Use of nutritional assessment surveys to inform food-based strategies to combat micronutrient deficiencies in young children

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Hunger and malnutrition

- Hunger or undernourishment defined as insufficient calories affects ~ 842 million people globally (FAO 2011-13)
  - 🇮🇩 Indonesia – Number of undernourished: 22.3 million

- Micronutrient malnutrition defined as limited access to micronutrient-rich foods and nutritious, diverse diets among the poor is a larger problem
  - Micronutrient deficiencies affect > 2 billion people globally

- Women and young children are particularly affected – with devastating consequences for society and future generations
Etiology of micronutrient malnutrition in childhood

- Poverty
- Inadequate care
- Poor sanitation, & access to health services
- Poor dietary intake
- Disease
- Household food insecurity

Outcome
Immediate causes
Underlying causes
Basic cause

UNICEF 2001
Identifying nutritional need for micronutrient intervention

- Number of programs to ensure adequate intake and improve micronutrient status
  - Vitamin A supplementation to reduce child mortality
  - Iron folic acid supplementation during pregnancy
  - Zinc as adjunct oral rehydration solution for treatment of diarrhea

- Focus on iron, iodine, vitamin A and lesser extent zinc and folic acid
  - However evidence suggests other micronutrients may also be limited

- Documented efficacy of many micronutrient interventions under controlled conditions but limited evidence of impact under programmatic conditions (effectiveness)

- Potential of an intervention to improve micronutrient status depends on:
  - Severity of the micronutrient deficit(s)
  - Extent to which the intervention addresses the specific cause of deficiency in a population group
Identifying nutritional need for micronutrient intervention

- **Nutritional assessment** defined as the interpretation of information from:
  - Laboratory
  - Dietary
  - Anthropometric
  - Ecological factors
Laboratory assessment

- Vitamin A
  - Serum retinol and retinol-binding protein (RBP)
- Iron
  - Hemoglobin, hematocrit, red cell indices and distribution width
  - Serum iron, TIBC and transferrin saturation
  - Serum ferritin and serum transferrin receptor
- Serum zinc
- Serum selenium
- Urinary iodine
- Folate
  - Serum and RBC folate
- Vitamin B12
  - Serum vitamin B12 and methylmalonic acid
- Riboflavin
  - Erythrocyte glutathione reductase activity (EGRAC)
- Thiamin
  - Erythrocyte transketolase
Vitamin and Mineral Nutrition Information System

- Formerly known as the Micronutrient Deficiency Information System established in 1991
- Part of the WHO’s mandate to assess the micronutrient status of populations, monitor and evaluate the impact of strategies for the prevention and control of micronutrient malnutrition
- Systematically retrieve, summarize and track data on micronutrient status of populations
- Provide tools and resources for assessing micronutrient status in populations
Anaemia as a public health problem by country: Preschool-age children

Source:

The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

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Category of public health significance (anaemia prevalence)
- Normal (<5.0%)
- Mild (5.0-19.9%)
- Moderate (20.0-39.9%)
- Severe (≥40.0%)
- No Data
Degree of Public Health Significance of Iodine Nutrition Based on Median Urinary Iodine

Source:

Data was produced by WHO using the best available evidence and do not necessarily correspond to the official statistics of Member States.
Indicators and Methods for Cross-Sectional Surveys of Vitamin and Mineral Status of Populations

Micronutrient Initiative
and the
Centers for Disease Control and Prevention

http://www.who.int/vmnis/toolkit/mcn-micronutrient-surveys.pdf?ua=1
Identifying nutritional need for micronutrient intervention

- **Biomarkers of micronutrient deficiency:** Challenges
  - Identifies only those who have reached a state of insufficiency
  - Cannot assess whether intakes are optimized or whether there is a risk of excess intake
  - Some biomarkers are tightly regulated e.g. calcium, zinc
  - Some biomarkers are not specific to the nutrient of interest and require additional information to interpret values
    - Example: Serum ferritin is elevated as a response to infection or inflammation need to measure C-reactive protein (CRP) and alpha-1-glycoprotein (AGP)
  - Invasive; many logistical concerns; costly
Dietary assessment

- Micronutrient deficiency occurs when needs and losses exceed dietary intake.

- Nutrient intake can be quantitated from consumption of foods with naturally occurring and fortified micronutrients and supplemental sources BUT actual uptake depend on multiple factors:
  - Bioavailability of nutrients in foods and supplements and inhibitors of absorption in the diet.
  - Example: iron and zinc absorption will depend on the phytate content of the diet.
Dietary assessment

Measuring food consumption

1. National level
   - FAO: Food Balance Sheets
   - Household Income & Expenditure Surveys

2. Individual level
   - National food consumption surveys
     - 24 hr recall method (repeat)
   - Weighed food records
   - Food frequency questionnaire

Assessing nutrient intakes

- Food composition tables
  - FAO: International Network of Food Data Systems (INFOODS) Directory compiles lists of FCT available by regions with contact details

Evaluation of nutrient intakes

- Nutrient intake are evaluated on the basis of age- and sex-specific reference values
  - Average Nutrient Requirement
  - Individual Nutrient Intake Level
  - Upper Nutrient Level
Other dietary assessment resources
Anthropometric assessment

- Distinguish disturbances in growth and body composition induced by micronutrient deficiencies (e.g., zinc) and imbalances in protein & energy

- Important role in targeting interventions through:
  - Screening
  - Assessing response to an intervention
  - Identifying determinants and consequences of malnutrition
Anthropometric assessment

Measuring anthropometrics

- Weight
- Length/Height
- Head circumference
- Mid-upper arm circumference (MUAC)
- Skinfold thickness

Interpretation and Evaluation

Growth indices

- Weight-for-age
- Length-for-age
- Weight-for-length
- BMI-for-age
- HC-for-age

WHO Child Growth Standards
WHO Multicentre Growth Reference Study (MGRS)

- 1997-2003: Undertaken to generate new growth curves that best described the physiological growth for children from birth to 5 yrs and to establish the breastfed infant as the normative model.

- Approximately 8500 children from widely different ethnic backgrounds and cultural settings (Brazil, Ghana, India, Norway, Oman and the USA).

- Online training course developed by the CDC to train health care providers and others on how to use the WHO growth standards.

http://www.cdc.gov/growthcharts/who_charts.htm
Z-score - measures the deviation of the anthropometric measurement from the reference mean or median in terms of SD
Software for calculating z-scores

- WHO Anthro 2011
- Statistical Macros
  - SPSS, SAS, S-Plus, Stata

<table>
<thead>
<tr>
<th>Z-score</th>
<th>Length/height-for-age</th>
<th>Weight-for-age</th>
<th>Weight-for-length/height</th>
<th>BMI-for-age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 3</td>
<td>See note 1</td>
<td></td>
<td>Obese</td>
<td>Obese</td>
</tr>
<tr>
<td>Above 2</td>
<td></td>
<td>See note 2</td>
<td>Overweight</td>
<td>Overweight</td>
</tr>
<tr>
<td>Above 1</td>
<td></td>
<td></td>
<td>Possible risk of overweight (See note 3)</td>
<td>Possible risk of overweight (See note 3)</td>
</tr>
<tr>
<td>0 (median)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below -1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below -2</td>
<td>Stunted (See note 4)</td>
<td>Underweight</td>
<td>Wasted</td>
<td>Wasted</td>
</tr>
<tr>
<td>Below -3</td>
<td>Severely stunted (See note 4)</td>
<td>Severely underweight (See note 5)</td>
<td>Severely wasted</td>
<td>Severely wasted</td>
</tr>
</tbody>
</table>

http://www.who.int/childgrowth/software/en/
Ecological factors

- Identify the causes of inadequate micronutrient intake and support the design of context-appropriate interventions
  - Socioeconomic and demographic data
  - Health and vital statistics
  - Other non-nutritional variables related to malnutrition such as infectious diseases

- Often overlooked – Availability and utilization of existing programmes and strategies to improve micronutrient status
Interventions for preventing micronutrient deficiencies

- Supplementation
- Fortification
  - National level – not designed for infant & young children
  - Targeted approach – for infant & child feeding
- Dietary diversification and modification (DDM)
- Biofortification
- All in combination with public health programmes
  - Breastfeeding; deworming; vitamin A capsules; growth monitoring; health education
Micronutrient interventions

Supplementation

- Sustainability: assured supplies; delivery; compliance
- Interactions with multiple MNs: optimal formulation uncertain
- Safety: Fe given to Fe-sufficient children may:
  - increase morbidity in settings with high rates of infection
  - adversely affect growth\textsuperscript{1,2}

Fortification

- Choice of fortificant & food vehicle; often high in phytate
- On-going quality assurance; accessibility to poor households
- May impair long-term development in Fe-sufficient children\textsuperscript{3}

Biofortification

- MN density too low for young children with low gastric capacity
- Poor MN bioavailability unless combined with flesh foods

\textsuperscript{1}Dewey et al. (2002); \textsuperscript{2}Iannotti et al. (2006); \textsuperscript{3}Lozoff et al. (2012)
Dietary diversification & modification

Advantages

- Can be designed to be culturally acceptable, sustainable, & safe
- Can prevent Fe, Zn, vit A, B-12 & Se deficiencies if animal foods are consumed & with no risk of antagonistic interactions
- Minimal inputs once behavior change achieved
- Enhance MN status of entire household & across generations
- Community-based: ability to empower community to help themselves

Challenges

- Require effective behaviour change
- Must include cellular animal food to meet requirements for Fe & Zn for young children: often expensive & inaccessible to poor
Benefits of adding animal source foods to diets of young children

- Rich source of multi-micronutrients with minimal risk of antagonistic interactions
  - WHO\(^1\) recommends beef liver as top “candidate” food to meet infant’s requirements for Fe, Zn, & vit A from complementary foods
- Enhance absorption of Zn\(^2\) & non-haem Fe\(^3,4\) in plant-based diets
- Improve growth: weight\(^5,6\), height\(^7\), MUAC\(^6\), HC\(^8\)
- Improve cognitive performance\(^9\) & physical activity
- May improve behaviour index\(^3\) & psychomotor development\(^5\)

\(^{1}\) WHO (1998); \(^{2}\) Krebs et al. (2012); \(^{3}\) Engelmann et al. (1998); \(^{4}\) Hallberg et al. (2003); \(^{5}\) Morgan et al. (2004); \(^{6}\) Grillenberger et al. (2003); \(^{7}\) Krebs et al. (2011); \(^{8}\) Krebs et al. (2006); \(^{9}\) Neumann et al. (2007)
## Sources of essential micronutrients in animal-source foods

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Important sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Dairy products (milk, yoghurt, cheese)</td>
</tr>
<tr>
<td>Iron</td>
<td>Beef, lamb, pork, venison, poultry, seafood</td>
</tr>
<tr>
<td></td>
<td>Absorption higher than plant foods</td>
</tr>
<tr>
<td>Zinc</td>
<td>Beef, lamb, pork, venison, poultry, seafood. Absorption higher than plant foods</td>
</tr>
<tr>
<td>Iodine</td>
<td>Sea fish, shell fish</td>
</tr>
<tr>
<td>Selenium</td>
<td>Seafood, liver, kidney, muscle meat, eggs</td>
</tr>
<tr>
<td>Vit B-2</td>
<td>Dairy products (milk, yoghurt, cheese); meat and fish</td>
</tr>
<tr>
<td>Vit B-12</td>
<td>Only found in foods of animal origin</td>
</tr>
<tr>
<td>Vit A</td>
<td>In oily fish, liver, butterfat, egg yolk</td>
</tr>
<tr>
<td>Vit D</td>
<td>In oily fish, some in liver</td>
</tr>
</tbody>
</table>
Percent of energy in food supply from animal source foods (ASF) in the world
Research Collaboration

- Universitas Padjadjaran
  - Dr Gaga Irawan Nugraha
  - Dr Aly Diana (PhD student)

- University of Otago
  - Professor Rosalind and Ian Gibson
  - Dr Lisa Houghton

- Funded by Meat & Livestock Australia
Nutritional Assessment Survey to inform food-based intervention

- 6 month longitudinal study designed to assess the micronutrient dietary inadequacies and deficiencies among breastfeed infants
  - 6 mo of age, n=200
  - Sumedang district of West Java

- Hypothesized that these infants will be at high risk for poor growth, anaemia and coexisting micronutrient deficiencies
  - Attributed to inadequate intake of micronutrients and energy
  - Poor child caring practices

- Purpose of the survey: To design an IYCF and home fortification programme using desiccated beef liver to enrich the rice-based diets of infants
Daily micronutrient intakes of Mongolian infants with and without 10 g serving of desiccated beef liver compared to WHO nutrient needs

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Intake</th>
<th>Intake + 10g Liver</th>
<th>WHO needs</th>
<th>Upper limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc (mg)</td>
<td>2.3</td>
<td>3.9</td>
<td>3.3</td>
<td>7</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>1.8</td>
<td>3.8</td>
<td>3.8</td>
<td>40</td>
</tr>
<tr>
<td>Vitamin A (RE)</td>
<td>50</td>
<td>410</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Selenium (µg)</td>
<td>7</td>
<td>16</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>3.0</td>
<td>8.5</td>
<td>4.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
<td>0.2</td>
<td>0.3</td>
<td>0.3</td>
<td>ND</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>30</td>
<td>112</td>
<td>80</td>
<td>300</td>
</tr>
</tbody>
</table>
Nutritional assessment survey

- Dietary: 2-day weighed food record
  - Infant and young feeding (IYCF)
  - Child caring feeding practices
  - Household and child food security
- Growth: weight, length, HC
- Socioeconomic and demographic data
  - Vital health statistics
  - Hygiene
  - Morbidity
- Cognitive function
  - Ages & Stages Questionnaire
Biochemical assessment

- Venipuncture and fingerprick blood collection
  - CBC including hemoglobin; genetic hemoglobin disorders
  - Iron: serum ferritin; transferrin receptor
  - Infection: C-reactive protein; alpha-glycoprotein
  - Zinc and selenium
  - Vitamin A: serum retinol-binding protein
  - Folate: serum and RBC folate
  - Riboflavin: EGRAC
  - Vitamin B12: serum B12 and MMA
  - Vitamin D: serum 25-hydroxyvitmain D

- Casual urine sample - iodine

- Stool sample – gut microbiota and parasitology
Timeline

- Preparation and training
- Study enrollment: August 2014
  - n=200 infants at 6 months of age
- Study visits at baseline (6 mo), 9 mo and 12 mo of age
  - Dietary, anthropometric, biochemical and ecological factors
- Data collection complete: May 2015
  - Analysis of data with dietary and biochemical prioritisation
- Desiccated beef liver acceptability trial: Mid-2015
- Double-blinded randomized control trial with IYCF education
  - Mid 2016
Thank you

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Resources

- ProPAN: A process for the Promotion of Child Feeding

- An Interactive 24-hour Recall for Assessing the Adequacy of Iron and Zinc by Rosalind Gibson and Elaine Ferguson
  - http://www.harvestplus.org/content/interactive-24-hour-recall-assessing-adequacy-iron-and-zinc-intakes-developing-countries

- Indicators for assessing infant and young child feeding practices