Adequate and Quality Nutrients are Essential for Optimal Human Health

Both Excess and Deficiency can Lead to Sub-Optimal Health
Truly a Hungry and Starving Nation or Misdirected Stigma?

Chapter 3: Addressing the Challenge of Hidden Hunger

Hidden hunger, also known as micronutrient deficiencies, affects more than 2 billion individuals, or one in three people, globally (FAO 2013). Its effects can be devastating, leading to mental impairment, poor health, low productivity, and even death. Its adverse effects on child health and survival are particularly acute, especially within the first 1,000 days of a child’s life, from conception to the age of two, resulting in serious physical and cognitive consequences. Even mild to moderate deficiencies can affect a person’s well-being and development. In addition to affecting human health, hidden hunger can curtail socioeconomic development, particularly in low- and middle-income countries.

A Different Kind of Hunger

Hidden hunger is a form of undernutrition that occurs when intake and absorption of vitamins and

Quantifying, Projecting, and Addressing India’s Hidden Hunger

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¹ School of GeoSciences, University of Edinburgh, Edinburgh, United Kingdom, ² Moray House School of Education, University of Edinburgh, Edinburgh, United Kingdom

It is estimated that more than two billion people suffer from ‘hidden hunger’ (micronutrient malnutrition) globally, with nearly half living in India. Despite being highlighted as one of the most cost-effective investments for human development, progress on addressing micronutrient deficiencies (MND) has been slow. The severe social, health, and economic costs of MND in India should make it a top priority for domestic governance and international donors alike. This study, for the first time, maps food system pathways from crop production through to household-level food availability, for a range of key vitamins, minerals, and amino acids. Results suggest widespread (~80% total Indian
“The Hidden-Hunger Trap”: An Indian Perspective

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Presentation Format

• Measuring “Hidden-Hunger”
  ▪ Principles & Indian norms
  ▪ Appropriate measures ?
  ▪ “One-size-fits-all” cut-off ?

• Functional benefits
• “Invisible” harms
• Practice & policy implications
Measuring risk of nutrient deficiency in populations

A plot of minimum intakes vs requirements in a normal population

Distribution and Median Intake

Distribution and Median Requirement

Distributions overlap in normalcy: nutrient intakes of 50% population are to the left of the median requirement

Courtesy: A.V. Kurpad
The Nutrient Requirement Values

We need a single population nutrient requirement value for each age/gender.

**EAR**: population requirement

**RDA**: Can ‘over-nourish’ populations

**TUL**: Tolerable Upper Limit of intake: Toxic Framework & Clinical

Nutrient requirement of population

Estimated Average Requirement (EAR)

Recommended Dietary Allowance

TUL

NIN-ICMR Indian Requirements 2020 have EAR

Courtesy: A.V. Kurpad
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Crude Methods and Non-Representative Samples Extrapolated

- Dated: ~Decade or more
- NNMB: Underprivileged mostly
- No robust quantification of national dietary intakes
- Biomarkers on filter paper (serum retinol ~20-30% lower)
Pathway analysis from crop production to supply at individual level: export, Import, stock variation, resown produce, animal feed, other non food uses

Presumes Equitable Distribution of Food

WRA Risk of Iron Deficiency by NSSO: Quantify Distribution Shift OR Apply Correction (-50%)

Top SES Gap=0 mg

Bottom SES Gap=5 mg

Courtesy: A.V. Kurpad
## Capillary vs Venous Blood Hb: NFHS vs CNNS

<table>
<thead>
<tr>
<th>Sample</th>
<th>Capillary blood g/dL</th>
<th>Venous Blood g/dL</th>
<th>Difference g/dL</th>
<th>Venous-Anaemia (Hb&lt;12 g/dL)</th>
<th>Capillary Anaemia (Hb&lt;12 g/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>11.4 ± 1.6</td>
<td>12.3 ± 1.7</td>
<td>0.9 (~7.5%)</td>
<td>35%</td>
<td>59%</td>
</tr>
</tbody>
</table>

Neufeld L, Kurpad AV.... Ann NY Acad Sci 2019;1450:172
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Comparison of Indian vs WHO cut-offs

![Graph showing comparison of haemoglobin concentrations between boys and girls with analytical sample 1 and WHO cut-offs.](image)

**Figure 3: Age-specific and sex-specific study cutoffs and WHO anaemia cutoffs in children and adolescents**

*Summary*

Background: WHO's haemoglobin cutoffs to define anaemia were based on few studies of predominantly White adult populations, done over 30 years ago. Therefore, a general recommissioning of the existing haemoglobin cutoffs is warranted for global application in representative healthy populations of children and adults. Such data are scarce in low-income and middle-income countries; however, a 2018 large-scale nationally representative survey of children and adolescents aged 0–19 years in India (Comprehensive National Nutrition Survey (CNNS)) offered an opportunity for this re-examination. Using this survey, we aimed to assess the age-specific and sex-specific prevalence of anaemia.
CNNS Healthy Subjects Serum Zinc Thresholds (2.5th Cen)

- 10-18 µg/dl lower than IZiNCG cut-offs
- Deficiency prevalence 2.7 (<10 yr) to 5.5 (>10 yr) lower
- No State public health problem (>20%) vs 9-27 States

Pullakhandam R,…Sachdev HS. Eur J Clin Nutr 2022
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Intervention Benefit: Biomarker Elevation Alone?

Study ID | WMD (95% CI) | % Weight
---|---|---
Pang Yan (2016) | 19.0 (12.0, 26.0) | 7.95
MS Barnes (2006) | 38.2 (21.9, 54.5) | 4.44
Kimmie Ng (2014) | 7.8 (4.7, 10.8) | 9.31
Mirjam M Oosterwerff (2014) | 37.0 (31.2, 42.8) | 8.42
Amin Salehpour (2013) | 23.5 (11.5, 35.5) | 5.88
Paulette D. Chandler (2015) | 34.7 (33.9, 35.5) | 9.67
Michael F. Holick (2008) | 25.3 (9.4, 41.1) | 4.55
Scott M Smith (2009) | 26.1 (15.0, 37.2) | 6.24
Amra Osmancevic (2016) | 37.3 (26.4, 48.2) | 6.34
Xiaomin Sun (2016) | 30.3 (29.1, 31.5) | 9.63
Rikke Andersen–men (2008) | 33.8 (29.7, 37.9) | 9.01
Rikke Andersen–women (2008) | 39.2 (36.2, 42.2) | 9.32
Eric Seibert et al. (2017) | 41.6 (38.2, 45.0) | 9.22
Overall (I-squared = 96.7%, p < 0.001) | 30.4 (25.7, 35.0) | 100.00

NOTE: P-value refers to weighted mean difference. Weights are from random effects analysis.

Fig. 2 Low dose (<1500 IU) vs. placebo in adult subjects with baseline 25(OH)D concentration <50 nmol/L

Biomarkers or Functional Benefits?

**WHO recommendation on antenatal vitamin D supplements**

Oral vitamin D supplementation is not recommended for all pregnant women to improve maternal and perinatal outcomes. *(Not recommended)*

<table>
<thead>
<tr>
<th>Maternal outcomes</th>
<th>Fetal/neonatal outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infections</td>
<td>Neonatal infections</td>
</tr>
<tr>
<td>Anaemia</td>
<td>Small for gestational age</td>
</tr>
<tr>
<td>Pre-eclampsia/eclampsia</td>
<td>Low birthweight</td>
</tr>
<tr>
<td>Gestational diabetes mellitus</td>
<td>Preterm birth</td>
</tr>
<tr>
<td>Mode of delivery</td>
<td>Congenital anomalies</td>
</tr>
<tr>
<td>Excessive weight gain</td>
<td>Macrosomia/large for gestational age</td>
</tr>
<tr>
<td>Side effects</td>
<td>Fetal/neonatal mortality</td>
</tr>
<tr>
<td>Maternal mortality</td>
<td></td>
</tr>
<tr>
<td>Maternal satisfaction</td>
<td></td>
</tr>
</tbody>
</table>
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Iodine Fortification and Hypothyroidism

Increased Incidence Rate of Hypothyroidism After Iodine Fortification in Denmark: A 20-Year Prospective Population-Based Study

Mads Petersen, Nils Knudsen, Allan Carle, Stig Andersen, Torben Jørgensen, Hans Perrild, Lars Ovesen, Lone Banke Rasmussen, Betina Heinsbæk Thuesen, and Inge Bülow Pedersen

Excessive Iodine Intake and Subclinical Hypothyroidism in Children and Adolescents Aged 6–19 Years: Results of the Sixth Korean National Health and Nutrition Examination Survey, 2013–2015

Min Jae Kang, Il Tae Hwang, and Hye Rim Chung

European Journal of Endocrinology (2011) 164 943–950

More than adequate iodine intake may increase subclinical hypothyroidism and autoimmune thyroiditis: a cross-sectional study based on two Chinese communities with different iodine intake levels

Xiaoqun Teng, Zhongyan Shan, Yanyan Chen, Yaxin Lai, Jiashu Yu, Ling Shan, Xue Bai, Yuanbin Li, Ningna Li, Zhidan Li, Sen Wang, Qian Xing, Haibo Xue, Lin Zhu, Xin Hou, Chenling Fan, and Weiping Teng

1Department of Endocrinology and Metabolism and 2National Key Laboratory of Endocrine Diseases, Institute of Endocrinology, The First Affiliated Hospital, China Medical University, No 155 Nanjing Bei Street, Hope District, Shengyang, People’s Republic of China

(Correspondence should be addressed to W. Teng: Email: twteng@cmu.edu.cn; Y. Teng: Email: tmytangchun@126.com)
Iron Excess and NCD Risk

Ferritin & diabetes in prospective data
J Clin Endocrinol Metab. 2019;104:4539

Increased risk of hypertension, dyslipidemia, GDM & PET
RCT evidence emerging

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Key findings

- The prevalence of vitamin A deficiency was 18% among pre-school children, 22% among school-age children and 16% among adolescents.

- Vitamin D deficiency was found among 14% of pre-school children, 18% of school-age children and 24% of adolescents.

- Nearly one-fifth of pre-school children (19%), 17% of school-age children and 32% of adolescents had zinc deficiency.

- The prevalence of vitamin B12 deficiency was 14% among pre-school children, 17% among school-age children and 31% among adolescents.

- Nearly one-quarter (23%) of pre-school children, 28% of school aged children and 37% of adolescents had folate deficiency.

- Adequate iodine status (median urinary iodine concentration ≥100 μg/L and ≤300 μg/L) was observed in all three age groups - 213 μg/L among
Natural diverse diets suffice for meeting requirements: Linear Programming Analysis
Diets 6-12 mo assuming 200 ml breast milk intake

<table>
<thead>
<tr>
<th>Food Name</th>
<th>Food Group</th>
<th>Quantity (gm)</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranth leaves (red)</td>
<td>Green leafy vegetables</td>
<td>13</td>
<td>0.34</td>
</tr>
<tr>
<td>Banana</td>
<td>Fruits</td>
<td>30</td>
<td>0.42</td>
</tr>
<tr>
<td>Red gram dhal</td>
<td>Pulse</td>
<td>22</td>
<td>1.85</td>
</tr>
<tr>
<td>Oil</td>
<td>Oil</td>
<td>26</td>
<td>2.11</td>
</tr>
<tr>
<td>Bottle Gourd</td>
<td>Other vegetables</td>
<td>5</td>
<td>0.07</td>
</tr>
<tr>
<td>Salt</td>
<td>Salt</td>
<td>5</td>
<td>0.09</td>
</tr>
<tr>
<td>Sugar</td>
<td>Sugar</td>
<td>14</td>
<td>0.259</td>
</tr>
<tr>
<td>Tapioca</td>
<td>Roots and tubers</td>
<td>5</td>
<td>0.11</td>
</tr>
<tr>
<td>Wheat flour atta</td>
<td>Cereals</td>
<td>43</td>
<td>1.63</td>
</tr>
<tr>
<td><strong>Optimal cost (in Rs)</strong></td>
<td></td>
<td><strong>6.87</strong></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Food Name</th>
<th>Food Group</th>
<th>Quantity (gm)</th>
<th>Cost (Rs)</th>
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<tbody>
<tr>
<td>Amaranth leaves (red)</td>
<td>Green leafy vegetables</td>
<td>18</td>
<td>0.47</td>
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<tr>
<td>Banana</td>
<td>Fruits</td>
<td>5</td>
<td>0.07</td>
</tr>
<tr>
<td>Red gram dhal</td>
<td>Pulse</td>
<td>30</td>
<td>2.52</td>
</tr>
<tr>
<td>Oil</td>
<td>Oil</td>
<td>23</td>
<td>1.86</td>
</tr>
<tr>
<td>Pumpkin (Orange)</td>
<td>Other vegetables</td>
<td>5</td>
<td>0.055</td>
</tr>
<tr>
<td>Salt</td>
<td>Salt</td>
<td>5</td>
<td>0.09</td>
</tr>
<tr>
<td>Rice</td>
<td>Cereals</td>
<td>60</td>
<td>2.76</td>
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<tr>
<td><strong>Optimal cost (in Rs)</strong></td>
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<td><strong>7.83</strong></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>EAR</th>
<th>% of EAR</th>
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</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>681</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>12</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>35</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>4</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>2</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Iodine (µg)</td>
<td>150</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Vitamin A RAE (µg)</td>
<td>279</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Vit B6 (mg)</td>
<td>19</td>
<td>&gt;100</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>73</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

St. John’s Research Institute, Bengaluru (Thomas, Kurpad, Sachdev, et al.)
Concluding Thoughts
Micronutrient Deficiencies Do Exist

Ignores Hidden-Harms

Magnified “Hidden-Hunger”