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Measures of Malnutrition

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Presentation Outline

1. Size as a measure of nutritional status in adults and children
   • Applications, strengths and weaknesses of common measures and data sets
   • Implications of the new WHO growth standard for counting the under and over nourished

2. Micronutrient status
   • Clinical versus population assessments
   • Applications, strengths and weaknesses of common biomarkers and data sets

3. Comments and new developments

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Reminder: Uses of information on nutritional status of populations

• Characterize magnitude and distribution of problems in the population
  • Identify subgroups at risk
  • Identify need for and target subgroups for intervention
• Monitoring the situation over time and across regions/countries
• Program monitoring and evaluation
Anthropometric measures of growth and size

Growth

• The process of changing from a simple to complex form, from a smaller to larger size
• Implies multiple measures

Size

• The physical magnitude of something
• Single measurement
Small size considered proxy for health status

Small size associated with

- Mortality and morbidity risk in children
- Risk of impaired cognitive developed in children
- Adverse pregnancy outcome

An important weakness:

- Single measures of size do not distinguish between children who are genetically small and those whose growth is faltering for nutritional or other causes
- We make assumptions on the basis of the frequency in the population and expected frequency in a healthy population

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## Common measures size in adults

<table>
<thead>
<tr>
<th>Measure</th>
<th>Indicator</th>
<th>Reflective of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Height</td>
<td>Past nutritional status (not usually used alone except in extreme short height)</td>
</tr>
<tr>
<td>Weight</td>
<td>Body mass index-for-age</td>
<td>Risk during pregnancy Risk of chronic disease</td>
</tr>
</tbody>
</table>
**Common measures of size* in children**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Indicator</th>
<th>Reflective of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Height-for-age</td>
<td>Long-term nutritional status</td>
</tr>
<tr>
<td>Weight</td>
<td>Weight-for-age</td>
<td>Long- and short-term nutritional status</td>
</tr>
<tr>
<td></td>
<td>Weight-for-height (0 to 5 y)</td>
<td>Short-term nutritional status</td>
</tr>
<tr>
<td></td>
<td>Body mass index-for-age (2 to 18 y)</td>
<td>Short-term nutritional status</td>
</tr>
<tr>
<td>Mid-upper arm circumference</td>
<td>MUAC compared to fixed cut off point (115 mm)</td>
<td>Short-term nutritional status</td>
</tr>
</tbody>
</table>

*"Growth" assessed by repeat measures of any indicator

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Anthropometric assessment of nutritional status

Healthy; well-nourished

Wasting; acute malnutrition

Stunting; chronic undernutrition

Normal height-for-age (HA), weight-for-age (WA), weight-for-height (WH)

WH <-2 (moderate) or -3 (severe) SD or MUAC <115 mm

HA <-2 SD below median
In reality, conditions may coexist

<table>
<thead>
<tr>
<th>Weight Height</th>
<th>Low</th>
<th>Adequate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Stunted</td>
<td>Stunted</td>
<td>Stunted</td>
</tr>
<tr>
<td></td>
<td>Wasted</td>
<td>Adequate weight</td>
<td>Overweight</td>
</tr>
<tr>
<td>Adequate</td>
<td>Adequate height</td>
<td>Adequate height</td>
<td>Adequate height</td>
</tr>
<tr>
<td></td>
<td>Wasted</td>
<td>Adequate weight</td>
<td>Overweight</td>
</tr>
</tbody>
</table>
All indicators have strengths and limitations to reflect health risks

<table>
<thead>
<tr>
<th>Height for age</th>
<th>Weight for height and MUAC</th>
<th>BMI for age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple determinants including macro and micronutrient deficiency, illness etc.</td>
<td>Used to identify MAM/SAM but low correlation between them</td>
<td>Still some debate whether BMI identifies children at risk of deficiency, excess</td>
</tr>
<tr>
<td>Measurement requires equipment, training, quality control</td>
<td></td>
<td>Appear to be population variation in the level of BMI associated with risk of poor health outcomes</td>
</tr>
</tbody>
</table>

WHO’s global Database on Child Growth and Malnutrition: [http://www.who.int/nutgrowthdb/en/](http://www.who.int/nutgrowthdb/en/)
The most commonly reported indicator: Prevalence of low weight for age (DHS data)

Based on NCHS/WHO reference. de Onis, M. et al. JAMA 2004;291:2600-2606
Weight-for-age

Strengths:
- Only indicator regularly monitored in many countries
  - Weight and age both easily measured
- Key indicator for MDG’s
  - Multiple years of data permit comparisons over time and across regions/countries

Important weaknesses:
- Does not distinguish between problems of chronic and acute malnutrition
  - Important differences in determinants and types of programs needed to respond to them
- Potential misrepresentation of nutritional problems in countries with persistent stunting and overweight

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High prevalence of overweight and obesity in populations where undernutrition persist

As countries develop, they face many of the problems common in industrialized nations. Obesity is one of the most worrisome.


A calculation of body mass index, or BMI, determines whether a person isn’t eating enough or is tipping the scales. Many developing countries are facing both problems simultaneously.


REF: Burslem, Chris, IFPRI (2004) Obesity in Developing Countries: People are Overweight But Still Not Well-Nourished.
Adoption of WHO Growth Reference Standard

• Greater acceptance internationally than previous NCHS/WHO
  • Multicenter study
• Change in interpretation of data
  • Reflective of how we think children should grow (standard) given current recommendation for child feeding practices, not just comparison with how other children grow (reference)
• Implications for counting the malnourished in a country
FIG.1. Change in overall prevalence with the adoption of the new WHO standards (percentage points). The box plots summarize the data from the 41 countries, showing medians, 25th and 75th percentiles, lower and upper adjacent values, and outside values.
Comparison of wasting (≤−2 WH) using NCHS (striped) and WHO growth standards (shaded), DHS data for 21 countries

Kerac M et al. Arch Dis Child doi:10.1136/adc.2010.191882
Important implications for countries with multiple years of survey data

**Figure 1. Prevalence of malnutrition in Mexican children in 1988, 1999 and 2006 using the NCHS/WHO references and the WHO-2006 growth standards**

Gonzalez-de-Cossio et al. Sal Pub Mex 2009
Assessing Micronutrient Status

Biomarkers

• Can detect deficiency before clinical signs appear
• Requires biological samples, usually blood or urine
• For most nutrients cut-off for risk of excess not defined

Clinical signs

• Usually not present until deficiency is severe
• Not always specific to micronutrient

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Biomarkers may reflect

1. **Exposure**: Amount of nutrient available to the body or system
   - Dietary intake of micronutrients
2. **Status**: Short or long term
   - Nutrient reserves in the body or plasma concentration
3. **Function**: Reflected in better performance of a system
   - Enzyme activity, health, cognitive development etc.

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The body responds differently to different nutrient deficiencies

- Conservation or utilization of body reserves
- Requirements for specific or generalized metabolic functions
  - Resulting in specific deficiency syndromes or generalized functional consequences (e.g. reduced growth)
- Sometimes referred to as
  - Type I: Iron, vitamin A, Iodine (utilization and specific metabolic functions)
  - Type II: Zinc (conservation and generalized metabolic functions)
Implications for biomarkers

**Type I:** Relative ease of diagnosis *in individuals*
- Clinical signs of deficiency
- Reduced concentration in tissues
- Effect on specific enzymes
- Diagnosis by biochemical tests (e.g. plasma)

**Type II:** Relative difficulty of diagnosis *in individuals*
- No clinical signs
- Controlled tissue content and interdependent with other nutrients
- Cannot be diagnosed in individuals with biochemical tests – no specific abnormalities
Estimate of risk of zinc deficiency* in populations (children 6 mo to 5 yr of age)

*Estimated National Risk of Zinc Deficiency in Populations based on the combination of the prevalence of childhood growth stunting and the percent of people at risk of inadequate zinc intakes.

<table>
<thead>
<tr>
<th>Type of indicator</th>
<th>Measurement</th>
<th>Reflects</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>VITAMIN A – Immune function, vision, normal cell development</td>
<td>Xerophthalmia</td>
<td>Function (individuals)</td>
<td>Expertise in identification</td>
</tr>
<tr>
<td>Clinical sign</td>
<td>Night Blindness</td>
<td>Function (individuals and population)</td>
<td>Surveys, local terminology</td>
</tr>
<tr>
<td>Biomarker</td>
<td>Serum Retinol</td>
<td>Status (population)</td>
<td>Venous blood samples, laboratory</td>
</tr>
<tr>
<td></td>
<td>Retinol binding protein</td>
<td>Status (population)</td>
<td>Venous or cap blood, equipment, laboratory</td>
</tr>
<tr>
<td>IODINE – Thyroid hormones, growth, fetal devel., cognitive devel.</td>
<td>Goiter</td>
<td>Function (individuals)</td>
<td>Expertise in identification (expect severe cases)</td>
</tr>
<tr>
<td>Clinical sign</td>
<td>Urinary Iodine</td>
<td>Exposure(population)</td>
<td>Urine; equipment; laboratory</td>
</tr>
<tr>
<td>Biomarker</td>
<td>Thyroglobulin</td>
<td>Status (Individuals, population)</td>
<td>Venous or capillary sample; equipment; laboratory</td>
</tr>
<tr>
<td>Type of indicator</td>
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<td>Reflects</td>
<td>Requirements</td>
</tr>
<tr>
<td>-------------------</td>
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<td>----------</td>
<td>--------------</td>
</tr>
<tr>
<td><strong>ZINC – Immune function, enzyme function, growth, many biological roles</strong></td>
<td>Dietary intake</td>
<td>Exposure (population)</td>
<td>Together with other</td>
</tr>
<tr>
<td>Clinical sign</td>
<td>Stunting</td>
<td>Function (population)</td>
<td>Combined w/ other indicators; not specific to Zn</td>
</tr>
<tr>
<td>Biomarker</td>
<td>Serum Zinc</td>
<td>Status (population)</td>
<td>Venous sample; equipment; laboratory</td>
</tr>
<tr>
<td><strong>IRON – Hb production (oxygen transport), immune function</strong></td>
<td>Zinc protoporphyrin</td>
<td>Status (Individuals, population)</td>
<td>Venous or cap sample; equipment; laboratory</td>
</tr>
<tr>
<td>Biomarker</td>
<td>Serum Ferritin</td>
<td>Status (Individuals, population)</td>
<td>Venous (or cap) sample; equipment; laboratory; elevated in infection</td>
</tr>
<tr>
<td></td>
<td>Transferrin Receptor</td>
<td>Status (Individuals, population)</td>
<td>Venous sample, equip, laboratory, ref values</td>
</tr>
<tr>
<td></td>
<td>Serum Iron, TIBC</td>
<td>Status (Individuals, population)</td>
<td>Venous or cap sample; equipment, laboratory</td>
</tr>
</tbody>
</table>
Only biomarker regularly monitored in many countries: Anemia. Prevalence in children 6 m to 5 y of age

*Pre-school aged children (6-59 mo); Anemia defined as Hb <110 g/L

Is anemia an appropriate proxy for micronutrient deficiency?

Nutritional Anemia
- Iron Deficiency
  - Vit B12 Deficiency
  - Folate Deficiency
- Vit A Deficiency
- Others

Parasitic Infection
- Malaria
- Hookworm
- Schistosomiasis
- Premature Birth, Low Birth Weight, Time of Umbilical Cord Clamping

Other Factors
- Eg. Sex, Iron status of mother, H. pylori
- HIV/AIDS
- Bacteremia
- Other
- G6PD Deficiency
- Sickle cell Disease
- Other hemoglobinopathies

~50% of cases of Anemia are due to Iron Deficiency... Validity of this assumption uncertain and likely highly variable by population.
Progress in improving available biomarkers of micronutrient status

Biomarkers of Nutrition in Development (BOND)¹

- NIH Initiative funded by Gates Foundation
- Focus on Research, Policies, Programs, Clinical
  - Objectives for the use of biomarkers in each context
  - Identification of existing options for use
  - Research Needs
- Technological innovation needs

¹ Publication under review Am J Clin Nutr.
Improvements in the compilation and accessibility to data

WHO’s upgraded Vitamin and Mineral Nutrition Information System (VMNIS)

Phase I: Database restructuring. The goal will be a database which is more efficient...

Phase II: Data migration. This phase includes the transfer of data currently in the VMNIS databases ...systematic search in the scientific literature and throughout the international community for all surveys containing information on micronutrients. ..

Phase III: Redesign of website. The redesign of the website will allow the end-user to query information by variables ...

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Adds another layer of complexity

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<th>Adequate</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micro-nutrient sufficient</td>
<td>MN deficient</td>
<td>MN sufficient</td>
</tr>
<tr>
<td>Low</td>
<td>Stunted</td>
<td>Stunted</td>
<td>Stunted</td>
</tr>
<tr>
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Conclusions

• Numerous measures for separate aspects of nutritional status are available
• None provide a comprehensive reflection of nutritional status of individuals or populations
• Current data from countries often focuses on 1-2 easy to measure indicators that provide a simplistic representation of a complex problem
  – Although there have been some improvements in recent years, quality of this data has often been difficult to assess
Thank you

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