnancy is difficult due to haemodilution. Plasma expansion during the 2nd and 3rd trimester affects all concentration based measures but is difficult to predict. **Method**: We present a novel stable isotope technique that allows to measure absolute changes in erythrocyte iron mass (EIM) during pregnancy. Changes in hemoglobin concentration (Hb) and EIM were monitored longitudinally in nine pregnant Malawian women. A single dose of 57FeSO4 was given intravenously at a gestational age of 15-24 weeks. Changes in EIM were calculated from the dilution of the 57Fe label in the mother's blood over the erythrocyte lifetime of 120 days. EIM was determined after isotopic analysis of blood samples taken at 14 days, 2 months and 4 months after injection. Blood volume (BV) was derived from EIM and the iron concentration in the mother's blood. Plasma volume (PV) was obtained from BV and haematocrit. **Results**: Most subjects became anemic (Hb < 110 g/L) over the course of the study (Hb: 75 g/L to 135 g/L). However, EIM increased continously in all subjects irrespective of changes in Hb concentration. Mean increase in EIM was 277±66 mg which is similar to current estimates. Large variations in PV and BV as observed during this study explain our findings. **Conclusion**: The first data obtained by this novel technique points clearly to the limited value of concentration based measures to assess iron status during pregnancy. Our results clearly show the potential of stable isotope techniques to monitor changes in EIM during pregnancy which may contribute to better define iron needs and to evaluate the benefits of iron supplementation or dietary modifications during pregnancy.

Th51 CONCURRENT IRON AND MICRONUTRIENT DEFICIENCIES IN FILIPINO SCHOOLCHILDREN WITH NORMAL AND DEFICIENT IODINE STATUS: THE NEED FOR COMBINED INTERVENTIONS. SV Amarra, DC Bongga, FB Cruz, JS Solis, EB Barrios, LP Ho, CVC Barba, J Madriaga, J Desnacido, J Marcos and MD Magsanoc. Phil. Women's University, Manila; University of the Phil. Diliman; Food and Nutrition Research Institute, Philippines.

Background: Iodine deficiency remains a public health problem in the Philippines despite universal salt iodization. Deficiencies in iron, vitamin A and selenium have been shown to limit the response of school-age children to iodine intervention. The extent to which these deficiencies occur in Filipino urban poor children with normal and deficient iodine status has not been examined. **Aim:** To determine whether anemia, vitamin A and selenium deficiencies occur among schoolchildren with normal deficient iodine status. **Methods:** Blood was extracted by venipuncture from 63 public schoolchildren aged 6 to 10 years. Hemoglobin, serum retinol and whole blood selenium were determined. The children were grouped on the basis of iodine status. Children with normal iodine status (n=32) had urinary iodine (UI) levels ≥100 µg/L and no goiter palpated. Iodine deficient children (n=31) had UI levels < 90 µg/L and grade 1 goiter. The presence of anemia, vitamin A deficiency and low selenium levels were compared between groups. **Results:** High prevalences of anemia (Hb<12 g/dL), vitamin A deficiency (serum retinol<0.7 µmol/L) and low blood selenium (Se<60 µg/L whole blood) existed in both groups. Thirty two percent were anemic and 60 percent had low blood selenium levels, with no significant difference between groups. Twenty five percent had vitamin A deficiency. Iodine deficient children were more likely to have vitamin A deficiency than those with normal iodine status (p=.064). **Conclusion:** The existence of multiple micronutrient deficiencies in schoolchildren with normal and deficient iodine status indicates that efforts to address iodine deficiency in this age group should be accompanied by efforts that will also address iron, vitamin A and selenium deficiencies.

Th52 NATIONAL SURVEY ON ANAEMIA MOROCCO 2000. M.Azelmat, R.El Aouad, A.Saad, E.Rjimati, A.Zerrari, H.Chekli, K.Loudghiri, M.Aljem, A.El Gandassi. Ministry of Health, Rabat, Morocco.

A National survey on anemia was carried out by the Ministry of Health in 2000. This survey was financed by (UNICEF). The principal objectives of this study are: a) to estimate the prevalence of anemia in various groups of population: women in childbearing age (15-49 years), children from 6 month to 5 years and men from 18 to 59 years b) to study of the factors of risk of occurred anemia through a questionnaire.

The size of sample of this investigation was estimated at 2500 households (1404 in urban and 1096 in rural area). These households are divided into 104 clusters (55 in urban and 49 in rural area). This sample is sufficient to have results significant to 95 % and representative at national level and type of area (residence).

Blood taking away were carried out for the dosage of hemoglobin DRABKIN technique) and ferritin (ELISA technique).

The prevalence of anemia (hemoglobin < 11 g/dl) in children from six months old to five years is estimated at the national level 31.5% (31.9%. urban and 31.1%. in rural area).

The prevalence of anemia (hemoglobin < 12 g/dl) among women childbearing age is 33.0% (33.9% in urban and 31.9% in rural area).

The prevalence of anemia (hemoglobin < 11 g/dl) among pregnant women is estimated at the national level at 37.2% (34.8 in urban and 39.5% in rural area).

Th53 **INTERACTION BETWEEN IODINE AND IRON DEFICIENCIES : EVALUATION OF FORTIFICATION STRATEGY OF SALT WITH IODINE IN MOROCCO.** I.Bahbouhi, R. Belahsen.

Background : Micronutrient deficiencies are problem of public health in the world especially in developing countries. Also there is an interaction between different micro nutrients such as vitamin iron and iodine. Iron deficiency anaemia can have several effects on the thyroid metabolism. **Aims** : The goal here was to evaluate the nutritional strategy of salt fortification with iodine enrolled in Morocco and to examine its impact on iron and iodine status among children and women from Doukkala region of Morocco. **Methods** : The survey was undertaken on children from 6 to 12 years old (n=176) and women (n=223) selected from rural and urban area. The status of iodine and iron are determined by evaluation of iodine and iron intake using 24 hours dietary recall, urinary iodine, serum thyroid hormones and anaemia prevalence was determined by blood haemoglobin and serum iron. The women knowledge on fortification of salt with iodine as well as the percentage of women consuming iodized salt were also examined. **Results**: The results showed that about 50 % of women and 60 % of children are anaemic, only 35 % of women know about existence of salt iodation and that 20 % consume iodized salt. On the other hand 48 % of women use salt not iodized and 30 % consume both types of salt. **Conclusion**: The results show that anaemia still persists in 33% of women and 55,88% of children using iodized salt.

Th54 ESTIMATION OF BIOAVAILABILITY OF DIETARY IRON AND IRON STATUS IN WOMEN FROM AN AGRICULTURAL REGION OF MOROCCO. R. Belahsen1, F. Fertat1, J. Zee2 and H. T-O'Brien2. 1Training and research Unit on Food Sciences, laboratory of Physiology Applied to Nutrition and Alimentation, Chouaïb Doukkali University, School of sciences, El Jadida, Morocco. 2Faculté des Sciences de l'agriculture et de l'Alimentation. Université Laval. Québéc, Canada.

Introduction : nutritional anaemia is a problem of health in the world especially in developing countries mostly in procreate, pregnant and lactating women.
Objectives : The goal was to study the determination of iron status in Moroccan women at procreating age and the iron bio availability.
Methodology : Iron status evaluation was performed on 632 women randomly sampled from urban and rural area of an agricultural region of Morocco, El Jadida province. Anaemia prevalence defined by blood haemoglobin (HB), iron depletion by low serum ferritin (F) concentration and iron intake using dietary 24 hours recall were determined. Dietary habits and socio-demographic data were also assessed with questionnaire. The dietary iron available was estimated using the Monsen model.
Results : Anaemia (HB < 12 mg/dl) was observed in 37,7% with a mean of HB concentration of 12,62 mg/dl. According to WHO references anaemia is severe in this region and was more severe in rural than urban area (40,8% Vs 37%, p<0,05). The frequency of iron depletion was observed in 44,7% of women and among anaemic women 50% had their iron depleted. Total iron intake is 28,39±8,78 mg/day.
Conclusion : The data show that iron deficiency is a problem of health in this region. The iron content of diet and the Bio availability of dietary iron are involved to explain these results. (Funded by IRDC, Canada and FICU (AUPELF- UREF- Agence universitaire de la francophonie).

Th55 **PREVALENCE OF ANAEMIA AMONG SCHOOLCHILDREN OF SRI LANKA, 2001-02.** R Jayatissa, MM Gunathilake.Department of Nutrition and Biochemistry, Medical Research Institute, Sri Lanka.

Background: Several studies concerning anaemia prevalence were carried out in Sri Lanka and found it to be the most prevalent nutritional problem. More recently, schoolchildren have become the target of those concerned with the issue. Hence the prevalence and the distribution pattern in districts were important for targeting corrective measures. **Aim**: To assess the prevalence of anaemia among schoolchildren. **Methods**: A school based cross sectional study was conducted in seven districts of Sri Lanka. Grade one, four and seven children of 5-15 years of age from each selected school were randomly included in the study. Birth date, sex, anthropometric measurements and haemoglobin were estimated with capillary blood. Blood films were also obtained. Anaemia was diagnosed when haemoglobin was less than 11.5 g/dl for children of 5 to 11.9 years and 12 g/dl for more than 11.9 years of age. **Results**: A total of 2220 children participated in the study out of which 1109 were boys and 1111 were girls. Overall prevalence of anaemia was 24.1% (21.8 - 26.4). District prevalence varied from 9.3% to 32.1%. The prevalence of anaemia among girls (24.8%) and boys (23.4%) were the same. The significant (P=0.000000) decreasing trend of anaemia prevalence was identified from grade one (35.6%) to grade four (23.1%) and further to grade seven (13.2%) children. Prevalence of anaemia was similar among urban/rural sectors and different types of schools. The mean weight and height was significantly lower in the anaemic group (20.9±6.1 and 120.3±12.9) than non-anaemic group (24.0±7.4 and 127.2±14.0) irrespective of the age (P=0.000). The commonest blood picture seen was microcytic hypochromic (35.4%). **Conclusions**: The present study revealed a high prevalence of anaemia among schoolchildren. Children in grade one were more at risk and the urgency in controlling this problem targeting grade one children or preschools giving priority for the districts with high prevalence.

Th56 **Pattern of Anaemia in children under five years in Sri Lanka**

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Background: Anaemia poses a major threat to the wellbeing of the children, particularly in developing countries. There is strong evidence of an association between severe anaemia and disease outcome in children significantly influencing the child mortality. In most instances, anaemia is due to a nutritional deficiency, particularly iron. A wide scale study has not being done to assess the situation in Sri Lanka and studying the prevalence pattern with regard to the age of children was considered helpful to identify the most vulnerable age groups and the aetiology of the problem.
Aims: This study was undertaken to determine the prevalence of anaemia in children under five years and to identify any pattern in relation to their age.
Methods: A representative sample was selected from seven agro-climatic zones of the country except the conflict stricken northern part. The study sample included 1749 pre-school children between the ages of six months to five years. All children were visited at their households in the presence of the mother or the principal caregiver to whom a structured questionnaire was administered.Their haemoglobin concentrations were measured with the indirect cyanmethaemoglobin method using a portable photometer (Hemcue). Cut off points recommended by the International Nutritional Anaemia Consultative Group for each age group were used to determine the prevalence. Statistical analyses were carried out for each age group separately. In addition, weights and heights of all children were taken. All procedures were carried out by experienced investigators all of whom were specially trained for the purpose before undertaking the study proper. **Results**: Out of the 1749 children examined, 545 were below the accepted cut off points. This gives an overall prevalence of 31.2% with a mean value of 11.5 mg/dl+1.3. There is no significant gender difference as prevalence for male and female children were 30.6% and 31.7% respectively. A notable finding was, as the age increased the prevalence of anaemia declined consistently. 59.3% of the children between 6 months to one year whereas the prevalence of 4 to 5 year age category gave a prevalence of 15.3%. Moreover, the mean haemoglobin value too showed a steady improvement as the age increased from 10.7mg/dl+1.5 in 6months to 1 year age category to 11.9mg/dl+1.1 in 4 to 5 year age category. **Conclusion**: Youngest of the under five children were the most affected physiological group showing the highest prevalence of anaemia. This may be attributed to poor iron reserves of the mother, giving them a poor start. High prevalence of anaemia in pregnant women supports this view. An in-depth study monitoring anthropometric characteristics and other aetiolgical factors acting in these age groups is a mandatory requirement as feeding practices and ill health during childhood may have an strong association with the anaemia status.

Th57 **ANEMIA IN GUINEA: A SEVERE PUBLIC HEALTH AND SOCIAL DEVELOPMENT PROBLEM. CAN IT BE CONTROLLED THROUGH A PROGRAMMATIC FOCUS ON ADOLESCENT GIRLS?** L Mahy, M Donzo, A Camara, A Touré, AB Bah, A Barry, MC Messier. National Institute for Nutrition and Child Health/INSE (MD, AC, AT), National Service for School and University Health (ABB), Stat-View Association (AB), and Helen Keller International-Guinea (LM, MCM).

Background: Guinea is a West-African country with high infant, child and maternal mortality rates. Early marriages and pregnancies are widespread. **Aims**: to assess the a) hemoglobin status in men and women throughout the lifecycle; b) relationship between hemoglobin and nutritional status, and mother/child anemia c) knowledge, attitudes and practices of women and men vis-à-vis anemia **Methodology**: A cross-sectional, nationally representative survey with a multi-stage proportional-to-size probability sample (n=7,236) of children (6 months to 17 years), women (18-49 years), and men (18-49 years). Hemoglobin was measured using the HemoCue™. **Results**: Prevalence of anemia is 79.0 % in children 6-59 months (89.8% in children 12-23 months), 51.7% in children 5-9 years, 44.6% in children 10-17 years, 50.3% in women of reproductive age, 63.2% in pregnant women and 23.4% in men. The prevalence of anemia in boys 15-17 years is lower (30.5%) (p=0.04) than in girls of the same age group (40.7%). In adolescent mothers (14-17 years), the prevalences of moderate and severe anemia were 1.49 and 6.4 times higher than in pre-conception adolescent girls. 41% of women believe it is normal for an adolescent girl to have a child. A significant correlation (p=0.0000) exists between mothers' anemia and anemia in their children with a linear relationship (R^2= 0.9364) for moderate anemia in mother-child couples. Distribution of iron supplements through the school health program reached 57% of children in public schools. **Conclusion**: In Guinea, anemia is a severe public health problem. Most vulnerable are children, adolescent mothers and pregnant women. Considering its extend and severity, comprehensive anemia control programs should be urgently implemented. Such multi-sectoral programs should have a strong focus on adolescent girls and include micronutrient supplementation and fortification, integrated school health programs, prevention of teenage pregnancies and increase of birth intervals.

Th58 PREVALENCE OF MALNUTRITION AND ANEMIA AMONG INFANTS AGED 4-12 MONTHS IN KILOSA DISTRICT. PS Mamiro, J Van Camp, PW Kolsteren, D Roberfroid, A Opsomer. Dept Food Tech and Nutr, Sokoine University of Agric, Morogoro Tanzania. Dept Food Tech and Nutr, Faculty of Agric and Applied Biol Sciences, Ghent University, Belgium. Nutrition and Child Health Unit, Inst of Tropical Medicine Antwerpen, Belgium.

Background: Infant malnutrition and anemia ranks as major nutritional problems in developing countries including Tanzania.
Objective: To evaluate the nutritional status and hemoglobin status in infants aged 4 to 12 months (mo).
Methods: A cross sectional study of the nutritional status of 338 infants aged 4-12-mo in Kilosa district, was undertaken in February-March 2001. Weight, length and hemoglobin concentration (Hb) of infants were measured and 24-hour dietary recalls were conducted.
Results: Stunting was more prevalent than other indicators of nutritional status. Severe stunting was observed in 9.2% of infants while 28.4% of infants were moderately stunted. 21% of the infants were underweight while only 2.1% of the infants had acute malnutrition even in the lean season. Conditions associated with stunting were low birth weight and mother's height. Food intake analysis showed that most complementary foods are cereal-based porridges with low iron and zinc content compared to WHO recommendations. Prevalence of diseases such as malaria and diarrhoea were high. Mean Hb was 8.40 +/-1.73 g/dL. Anemia was prevalent in Kilosa district; the majority of the infants (76%) had moderate Hb values ranging between 7 and <11 g/dL. More than 20% of the infants had Hb below 7 g/dL. Only 3.6% of the infants had Hb levels above 11 g/dL, the minimum WHO recommended cut-off point for normal Hb for infants. There was a significant drop (P<0.05) of Hb between 4-6-mo and 7-9-mo. The lowest Hb, mean 7.8g/dL was observed in infants 7-9-mo old while 4-6-mo infants had a mean Hb of 9.64g/dL. Infants between 10-12-mo old had mean Hb of 8.2g/dL.
Conclusion: A sustainable intervention to correct the situation is deemed urgent, through improving quality of complementary food based on locally available staples. However, such endeavor should also control diseases such as malaria and diarrhoea in the infants.

Th59 ANEMIA IN ADOLESCENT SCHOOLGIRLS IN RURAL MOZAMBIQUE. A CROSS-SECTIONAL SURVEY. S Meershoek, E Wetzler, J Roley and C MacArthur. Helen Keller International-Mozambique.

Background: Surveys in Mozambique have shown high prevalences of anemia in pregnant and non-pregnant women (50-60%). Current government policy for the control of iron deficiency and iron deficiency anemia is limited to providing iron/folate supplements to pregnant women. Yet, one of the critical points is to control iron deficiency and iron deficiency anemia in girls before and during puberty so as to ensure that girls enter adulthood and motherhood with adequate iron status. Aim: To assess the anemia status of adolescent schoolgirls and explore the socio-economic and health determinants of anemia in this population group. Methods: Cross-sectional survey of adolescent schoolgirls in 12 schools in Central Mozambique. Qualitative and quantitative data on adolescent girls' knowledge about anemia, their food habits, and their families' socio-economic status were collected. Capillary blood hemoglobin (Hb) levels were measured using HemoCue™B-Hemoglobin photometer. Results: Preliminary analysis shows that 45% of adolescent girls are anemic (Hb<12 g/dl). 50% of the adolescent girls had suffered some form of disease in the two weeks prior to the survey and 77% had had malaria at least once in the year before the survey. Less than 50% of the adolescent girls have access to clean drinking water and only 18% of them have access to cement latrines. The families of the girls are in general poor. None of the health and socio-economic indicators shows a significant relation with anemia. Only 7% of the girls had heard of anemia. Misconceptions about the nutrient and micronutrient content of foods are widespread. Food consumption is not related to the perceived nutrient content of food items but to access and economic determinants. Conclusions: The high prevalence of anemia and the poor knowledge about nutrition and anemia justify school-based iron/folate supplementation and health/nutrition education interventions to effectively control anemia in adolescent girls.

Th60 **ASSESSMENT OF ANAEMIA STATUS OF SRI LANKANS**

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Background: Anaemia is the condition that results when the erythropoietic tissue is unable to maintain a normal haemoglobin concentration because of an inadequate supply of one or more essential nutrients. Similar to most developing countries across the globe, Sri Lanka too is heavily burdened with the problem of anaemia mostly due the nutritional deficiency of iron. Although many programmes to prevent and control of this problem, there is a dearth of data on the current situation in the country as full 6 years have elapsed from the last major prevalence study. In this backdrop, a national study was implemented to assess the situation.
Aims: This study was undertaken to determine the prevalence of anaemia in children, adolescents and women of childbearing age, to describe the geographic distribution of anaemia and to study the associated socio economic and other factors.
Methods: A representative sample was selected from seven agro-climatic zones of the country except the conflict stricken northern part. The study sample included 1749 pre-school children 2469 primary school children 2717 adolescents, 4657 non-pregnant women in 4810 households and 1479 pregnant women attending the clinics of the sampled primary sampling units. The study was carried out as a household survey and the principal caregiver of each household was interviewed using a structured questionnaire. Each member of the target physiological group, namely preschool children, school children, adolescents and women of child bearing age was measured using height measuring board or anthropometric rod and solar powered electronic weighing scales. Their haemoglobin concentrations were measured with the indirect cyanmethaemoglobin method using a portable photometer (Hemcue). All results were weighted in order to achieve better representative ness. Prevalence of anaemia was determined using the standard WHO cut off points following an altitude correction where applicable.
Results: Overall prevalence of anaemia shows a steady decline in all physiological groups. The preschool children between the ages of 6 months to 5 years shows a prevalence of 31.2 (mean of 11.5 g/dl+1.3) while prevalence for primary school children was 21.0% (mean 12.3g/dl+1.1), 21.5% of the adolescent children are anaemic (mean 12.9g/dl+1.3). The comparative figure for women of childbearing age is 31.9% (mean 12.4g/dl+1.4). Out of the pregnant women selected, 30.0% (mean 11.6g/dl+1.3) were anaemic.
Conclusion: Iron deficiency anaemia in Sri Lanka is still a public health problem of moderate magnitude in spite of all the extensive interventions. Most affected groups were infants, preschool children and women of childbearing age groups including pregnancy.

Th61 ANEMIA IN MOROCCO: THE CASE OF THE KHENIFRA REGION IN THE MIDDLE ATLAS. M Raksi, MB Essat ara. Hassan II Institute of Agronomy and Veterinary Science, Rabat, MOROCCO. M Christensen. Brigham Young University, Provo, Utah, U.S.A.
The prevalence of anemia in Morocco is high. The 1995 National Iron and Iodine Survey found that 35.40% of children<5 years, 30.08% of childbearing age women, 45.50% of pregnant women, and 9.9% of adult men had hemoblobin levels below the World Health Organization cut-offs.
The Khenifra area of the Middle Atlas Mountains is an area known for its poverty. We conducted interviews with 75 families in the Agoudim locality in Khenifra to determine the frequency of consumption of basic foodstuffs. From among these families, 100 individuals were randomly chosen for measurement of blood hemoglobin and ferritin levels: 40 women in childbearing age, 30 men and 30 children (6 to 12 years of age). The WHO cut-off points for hemoglobin for diagnosing anemia were used: men, Hb<13g/dl; women in childbearing age, Hb<12g/dl; school age children, Hb<12g/dl. Likewise, the WHO cut-off points for inadequate iron stores were used: adult men and women, ferritin<12mcg/l; children, ferritin< 10mcg/l.
We found that 33% of children, 42.5% of females, and 20% of males were anemic according to the WHO standard for hemoglobin. Serum ferritin levels showed that, among these anemic persons, 50% of children, 47% of females and, 57% of males had depleted iron stores.
The high prevalence of anemia in this region is consistent with the low consumption of heme iron rich foods reported in the food frequency interviews. Half of the families surveyed consumed meat (beef, poultry or lamb) only once a week and 70% of the population did not eat fish. In addition, other factors such as consumption of large amounts of tea (5-6 cups/day) rich in tannins and consumption of cereals rich in phytates, may inhibit iron absorption and bioavailability. Correlations between measures of iron status and other potential determinants – supplement use, contraception, education, infant breast feeding, standard of living – are currently being analyzed.

Th62 PREVALENCE OF HEMOGLOBINOPATHY AMONG ANEMIC CHILDREN IN NORTHEAST BRAZIL. PHC Rondo, A Conde, PH Correa, FG Nogueira.

Background: Anemia is a serious health problem in many countries. WHO estimates that 2 billion people are anemic, mainly due to iron deficiency. In everyday practice, therapy with iron supplementation is very used. It is considered the most sensitive and inexpensive mean of confirming iron deficiency. Although iron deficiency is characterized as the main cause of anemia, in some geographical areas with a large variety of phenotypes, some hemoglobinopathies may be important. Aims: The purpose of this study was to determine the prevalence of hemoglobinopathies among 223 selected anemic children, aging 2 to 11 years in the northeast of Brazil.
Methods: The following hematological and biochemical measurements were performed: 1) cellulose acetate electrophoresis at alkaline pH for diagnosis of the hemoglobin variants and thalassemia syndromes; 2) citrate agar electrophoresis at pH 6.0 to confirm the pattern obtained in the electrophoresis of hemoglobin at alkaline pH; 3) fetal hemoglobin was estimated by the method based on its resistance to denaturation at alkaline pH; 4) hemoglobin (Hb) concentration and red blood cells by an automated cell counter (Cell Dyn 3,000, Abbott Laboratories). The cut-off points adopted in the diagnosis of anemia were: Hb < 11g/dL or children < 6 years of age and < 12g/dL for children > 6 years.
Results: Of the 223 anemic children investigated, 50 (22.4%) presented hemoglobinopathies: 30 (60%) had Hb AS; 17 (34%) Hb AC; 2 (4%) Hb SC and 1(2%) Hb CC.
Conclusion: According to our results, in some regions of the world it is important to differentiate the different types of anemia, particularly those caused by hemoglobinopathies. Iron supplementation may have consequences in these children, if the diagnostic is not properly investigated.

Th63 PREVALENCE OF ANEMIA AMONG CHILDREN AND PREGNANT WOMEN IN MONGOLIA. B.Gereljargal, Public Health Institute, Sh.Oyunbileg, M.Tuya, UNICEF, L. Narantuya, Public Health Institute, Ulaanbaatar, Mongolia

Backgrtound: In Mongolia, 27.8% of children under 5 years old suffered from iron deficiency anemia in 1992. In 1997, the number reached 30.3%, and in 1999 it increased to 42.0%. Prevalence of anemia among pregnant women was also noted to be high. In order to reduce anemia among women, iron folate distribution for pregnant women has been organizing nationwide since 1994. There is a need to evaluate the iron supplementation program and identify contributing factors to anemia in more detail. **Objective**: to determine the prevalence of anemia and iron deficiency among children under 5 and pregnant women. **Methods**: Nine hundred and thirty seven children aged 6-59 months were randomly selected from 58 villages of 21 provinces and 782 pregnant women selected from the capital city and 3 provinces. Hemoglobin level of selected individuals is measured by using HEMO-CUE and serum ferritin determined by enzyme–immunoassay analysis. The assessment indicator is done in compliance with WHO criteria and classification related to long term altitude exposure. **Results**: One third of children aged 6-59 months were anemic. In particular, more than half of children aged 6-23 months is anemic. Prevalence of anemia is 12.4% among pregnant women, 14% of whom are over 28 gestation weeks. Approximately half of children 6-59 months of age and 47.1% of pregnant women were found to have a low level of serum ferritin (<24ng/l). Prevalence of severe iron deficiency (serum ferritin is <12ng/l) among anemic children 6-59 months of age, was 58.3% and among pregnant women was 41.7%. One fifth of children aged 6-59 months and one fifth of pregnant women have sub-clinical iron deficiency anemic. With regard to iron supplementation among pregnant women, half of the surveyed pregnant women received iron-foliate and 66% of pregnant women at over 28 gestation weeks received iron foliate. **Conclusion**: Prevalence of anemia among children aged 6-23 months is high. In Mongolia, one of the major causes of anemia among children and pregnant women is iron deficiency in Mongolia. Sub-clinical iron deficiency is common among young children and pregnant women. Iron supplementation programme among pregnant women was effective. A Policy on adequate nutritious food is required, including food fortification.

Food Fortification

Th64 **STABILITY OF IRON FORTIFIED RICE (IFR) PACKED IN FOUR TYPES OF PACKAGING MATERIALS**. M.V.Capanzana, A.F.Dara-ug, W.N. Lainez and E.M.Fidel. Food and Nutrition Research Institute, Dept. of Science and Technology, Bicutan, Taguig, Metro Manila.

This study aimed to evaluate the sensory acceptability, iron retention and changes in the physico-chemical properties of iron fortified rice (IFR) during storage at room temperature when packed in polyethylene plastic sack, PE bag, PE bag in a box and sachet. The IFR was prepared by mixing one part of IFR premix rice with 200 parts ordinary rice, packing and storing for eight months. Results of the study showed a decreased in the level of iron content of IFR and uncooked enriched rice packed in four packaging materials ranging from 20-30%, while the cooked enriched rice showed slight decrease during the entire storage period. The color (L value) of fortified and unfortified samples changed significantly during storage. The fortified sample was slightly grayish in color. Sensory evaluation of the cooked samples kept in PE bag and PE plastic sack showed noticeable insect infestation on the 6th month of storage. Less infestation was observed in samples kept in PE bag in the box. There was also a perceptible off-taste during this period of storage. On the other hand, IFR sample kept in sachet was acceptable up to the 8th month of storage in terms of color, odor, taste, texture and general acceptability. This study demonstrated the changes in the quality of IFR during storage. IFR kept in sachet and mixed with ordinary rice before cooking appeared to be a more ideal system to enrich rice, especially when it has to be kept for an extended period.

Th65 **DEVELOPMENT OF IRON AND VITAMIN A FORTIFIED TABLE SUGAR: THE PHILIPPINE EXPERIENCE.** L.M. Marero, M.C.Saises, C.S.Quindara and M.V. Capanzana. Food and Nutrition Research Institute, Dept. of Science and Technology, Bicutan, Taguig, Metro Manila, Philippines.

This study was aimed at developing a technology for double fortification of sugar (refined and washed sugar) with vitamin A and iron. Vitamin A plamitate 250 CWS was used as vitamin A fortificant while ferrous sulfate, ferric sodium EDTA, ammonium ferric citrate and ferrochel amino acid chelate were investigated as possible source of iron. The level of fortification was 1/3RDA of 4-6 year-old children. The double fortified sugar should have a minimum iron content of 3.3 mg and vitamin A content of 125 ug retinol per 12 g sugar. The processing and storage losses were accounted for in the final product. Quality control measures of raw materials and during processing such as homogeneity of mixing and control of finished product e.g. vitamin A and iron stability, were monitored. Acceptability of double forified sugar and their commonly used recipes and application were tested. Retention test was also conducted in different food products. Results of the study showed that double fortified sugar was stable for six months at ambient temperatures (28-32C), except for a slow progression of grayish to brownish discoloration that is noticeable at the later part of the storage. The double fortified sugar was moderately acceptable when used in food preparation, like juices, milk except of tea, coffee with creamer, rice cake and other preparations. Both nutrients were retained in beverages, like calamansi (lime) juice, coffee and baked products. This study demonstrated the possibility of fortifiying sugar with vitamin A and iron, although sligh discoloration towards the end of six months storage was noted. The availability of fortified staple foods, like sugar, will increase intake of children for iron and vitamin A, both of which remain as a public health concern in the Philippines.

Th66 PROCESS EVALUATION OF THE DISTRIBUTION OF MICRONUTRIENT SPRINKLES IN OVER 10,000 MONGOLIAN INFANTS USING A NON-GOVERNMENTAL ORGANIZATION (NGO) PROGRAM MODEL.

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Background Economic instability and severe winters have resulted in food shortages across Mongolia. As a result, micronutrient deficiencies (iron and vitamin D) are common among children. 'Sprinkles' containing iron and other micronutrients (including Vitamin D) were developed as an inexpensive micronutrient supplement. **Objectives** 1. To determine the prevalence of anemia and rickets in children <5 years. 2. To develop an NGO distribution model to deliver Sprinkles to infants 6-36 mo. and achieve 80% coverage. 3. To monitor and evaluate process and biological outcome indicators. **Methods** A cross-sectional baseline survey was conducted among 1478 children. Assessment of anemia was based on hemoglobin (Hb). Assessment of rickets was based on a physical examination. Program design, monitoring and evaluation were based on the Triple A Process (Assessment, Analysis, Action). A monitoring system was developed to measure indicators of project activities and outcomes. Monthly process evaluation included number of Sprinkles distributed, program coverage and random spot checks of families to assess adherence to the program by counting number of Sprinkles consumed by children. **Results** At baseline prevalence of anemia (Hb<115 g/L) and rickets were 42% and 33%, respectively. 13,301 eligible children in 8 regions were identified for participation in the program. Program outputs included adequate procurement, supply and delivery of Sprinkles to distribution points and training of 107 community volunteer nutrition workers who provide counseling and deliver Sprinkles bi-weekly to families Distribution began in August 2001; one year into the program, coverage reached 84% of eligible children in target regions. Level of acceptance and adherence to Sprinkles remains high with a mean of 74% of the monthly supply of daily Sprinkles being consumed by children. **Conclusion** Anemia and rickets are serious public health problems among Mongolian children. The NGO model for distribution is feasible. Sprinkles are being well accepted by the population. (Supported by World Vision Canada and the HJ Heinz Company Foundation)

Th67 **THE EFFECT OF RETINOL ADDED TO IRON FORTIFIED CORN PORRIDGE ON ERYTHROCYTE INCORPORATION OF IRON IN AFRICAN CHILDREN WITH SUB-CLINICAL VITAMIN A DEFICIENCY.**

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Background: Retinol added to iron-fortified corn bread has been reported to enhance iron absorption in adult Venezuelan subjects but not in Western Europeans. It is not known to what extent these results were influenced by differences in vitamin A status of study subjects.
Objective: To evaluate the influence of retinol added to iron fortified corn porridge on erythrocyte incorporation of iron in children with sub-clinical vitamin A deficiency, before and after vitamin A supplementation.
Design: Erythrocyte incorporation of iron stable isotopes was measured 14 days after intake of corn porridge (2.0 mg iron added as ferrous sulfate) with and without added retinol (1000 µg). The study was repeated 3 weeks after vitamin A supplementation (210 µmol retinol: 200, 000 IU). Vitamin A status was evaluated by the Modified Relative Dose Response (DR:R ratio) technique.
Results: Retinol added to the test meal reduced erythrocyte incorporation of iron at baseline; geometric mean 4.0 % versus 2.6 % (p=0.008; n=13; paired t-test). Three weeks after vitamin A supplementation, geometric mean erythrocyte incorporation was 1.9 % and 2.3 % respectively from the test meal with and without added retinol (p=0.283). Mean DR:R ratios were 0.155 and 0.125 before and after vitamin A supplementation (p=0.15).
Conclusions: Added retinol significantly decreased erythrocyte incorporation of iron from the test meal in children with sub-clinical vitamin A deficiency but had no influence 3 weeks after vitamin A supplementation. The difference in response to added retinol on erythrocyte incorporation of iron before and after vitamin A supplementation indicates changes in vitamin A status not measurable by the MRDR technique. The lack of conclusive data on the effect of retinol on iron absorption indicate the complexity of the interactions between vitamin A status, dietary retinol and iron metabolism.

Th68 INFLUENCE OF NA2EDTA ON IRON ABSORPTION FROM FERROUS FUMARATE AND FERROUS SULFATE FORTIFIED INFANT CEREAL.

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Background: Na2EDTA has repeatedly been shown to enhance iron absorption from ferrous sulfate. However, recent studies have indicated that Na2EDTA may not influence iron absorption from non-water soluble iron compounds, such as ferrous fumarate. Aim: To compare the enhancing effect of Na2EDTA on iron absorption from ferrous fumarate and ferrous sulfate fortified infant cereal. Method: Iron absorption was based on erythrocyte incorporation of stable isotopes (57Fe and 58Fe) 14 days after intake of labeled test meals. Ten women (age 22-26) each received 4 test meals (roller-dried wheat-based infant cereal (50 g) prepared with milk) fed in a crossover design. The first two test meals where fed on day 1 and day 2 and fortified with either ferrous fumarate or ferrous sulfate. After a blood sample was drawn on day 15, test meals fortified with ferrous fumarate and Na2EDTA and ferrous sulfate and Na2EDTA (molar ratio Fe:EDTA of 1:1) were fed on days 16 and 17. On day 30, a blood sample was drawn. Results: There was no statistically significant difference between the geometric mean iron absorption (-SD, +SD) from the ferrous fumarate and ferrous sulfate fortified infant cereal (3.0 (1.6, 5.5)% and 3.1 (1.3, 7.4)%, respectively, p= 0.85). However, when Na2EDTA was added the geometric mean iron absorption from ferrous sulfate fortified infant cereal was statistically significantly higher than from ferrous fumarate (5.3 (3.2, 8.6)% vs. 3.3 (2.2, 5.0)%, p=0.001). Discussion: The earlier observed high relative bioavailability of ferrous fumarate in healthy adults was confirmed in this study. The bioavailability of ferrous fumarate was not improved by the addition of Na2EDTA. This is probably due to the solubility properties of ferrous fumarate in the gastric juice. These results show that enhancers of water soluble iron compounds do not necessarily enhance iron absorption from non-water soluble compounds.

Th69 HIGH RELATIVE BIOAVAILABILITY OF ENCAPSULATED FERRIC PYROPHOSPHATE WITH REDUCED PARTICLE SIZE (SUNACTIVE FE®). MC Fidler, T Walczyk, L Davidsson, C Zeder, N Sakaguchi, L Juneja, RF Hurrell. Laboratory for Human Nutrition, Institute of Food Science and Nutrition, ETH Zurich, PO Box 474, 8803 Rueschlikon, Switzerland and Taiyo Kaguka, 9-5 Akahori-Shinmachi, Yokkaichi, Mie 510-0825, Japan.

Background: Ferric pyrophosphate is a water-insoluble iron compound often used to fortify infant cereals and chocolate drink powders as it causes no adverse color and flavor changes to the food vehicle. However, it is only of low absorption in man. Recently, a novel ferric pyrophosphate compound has been developed (Sunactive Fe®, Taiyo Kagaku, Japan) based on small particle size ferric pyrophosphate (average: 0.5 µm) and encapsulation with a mixture of emulsifiers, so that it remains in suspension in liquid products. Aim: To compare iron absorption of Sunactive Fe® with that of ferrous sulfate in an infant cereal and a yogurt drink. Method: Iron absorption was based on the erythrocyte incorporation of stable isotopes (57Fe and 58Fe) 14 days after intake of labeled test meals. Twenty apparently healthy female students (age 19-31) were randomly assigned to the 2 separate studies (10 subjects/study). The test meals consisted of a roller-dried wheat-based infant cereal (50 g) prepared with 8 g milk powder and 75 mL water in Study 1 and a yogurt drink (170 g yogurt + 100g milk) in Study 2. Each test meal contained 5 mg added Fe, including 4 mg labeled 58FeSO4 plus 1 mg of FeSO4 of natural isotopic composition or 5 mg of 57Fe labeled Sunactive Fe®. Results: There was no statistically significant difference between the geometric mean iron absorption (-SD, +SD) from Sunactive Fe® and ferrous sulfate fortified infant cereal (3.4 (2.0, 5.6) % and 4.1 (2.2, 7.6) %, respectively, p= 0.24) and from Sunactive Fe® and ferrous sulfate fortified yogurt drink (3.9 (1.5, 10.5) % and 4.2 (1.7, 10.3) %, respectively, p=0.72). Conclusion: The results of these studies show that Sunactive Fe® is as well absorbed a ferrous sulfate in adults. The high relative iron bioavailability of Sunactive Fe® (encapsulated ferric pyrophosphate with reduced particle size) indicates the potential usefulness of this novel compound for food fortification.

Th70 **ELEMENTAL IRON POWDER USED FOR FOOD FORTIFICATION: DOES PHYSICOCHEMISTRY PREDICT BIOAVAILABILITY?** JH Swain and JR Hunt. Grand Forks Human Nutrition Research Center, Grand Forks, ND, USA

Background: The bioavailability of elemental Fe powders used widely as food fortificants is poorly documented. Rapid, economical measures of bioavailability are needed. **Aims**: To determine the extent that physicochemistry predicts the bioavailability of six commercially produced (~2001) elemental Fe powders, collected by SUSTAIN (Sharing U.S. Technology to Aid in the Improvement of Nutrition, Washington, D.C., USA). **Methods**: The relative biological value (RBV) of the Fe powders was determined using the AOAC hemoglobin repletion/slope ratio method in 220 weanling, male Sprague-Dawley rats. After dietary Fe depletion (24 d;~1.5 mg Fe/kg AIN93G diet), rats consumed a repletion diet (14 d; AIN93G diet) fortified with one of six elemental Fe (all > 97% Fe) powders (each ~12, 24, and 36 mg Fe/kg), ferrous sulfate ($FeSO_4 \cdot H_2O$; ~6, 12, 18, and 24 mg Fe/kg), or no added Fe (~1.5 mg Fe/kg); n=9-10/diet. Solubility was measured (n=3) in dilute (0.02 M) hydrochloric acid, by assaying Fe in solution at 15 to 150 min time points. Surface area (n=6) was determined by gas adsorption (30 mol % helium and 70 mol % nitrogen; BET method). **Results**: The RBV ($FeSO_4$=100%) of the Fe powders differed significantly (values marked with the same letters are not different ($p<0.05$)): Carbonyl (Ferronyl, U.S.), 64%a; Electrolytic (A-131, U.S.), 54%b; Electrolytic (Electrolytic Fe, India), 46%bc; H-Reduced (AC-325, U.S.), 42%c; Reduced (ATOMET 95SP, Canada), 24%d; and CO-Reduced (RSI-325, Sweden), 21%d. Solubility also differed, ranging from 10 to 60% at 15 min and 51 to 97% at 150 min, but with an inconsistent rank/order at different time points. Surface area of the Fe powders ranged from 90 to 370 m2/kg, and was more predictive of bioavailability than was solubility at any time: R2=0.80 vs. an increasing R2 of from 0.40 at 15 min to 0.64 at 150 min. **Conclusions**: The bioavailability of elemental Fe powders differed considerably, and was better predicted by surface area than by solubility.

Th71 **A NEW CONCEPT OF FERRIC PYROPHOSPHATE FORTIFICATION IN FOODS (SUNACTIVE FE™).** LR Juneja, H Nakata, N Sakaguchi and H Nanbu. Nutritional Foods Division, Taiyo Kagaku Co., Ltd., Japan.

Background: Nonreactive iron compounds are needed for fortification of foods because it has less of an "iron taste" compared to soluble iron. However, due to its insolubility precipitation of the iron prevents fortification in foods. We prepared a formulation of ferric pyrophosphate, SunActive Fe™, which disperses insoluble iron in liquid formulations and produces no precipitation. **Aims**: To evaluate taste, stability, relative biological values, hemoglobin regeneration efficacy and gastric torelance of SunActive Fe™ with that of ferric pyrophosphate , ferrous sulfate, and sodium ferrous citrate. **Methods**: Freshly prepared ferric pyrophosphate was dispersed in solution with a mixture of emulsifiers to make its soluble form (SunActive Fe™). The sensory evaluation and stability test were carried out in different conditions. Iron absorption and bioavailability of SunActive Fe™ was investigated by serum iron method (Pagella, et al., 1984) and hemoglobin regeneration efficiency (HRE) method (Forbes, et al, 1989) in rats. Gastric tolerance in various of iron sources was determined (Adami method) in rats. **Results**: "SunActive Fe™" did not affect the flavor and taste of the final food products. "SunActive Fe™" was stable under the condition of heating and high salt concentrations. The relative biological values (RBV) of iron sources per ferrous sulfate were 1.05, 0.78, and 1.00 for SunActive Fe™, ferric pyrophosphate and sodium ferrous citrate, respectively in rats. SunActive Fe™ showed the highest value of HRE among the Fe compounds tested. "SunActive Fe™" did not show any toxic effect on the gastrointestinal system as compared to other iron sources. **Conclusion**: Using SunActive Fe™, it has become possible to fortify foods with iron having merits of stability, taste, safety and bioavailability. Many SunActive Fe™ fortified products like milk, yogurt, and beverages including sports drinks have been launched in Japanese market and abroad.

Th72 **COMMUNITY-BASED FORTIFICATION OF MAIZE FLOUR AT VILLAGE MILLS IN TANZANIA.** B Kindoli, J Hildebrand, S Blaney, K Siekmans. World Vision Canada, World Vision Tanzania. **Problem**: Baseline survey hemoglobin (Hb) data (1998) from World Vision's MICronutrient And Health (MICAH) program in Tanzania confirmed high levels of anemia among women of childbearing age (WCBA) and children under five (U5s). **Framework/design**: Fortification of staple foods is a key strategy to increase dietary intake and improve micronutrient status. Since commercially available fortified foods do not reach MICAH's targeted rural areas, a community-based approach to fortify maize flour at local village hammer mills was planned, in collaboration with the Tanzania Food and Nutrition Centre (TFNC). Fortification commenced in mid-2001, targeting 5000 households, 43 millsand 14 villages. **Objectives**: 1. Reduce prevalence of iron deficiency amongWCBA and U5s. 2. Strengthen community capacity to implement fortification activities. **Results**: Baseline survey results (1998) showed anemia rates of 95% (n=1075) among U5s, 87% (n=62) among pregnant women and 72% (n=1038) among WCBA. Additional Hb data was collected during May 2001 as a baseline for the fortification initiative, and one year later in May 2002. Mean Hb levels increased among WCBA from 10.74 g/dL (n=510) to 10.81 g/dL (n=334) however prevalence of anemia increased from 50.4% (n=510)to 64.4% (n=334). Among children U5, mean Hb levels increased from 8.96 g/dL (n=765) to 9.43 g/dL (n=527) while prevalence of anemia increased from88.1% (n=765) to 95.8%(n=527). An informal survey in one village indicated 89% acceptance of the fortified maize. **Implications**: Community-based fortification has potential to sustainably increase iron intake among vulnerable populations and improve micronutrient status. Multi-sectoral collaboration involving various stakeholders has contributed to community acceptance and capacity to implement fortification at local mills. A national fortification task force has recently been formed, whose mandate is to expand fortification initiatives within Tanzania. (Funded by CIDA)

Th73 IRON CONTAINING MULTIPLE VITAMIN AND MINERAL FORTIFIED POWDER DRINK: BIOAVAILABILITY, STABILITY AND PRODUCT ACCEPTANCE EVALUATION. H Mehansho[1], DL Hughes[1], DB Compton[1], T Walter[2]. [1]P&G Nutrition Science Institute, The Procter & Gamble Company, Cincinnati Ohio, and [2]The Institute for Nutrition and Food Technology, University of Chile, Santiago.

Food fortification is widely used as a means to combat micronutrient malnutrition including iron deficiency anemia. The challenges in food fortification, particularly with iron, include unacceptable taste, off-color, poor-stability, and low bioavailability. We have addressed these problems by developing a unique fortification technology called "GrowthPlus". Using the GrowthPlus technology, multiple-micronutrient, fortified-powder fruit drink has been formulated and extensively evaluated. One serving of the product delivered (in Venezuela RDI) 25% of iron, vitamin A and iodine, 100% of vitamin C, and 25-50% of zinc, folate, B^2, B^6, B^{12}, and vitamin E. This was accomplished by identifying the right fortificants and understanding and managing the chemical and physical properties that contribute to the multiple organoleptic problems. Data from a double-blink, home-use test showed fortification with the "GrowthPlus Technology" has no effect on the overall acceptance, appearance, and flavor of the finally consumed powder beverage. One-year stability studies demonstrated iodine, vitamin A, vitamin E, vitamin C, and the B vitamins from the powder fruit drink have adequate stability. Furthermore, bioavailability of the iron was evaluated by using the extrinsic-tag, double-isotope labeling technique in human subjects. The bioavailability of the iron from the orange-flavored powder drink was tested (a) alone, (b) with rice, and (c) with calcium. The results showed the bioavailability of the iron from fortified beverage alone, fortified beverage plus calcium (as calcium citrate malate) and fortified beverage plus rice were 23.4%, 18%, and 10.7%, respectively. The results demonstrate that the fortified, orange-flavored beverage delivers highly bioavailable iron, stable vitamins, and iodine without compromising the taste and appearance.

Th74 THE CONTRIBUTION OF IRON FROM A MULTI-MICRONUTRIENT FORTIFIED CONDIMENT SPREAD TO THE TOTAL DIETARY IRON FROM MAIN-DISH RECIPES OF URBAN AND RURAL LOW-INCOME GUATEMALAN HOUSEHOLDS. M Orozco, NW Solomons, A Briend. CeSSIAM, Guatemala City, and ISTNA/CNAM, Paris, France.

Background: Finding potentially selective and targeted- but effective-ways to increase iron intake and absorption in at-risk sub-populations may be a key to reducing endemic iron deficiency. Aims: To present low-income Guatemalan women with a high-density nutrient spread (HDNS) in the form of a condiment seasoning, to determine how they would incorporate it into household cuisine; and determine the distribution and inter-individual variance of extrinsic and total iron from these main-meal dishes. Methods: A total of 30 main-meal recipes (15 rural; 15 urban) were collected from women presented with the condiment spread containing 166 mg of iron per 100 g in form of a ferrous salt, and the micronutrient values calculated by recipe and by portion consumed by family members. Results: A total of 30 main-meal recipes (15 rural; 15 urban) were collected. Meals were consumed by 2 to 11 persons (median: 5). The intrinsic iron density of the main meals, ranged from 2.7 to 280.0 g/1000 kcal, with 1.7 to 57.0 mg/meal, for an average individual consumption of 3.7 ± 3.8 mg per consumer. Women added from 2 to 20 g of the HDNS to the recipes. This raised the total iron consumption statistics for main meals to 8.6 to 389.2 mg/1000 kcal, with 18.3 to 94.9 mg/meal, for 14.2 ± 8.7 mg per consumer, helping most consumers to meet or exceed their daily iron intake recommendations from this meal alone. Conclusions: Iron content of meals was increased by HDNS addition by 1.4 to 20.2 times, but interindividual exposure varied widely. More than 1/3 of the WHO iron recommendation (assuming 10% Fe bioavailability) was achieved in the meals for 33% of women.

Th75 COMPARISON OF DOSING FREQUENCY AND SAFETY OF SPRINKLES ON IRON STATUS IN PRESCHOOL CHILDREN IN NORTHERN CHINA. M Chan, S Zlotkin, SA Yin, W Sharieff, C Schauer. The Hospital for Sick Children, Research Institute, Canada; Departments of Paediatrics, Nutritional Sciences, and Centre for International Health, University of Toronto; Institute of Nutrition and Food Hygiene, Chinese Academy of Preventive Medicine, Beijing, China.

Adherence to iron supplementation has been disappointing in unsupervised settings. Evidence suggests that in supervised settings, such as in schools, intermittent dosing may be as efficacious as daily dosing. Sprinkles containing iron and other micronutrients can easily be added to school meals. Aims: (1) To determine whether Sprinkles given once/week would yield similar increases in hemoglobin (Hb) and ferritin (Fn) as Sprinkles given 5-days/week; (2) To explore whether a 30mg Fe dose would be safe to administer to preschool children. Methods: A 3-arm RCT using cluster randomization was conducted in a preschool in Northern China. 386 children ages 3-6 yrs, in 16 classes were enrolled. Classes were randomized to receive either Sprinkles for 5-days/week, or once weekly, or no intervention for 3 months. At baseline and at the end, socioeconomic and dietary variables, and Hb and Fn concentrations were determined. Results: Baseline characteristics between groups were similar; overall, mean Hb and geometric mean Fn concentrations were 131±9 g/L and 51µg/L (range; 2.5-155), respectively. Prevalence of anemia was only 5%. At the end, there was no significant change in Hb within or among the Sprinkles groups compared to baseline. Final mean Hb concentration was 129±10 g/L in the 5-days/week regimen; 128±9 g/L in the once/week regimen; and 127±8 g/L in the control. There was a greater increase in Fn in the 5-days/week group compared to the once/week group (p=0.0056). Geometric mean Fn concentration at the end was 75µg/L (range; 27-189) in the 5-days/week group; 65µg/L (range; 10-181) in the once/week group; and 63µg/L (range; 7-183) in the control (p=0.0011). Conclusions: Since the prevalence of anemia was low, detecting an effect on Hb was not possible. Sprinkles provided 5-days/week improved iron stores over once/week dosing. Safety of a 30mg Fe dose of Sprinkles was demonstrated by the absence of any Fn values outside the normal range. (Supported by the Heinz Fdt & CIHR.)

Th76 IRON ABSORPTION FROM INTRINSICALLY LABELED MICROENCAPSULATED FERROUS FUMARATE (SPRINKLES) IN ANEMIC & NON-ANEMIC INFANTS. M Tondeur, S Zlotkin, C Schauer, S Newton, S Owusu-Agyei. Departments of Paediatrics, Nutritional Sciences, and Centre for International Health, University of Toronto; The Hospital for Sick Children, Research Institute, Canada; Kintampo Health Research Centre Health Research Unit, Ministry of Health, Ghana.

Microencapsulated ferrous fumarate (Sprinkles) is a new supplement for 'home-fortification'. The contents of a sachet can be added to any complementary food without changing the colour or taste. We believe this intervention may decrease the burden of iron deficiency anemia (IDA) in the developing world. However, the most appropriate dose of iron (Fe) to include is not known since its bioavailability has not been studied. Aim: To determine the absorption of 2 doses of Sprinkles when added to a complementary food provided to anemic and non-anemic infants. Methods: In a prospective triple-masked, randomized trial, 39 anemic (hemoglobin (Hb) <100 g/L) and 40 non-anemic infants (Hb>100 g/L) aged 6-18 mo were studied in rural Ghana. Infants received either 30 or 45 mg of elemental Fe containing 6.15 or 9.22 mg respectively of intrinsically labeled 57Fe as microencapsulated ferrous fumarate plus ascorbic acid and vitamin A, added to a standardized maize porridge on 3 consecutive days. Blood was drawn at baseline and 14 days later to determine erythrocyte incorporation of 57Fe by ICP-MS. Fe absorption was calculated based on the assumption of 80% erythrocyte incorporation. Results: At baseline, the anemic group had a mean Hb level of 89.2±7.7g/L and geometric mean ferritin concentration (Fn) of 18.1µg/L; in the non-anemic group, Hb level was 108.0±7.2g/L and Fn 32.5µg/L. Fe absorption was found to be similar at both doses within groups (p>0.05): Mean absorption was 11.1 vs 9.1% in the anemic group and 6.6 vs 6.0% in the non-anemic group for the 30 and 45 mg Fe dose, respectively. Fe absorption at both doses was significantly higher in anemic infants (p<0.05). Conclusion: There was no effect of dose on Fe absorption. Percent absorption of Sprinkles was higher in anemic infants independent of the dose provided. These results will enable us to determine the optimal dose of Fe to safely treat and prevent IDA. (Supported by the CIHR, Particle Dynamics Inc. and the HJ Heinz Fdt.)

Th77 **The effect of bread fortified with ferrous bisglycinate or reduced iron on the iron status of young schoolchildren.** ME van Stuijvenberg, P Wolmarans, CM Smuts, MA Dhansay, CJ Lombard, AJS Benadé. Nutritional Intervention Research Unit and Biostatistics Unit, Medical Research Council, Cape Town, South Africa.

Background: Food fortification is an important strategy for addressing micronutrient deficiencies in developing countries. However, finding the ideal iron fortification compound (i.e. a compound of high bioavailability, but one that will not cause organoleptic changes) remains a challenge. Chelated iron compounds are less affected by inhibitors of iron absorption, and are also less likely to cause organoleptic problems. ***Objective:*** In this study the effect of an iron amino acid chelate (ferrous bisglycinate), used as a fortificant in bread, was compared with the effect of reduced iron on the iron status of schoolchildren in a randomised controlled trial. ***Design:*** Primary school children (n=160), aged 6-11 years, with low iron stores (serum ferritin <20 µg/L) were randomly assigned to one of three treatment categories: (i) a group receiving standard unfortified brown bread; (ii) a group receiving fortified brown bread using reduced iron (electrolytic) as iron fortificant (ER); and (iii) a group receiving fortified brown bread using ferrous bisglycinate as iron fortificant (FB). Each child received four slices of bread per school day over two meal periods. The fortified bread supplied 2.5 mg (25% RDA) elemental iron per day for a period of 4.5 months and 5 mg (50% RDA) for the remaining 3 months. The bread was distributed under close supervision, and compliance monitored daily. Haemoglobin, serum ferritin, iron, transferrin, and C-reactive protein were measured before and after 7.5 months of intervention. ***Results:*** At baseline stunting, underweight and wasting were present in 27.3%, 28.0% and 5.8% of the children, respectively. Mean haemoglobin was 12.63 ± 0.86 g/dL and 7.5% were anaemic. In children with serum ferritin <15 µg/L, there was a significant increase in haemoglobin in the FB group compared to the control ($P = 0.044$), but not in the ER group. Serum iron and transferrin saturation in the FB group increased significantly compared to both the control and ER groups ($P < 0.05$). There was no significant increase in serum ferritin in either the FB or ER groups. ***Conclusion:*** Ferrous bisglycinate as iron fortificant in bread performed better than electrolytically reduced iron in this group of non-anaemic iron deficient children over a period of 7.5 months.

Th78 KAP STUDYABOUT FORTIFIED FOOD : USE AND PROMOTION. A. Zerrari, Mr. Lazrak, E Rjimati, Mr. Mahfoudi, H. Chekli, A. Khounfi, Ministry of Health Morocco 2002.

In Morocco, the investigations carried out by the Ministry for Health during the ten last years showed that micronutrients deficiency is a real problem of health. Conscious of the problem, the Ministry of health developed a national strategy for controlling the micronutrients deficiencies. This strategy is based on nutritional education, supplementation, and food fortification (salt, flour, oil and milk) by iodine, iron and vitamins A and D. The fortification of food needs a good knowledge of the population food practices and habits, the circuit of food before consumption and their storage at various levels, their availability and their distribution. For these objectives, a KAP study is planned to know the likely factors influencing or changing general aspects of these products and reduce their content of micronutients. This study will be conducted in four areas of the kingdom : North, Center, Oriental and South. In each area, 150 individual interviews will be carried out (100 households, 25 grocers and wholesalers and 25 health workers and all producers of fortified food in this area). The sample is representative of urban, suburban and rural in four areas. In this study, for each investigated profile, appropriate questionnaire will carefully be prepared to cover all aspects of process, use and promotion of fortified food. This study will start in early September of this year, will take less then one month. The preliminary results will be available in November. The aim of this KAP survey is to come up with a national IEC strategy and the messages which have promoted. It will be a pertinent tool to accompany the whole food fortification process which will be launched in July 02. The results of this study will be presented in the next IVACG/INACG meeting.

The effect of bread fortified with ferrous bisglycinate or reduced iron on the iron status of young schoolchildren. ME van Stuijvenberg, P Wolmarans, CM Smuts, MA Dhansay, CJ Lombard, AJS Benadé. Nutritional Intervention Research Unit and Biostatistics Unit, Medical Research Council, Cape Town, South Africa.

Background: Food fortification is an important strategy for addressing micronutrient deficiencies in developing countries. However, finding the ideal iron fortification compound (i.e. a compound of high bioavailability, but one that will not cause organoleptic changes) remains a challenge. Chelated iron compounds are less affected by inhibitors of iron absorption, and are also less likely to cause organoleptic problems. ***Objective***: In this study the effect of an iron amino acid chelate (ferrous bisglycinate), used as a fortificant in bread, was compared with the effect of reduced iron on the iron status of schoolchildren in a randomised controlled trial. ***Design***: Primary school children (n=160), aged 6-11 years, with low iron stores (serum ferritin <20µg/L) were randomly assigned to one of three treatment categories: (i) a group receiving standard unfortified brown bread; (ii) a group receiving fortified brown bread using reduced iron (electrolytic) as iron fortificant (ER); and (iii) a group receiving fortified brown bread using ferrous bisglycinate as iron fortificant (FB). Each child received four slices of bread per school day over two meal periods. The fortified bread supplied 2.5 mg (25% RDA) elemental iron per day for a period of 4.5 months and 5 mg (50% RDA) for the remaining 3 months. The bread was distributed under close supervision, and compliance monitored daily. Haemoglobin, serum ferritin, iron, transferrin, and C-reactive protein were measured before and after 7.5 months of intervention. ***Results***: At baseline stunting, underweight and wasting were present in 27.3%, 28.0% and 5.8% of the children, respectively. Mean haemoglobin was 12.63 ± 0.86 g/dL and 7.5 % were anaemic. In children with serum ferritin < 15 µg/L, there was a significant increase in haemoglobin in the FB group compared to the control (*P*=0.044), but not in the ER group. Serum iron and transferrin saturation in the FB group increased significantly compared to both the control and ER groups (*P*<0.05). There was no significant increase in serum ferritin in either the FB or ER groups. ***Conclusion***: Ferrous bisglycinate as iron fortificant in bread performed better than electrolytically reduced iron in this group of non-anaemic iron deficient children over a period of 7.5 months.

Th79 **DUAL FORTIFICATION OF SALT WITH IODINE AND ENCAPSULATED IRON: A RANDOMIZED, DOUBLE BLIND, CONTROLLED TRIAL IN MOROCCAN SCHOOLCHILDREN.** MB Zimmermann, C Zeder, N Chaouki, A Saad, T Torresani, RF Hurrell. Swiss Federal Institute of Technology, Zürich, Switzerland; The Ministry of Health, Rabat, Morocco; University of Zürich Children's Hospital, Zürich, Switzerland. **Background**: In many developing countries, children are at high risk for both goiter and iron-deficiency anemia. Iron-deficiency anemia (IDA) adversely effects thyroid and iodine metabolism and reduces efficacy of iodine prophylaxis in areas of endemic goiter. **Aim**: In a series of studies in northern Morocco, we tested a novel form of dual fortified salt (DFS) containing iodine and encapsulated iron (Fe). **Methods**: To establish the DFS fortification level, we measured salt intake by 3-day weighed food records and estimated Fe bioavailability from the local diet using published algorithms. We then formulated a DFS containing 25 µg iodine/g salt (as potassium iodide) and 1 mg Fe /g salt (as ferrous sulfate hydrate encapsulated with partially-hydrogenated vegetable oil). After storage and acceptability trials, we compared the efficacy of the DFS to iodized salt (IS) in a 9-month, randomized, double-blind trial in severely iodine-deficient 6-15 yr-old children (n=377) with a high prevalence of iron-deficiency anemia. **Results**: Salt intake in school-age children was 7-12 g/day, and estimated Fe bioavailability from the local diet was 0.4-4.3%. After storage for 20 weeks, there were no significant differences in iodine content between the DFS and IS, and color stability was acceptable when added to local meals. During the efficacy trial, after 9 months, mean Hb increased by 14 g/L ($p<0.01$) and serum ferritin, transferrin receptor and zinc protoporphyrin were significantly improved ($p<0.05$) in the DFS group compared to the IS group. The prevalence of IDA was reduced from 35% to 8% in the DFS group at 9 months ($p < 0.001$). There were no significant differences in median urinary iodine (UI) between the two groups throughout the study. In both groups, from 2 through 9 months, median UI significantly increased compared to baseline ($p<0.001$) and was above the cut-off value (100 µg/L) for risk of iodine deficiency. At 9 months, the mean decrease in thyroid volume measured by ultrasound in the DFS group (–38%) was twice that of the IS group (–18%) ($p<0.01$). At 9 months, the goiter rate was significantly decreased in the DFS group compared to the IS group ($p<0.001$). Mean serum T_4 increased significantly from baseline in the DFS group ($p<0.02$) and was significantly greater than in the IS group at 5 and 9 months ($p<0.05$). At 5 and 9 months, the prevalence of hypothyroidism ($T_4 < 65$ nmol/L) was significantly reduced in the DFS group compared to the IS group ($p<0.001$). **Conclusion**: Addition of encapsulated Fe to iodized salt improves the efficacy of iodine in goitrous children with a high prevalence of anemia. A DFS containing iodine and encapsulated Fe can be an effective combination fortification strategy.

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