Micronutrient Malnutrition and Effective Interventions: The Global Picture
Nutrients

**MACRO**
Body needs in large amounts

**MICRO**
Body needs in small amounts
Micronutrient Malnutrition

Also known as Hidden Hunger
Micronutrient Malnutrition

*Also known as Hidden Hunger*

- Corneal ulceration

- Night blindness

[www.blogspot.com](http://www.blogspot.com)

[www.motherandchildnutrition.org](http://www.motherandchildnutrition.org)

[www.steadyhealth.com](http://www.steadyhealth.com)
Micronutrient Malnutrition

Also known as Hidden Hunger

- PREVALENCE +

- SEVERITY -

Night blindness (38.4%)

Corneal ulceration or xerosis (1.7%)

# Micronutrient Malnutrition

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Global Burden of Disease¹</th>
<th>Lancet²</th>
<th>Food fortification³*</th>
<th>VMNIS⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Folate</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iodine</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Iron [anemia]</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Others</em>*</td>
<td>Vitamins B1, B2, B3, B6, C, D, Calcium, Selenium, Fluoride</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

⁴WHO. Vitamin and Mineral Nutrition Information System.
Micronutrient Malnutrition: Folate

Physiological functions:
• “Essential for DNA biosynthesis
• Donates methyl (methylation) to lipids, hormones, DNA and proteins”

Consequences of deficiency:
• Anemia
• Neural tube defects (NTDs)

Consequences of insufficiency:
• Neural tube defects

Folate Sufficiency
“Has a protective role against first occurrence and recurrence of NTDs”

IOM 1998. Dietary Reference Intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline.
Daly 1995. Folate levels and neural tube defects.
FIG. 3. Prevalence of folate deficiency in countries with nationally representative data.
Micronutrient Malnutrition: Iodine

Thyroid Hormones

• “Play major role in growth & development of brain and central nervous system
• Control several metabolic processes”

Iodine Deficiency
The greatest cause of preventable brain damage in childhood

Images courtesy of Glen Maberly

Stanbury. The damaged brain of iodine deficiency.
Micronutrient Malnutrition: Iodine

Proportion of School-age Children Estimated to be At Risk for Mild, Moderate and Severe Iodine Deficiency, by WHO Region, 2011

UIC: Urinary iodine concentration

Micronutrient Malnutrition: Iron

Physiological functions:
• “Carries oxygen from the lung to tissues
• Transports electrons within cells
• Part of enzyme systems in various tissues”

Consequences of deficiency:
• Decreased hemoglobin production
• Impaired delivery of oxygen to tissues (anemia)
• Reduced cognitive development
• Reduced work capacity

Iron Deficiency
The most common nutritional deficiency in the world

www.thegreenleaves.wordpress.com
Micronutrient Malnutrition: Iron

*Anemia used as a proxy indicator for iron status*

<table>
<thead>
<tr>
<th>WHO region</th>
<th>Preschool-age children*</th>
<th>Pregnant women</th>
<th>Non-pregnant women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevalence (%)</td>
<td># affected (millions)</td>
<td>Prevalence (%)</td>
</tr>
<tr>
<td>Africa</td>
<td>67.6</td>
<td>83.5</td>
<td>57.1</td>
</tr>
<tr>
<td>Americas</td>
<td>29.3</td>
<td>23.1</td>
<td>24.1</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>65.5</td>
<td>115.3</td>
<td>48.2</td>
</tr>
<tr>
<td>Europe</td>
<td>21.7</td>
<td>11.1</td>
<td>25.1</td>
</tr>
<tr>
<td>Eastern Mediterranean</td>
<td>46.7</td>
<td>0.8</td>
<td>44.2</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>23.1</td>
<td>27.4</td>
<td>30.7</td>
</tr>
<tr>
<td>Global</td>
<td>47.4</td>
<td>293.1</td>
<td>41.8</td>
</tr>
</tbody>
</table>

*Population subgroup definitions:* Preschool age children (0.00–4.99 yrs); Pregnant women (no age range defined); Non-pregnant women (15.00–49.99 yrs).

*95% Confidence Intervals.*
Micronutrient Malnutrition: Iron

Iron Deficiency

Iron-Deficiency Anemia

Anemia

Causes:
- Deficient iron intake
- Excessive iron loss

Causes:
- Deficiency of iron, vitamin B12, folate, vitamin A
- Hemoglobinopathies
- Infections

Micronutrient Malnutrition: Vitamin A

Physiological functions:

- “Needed for normal functioning of the visual system
- Required for growth and development
- Used in maintenance of epithelial cellular integrity, immune function, and reproduction”

Micronutrient Malnutrition: Vitamin A

Consequences of deficiency:
- Xerophthalmia
- Anemia
- Worsen infection
- Increase mortality

**Table 1: Classification of xerophthalmia**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XN</td>
<td>Night blindness</td>
</tr>
<tr>
<td>X1A</td>
<td>Conjunctival xerosis</td>
</tr>
<tr>
<td>X1B</td>
<td>Bitot’s spot</td>
</tr>
<tr>
<td>X2</td>
<td>Corneal xerosis</td>
</tr>
<tr>
<td>X3A</td>
<td>Corneal ulceration/keratomalacia (&lt; 1/3 corneal surface)</td>
</tr>
<tr>
<td>X3B</td>
<td>Corneal ulceration/keratomalacia (≥ 1/3 corneal surface)</td>
</tr>
<tr>
<td>XS</td>
<td>Corneal scar</td>
</tr>
<tr>
<td>XF</td>
<td>Xerophthalmic fundus</td>
</tr>
</tbody>
</table>

Vitamin A Deficiency
One of the most important causes of preventable childhood blindness
Major contributor to morbidity and mortality from infections

# Micronutrient Malnutrition: Vitamin A

## Table 11

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<td>Africa</td>
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<tr>
<td>Americas</td>
<td>15.6</td>
<td>8.68</td>
</tr>
<tr>
<td>South-East Asia</td>
<td>49.9</td>
<td>91.5</td>
</tr>
<tr>
<td>Europe</td>
<td>19.7</td>
<td>5.81</td>
</tr>
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<td>Eastern Mediterranean</td>
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<td>13.2</td>
</tr>
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<td>Global</td>
<td>33.3</td>
<td>190</td>
</tr>
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</table>

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*Population subgroups: Preschool-age children (<5 years); Pregnant women (no age range defined). |
*Numerator and denominator excludes countries with a 2005 GDP ≥US$ 15 000. |
*95% Confidence Intervals.
Micronutrient Malnutrition: Vitamin B12

*Cobalamin*

**Physiological function:**

“As a cofactor for the enzymes methionine synthase and L-methylmalonyl-CoA mutase”

**Consequences of deficiency:**

- Anemia
- Neurological complications

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Vitamin B12
Essential for normal blood formation and neurological function

IOM 1998. Dietary Reference Intakes for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline.
Smith 2009. Vitamin B-12 and cognition in the elderly.
FIG. 4. Prevalence of vitamin B$_{12}$ deficiency in countries with nationally representative data.

Physiological function:
“Essential component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids as well as in the metabolism of other micronutrients”
Micronutrient Malnutrition: Zinc

Consequences of deficiency:

<table>
<thead>
<tr>
<th>Severe Zinc Deficiency</th>
<th>Mild Zinc Deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth retardation</td>
<td>Growth retardation</td>
</tr>
<tr>
<td>Delayed sexual &amp; bone maturation</td>
<td></td>
</tr>
<tr>
<td>Skin lesions</td>
<td></td>
</tr>
<tr>
<td>Diarrhea</td>
<td></td>
</tr>
<tr>
<td>Alopecia</td>
<td></td>
</tr>
<tr>
<td>Impaired appetite</td>
<td>Impaired immunity</td>
</tr>
<tr>
<td>Impaired immunity</td>
<td></td>
</tr>
<tr>
<td>Behavioral changes</td>
<td></td>
</tr>
</tbody>
</table>

Zinc Deficiency Increases morbidity and mortality and delays growth

Micronutrient Malnutrition: Zinc

Countries’ Risk for Zinc Deficiency

IZiNCG. Advocacy brochure.
Public Health Interventions

Multiple and complementary

- Supplementation
- Fortification
- Crop Biofortification
- Dietary Diversity
- Improved Health Care
- Reduce Micronutrient Malnutrition

Nutrition Education
Public Health Interventions

What they are & impact evidence

- Supplementation
- Fortification
- Improved Health Care
- Reduce Micronutrient Malnutrition
- Crop Biofortification
- Nutrition Education
- Dietary Diversity

Large doses of micronutrients provided in liquid, pill or tablet form

Public Health Interventions

What they are & impact evidence

- Fortification
- Dietary Diversity
- Supplementation
- Nutrition Education
- Crop Biofortification
- Improved Health Care

Reduce Micronutrient Malnutrition

Reduces illnesses which compromise micronutrient status

Public Health Interventions

*What they are & impact evidence*

- Fortification
- Supplementation
- Dietary Diversity
- Nutrition Education
- Improved Health Care
- Crop Biofortification

*Encouraging behaviors to increase micronutrient intake*

Public Health Interventions

*What they are & impact evidence*

- Fortification
- Supplementation
- Improved Health Care
- Nutrition Education
- Crop Biofortification
- Dietary Diversity

More foods in the diet lead to intakes of more micronutrients

Tontisirin 2002. Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world.
Public Health Interventions

What they are & impact evidence

- Fortification
- Supplementation
- Improved Health Care
- Nutrition Education
- Dietary Diversity
- Reduce Micronutrient Malnutrition
- Crop Biofortification
- Crops bred to have higher micronutrient levels

Copenhagen Consensus 2008.
Public Health Interventions

*What they are & impact evidence*

- Fortification
- Supplementation
- Improved Health Care
- Nutrition Education
- Dietary Diversity
- Crop Biofortification
- Reduce Micronutrient Malnutrition

Micronutrients added to foods during industrial processing

Public Health Interventions

How they work

Supplementation

Fortification

Crop Biofortification

Dietary Diversity

Nutritious options available for consumption
**Public Health Interventions**

*How they work*

Nutritious options available for consumption

People choose to consume more nutritious options
Public Health Interventions

*How they work*

Nutritious options available for consumption

People choose to consume more nutritious options

People eat more micronutrients
Public Health Interventions

*How they work*

Nutritious options available for consumption

People choose to consume more nutritious options

People eat more micronutrients

Body can better absorb and utilize micronutrients

Improved Health Care
Public Health Interventions

How they work

Nutritious options available for consumption

People choose to consume more nutritious options

People eat more nutrients

Body can better absorb and utilize micronutrients

Reduce Micronutrient Malnutrition
Conclusions

• Micronutrient malnutrition negatively affects the health, development and productivity of millions
• Successful interventions exist to reduce micronutrient malnutrition
• For countries to consider:
  – What are the key nutrient deficiencies faced?
  – What interventions, alone or in combination, can best address these problems?
For More Information

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Flour Fortification Initiative online:
FFInetwork.org
Facebook.com/ffinetwork
Twitter.com/ffinetwork
LinkedIn.com
References (1)


References (2)


