Measuring food insecurity and assessing the sustainability of global food systems
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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

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

Photo credit: WHO/UNICEF, 2009

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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

Common measures size in adults

Measure	Indicator	Reflective of
Height	Height	Past nutritional status (not usually used alone except in extreme short height)
Weight	Body mass index-for-age	Risk during pregnancy Risk of chronic disease

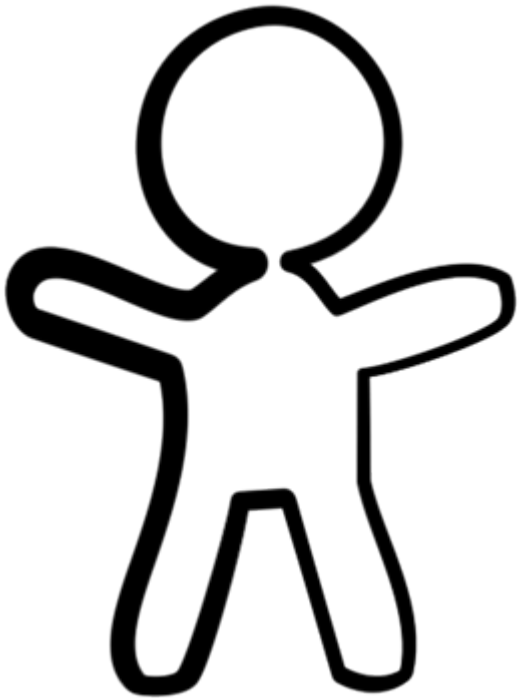
Common measures of size* in children

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

*"Growth" assessed by repeat measures of any indicator

Anthropometric assessment of nutritional status

Healthy;
well-nourished



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

Wasting;
acute malnutrition

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

Stunting;
chronic undernutrition

HA <-2 SD below median

In reality, conditions may coexist

Weight → / Height ↓	Low	Adequate	High
Low	Stunted Wasted	Stunted Adequate weight	Stunted Overweight
Adequate	Adequate height Wasted	Adequate height Adequate weight	Adequate height Overweight

All indicators have strengths and limitations to reflect health risks

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

WHO's global Database on Child Growth and Malnutrition: http://www.who.int/nutgrowthdb/en/

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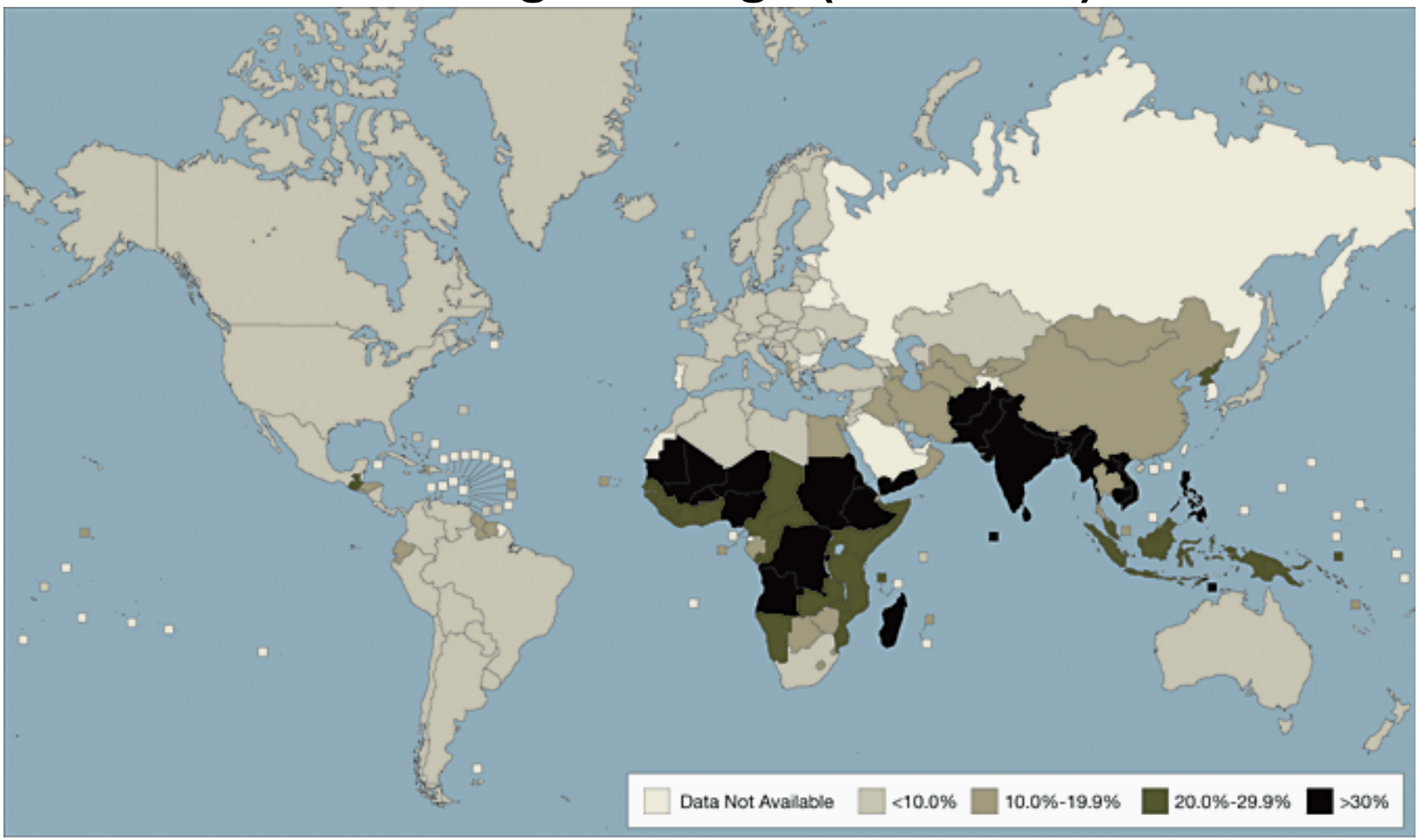
The most commonly reported indicator: Prevalence of low weight for age (DHS data)



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

JAMA

Weight-for-age

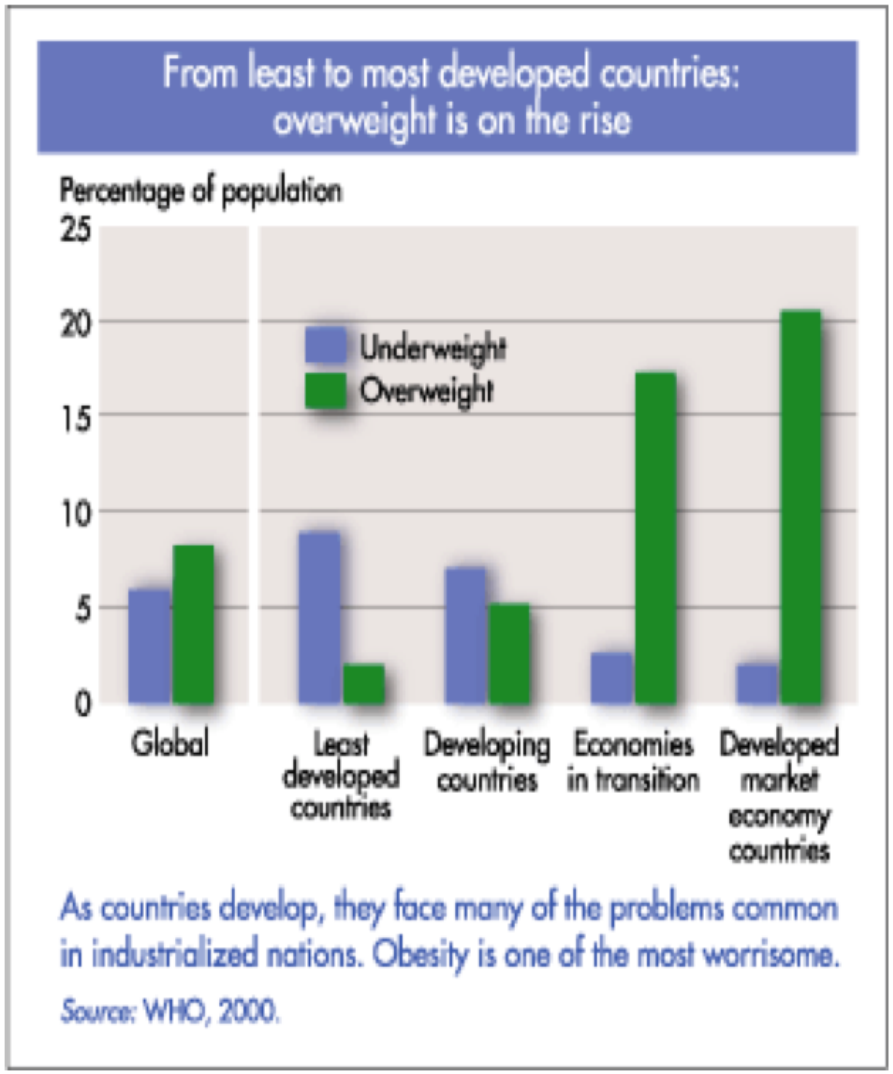
Strengths:

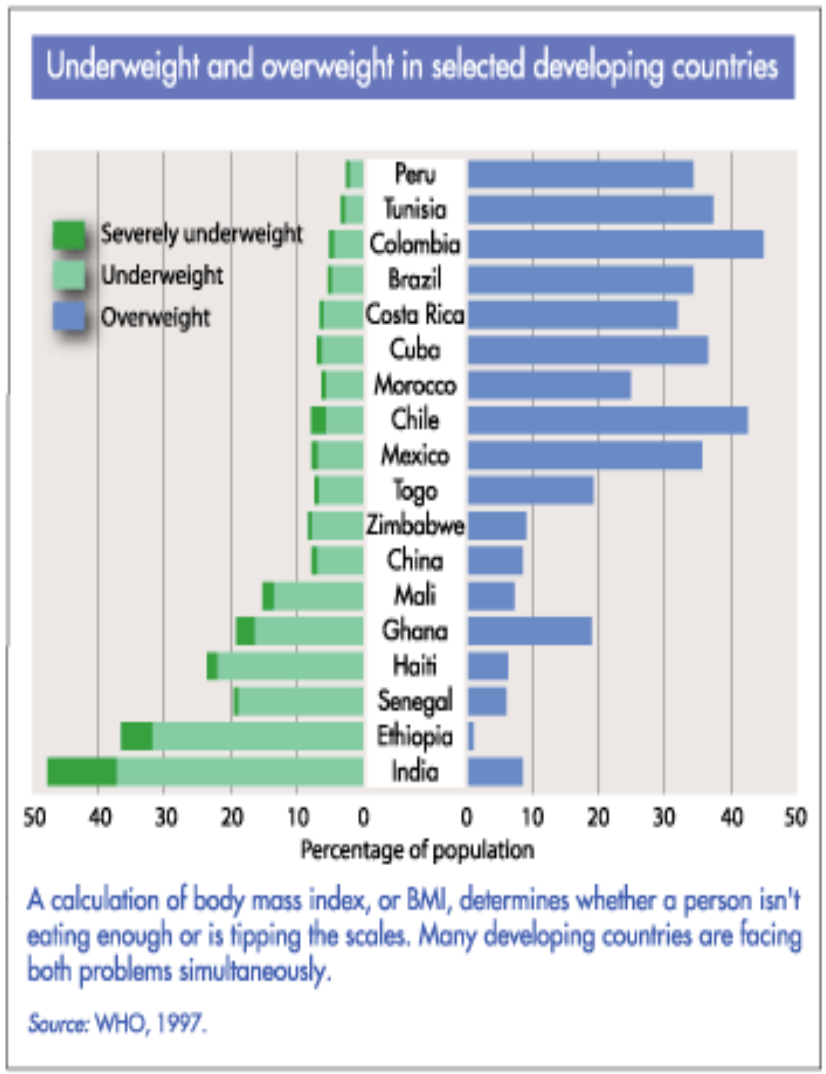
- Only indicator regularly monitored in many countries
  - Weight and age both easily measured
- Key indicator for MDG's
  - Multiple years of data permit comparisons over time and across regions/countries

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

High prevalence of overweight and obesity in populations where undernutrition persist





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REF: Burslem, Chris, IFPRI.(2004) Obesity in Developing Countries: People are Overweight But Still Not Well-Nourished.

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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

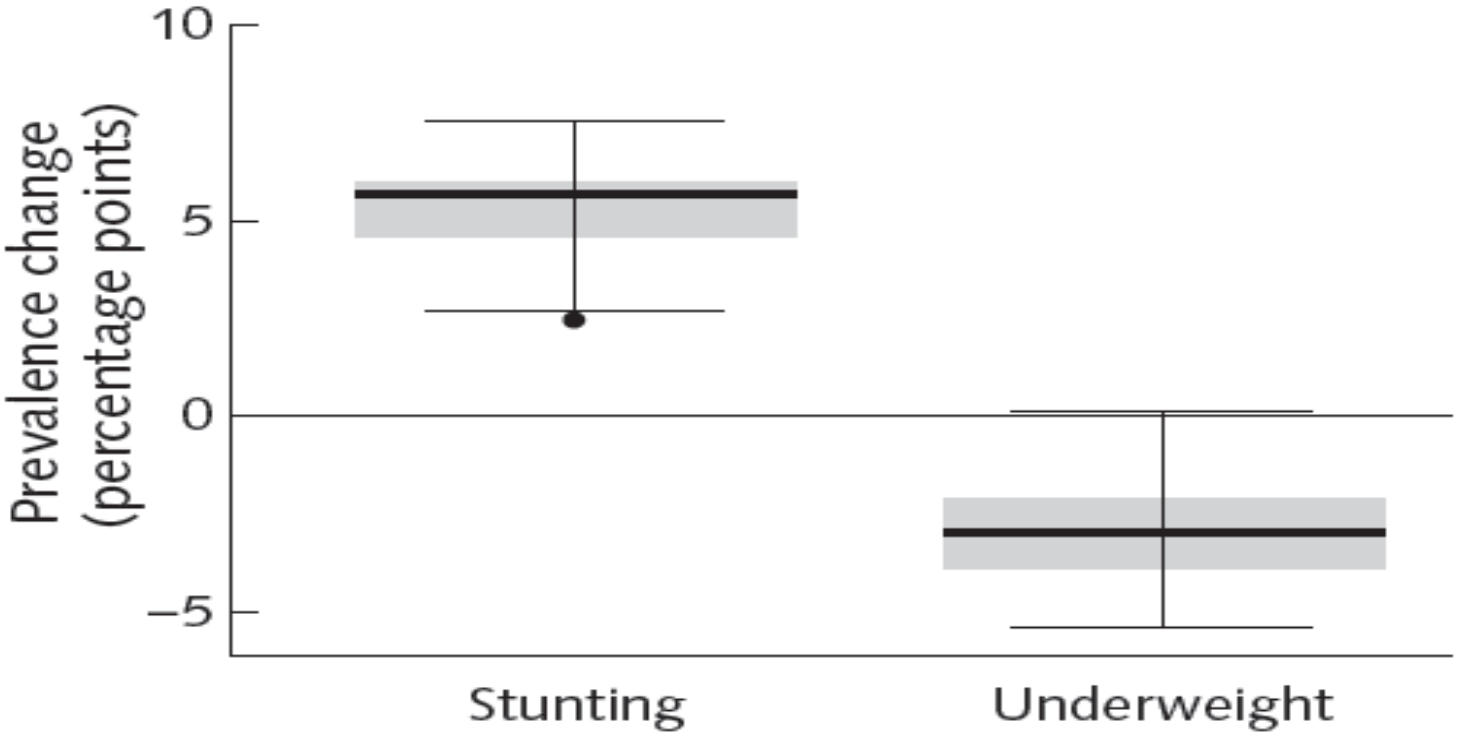
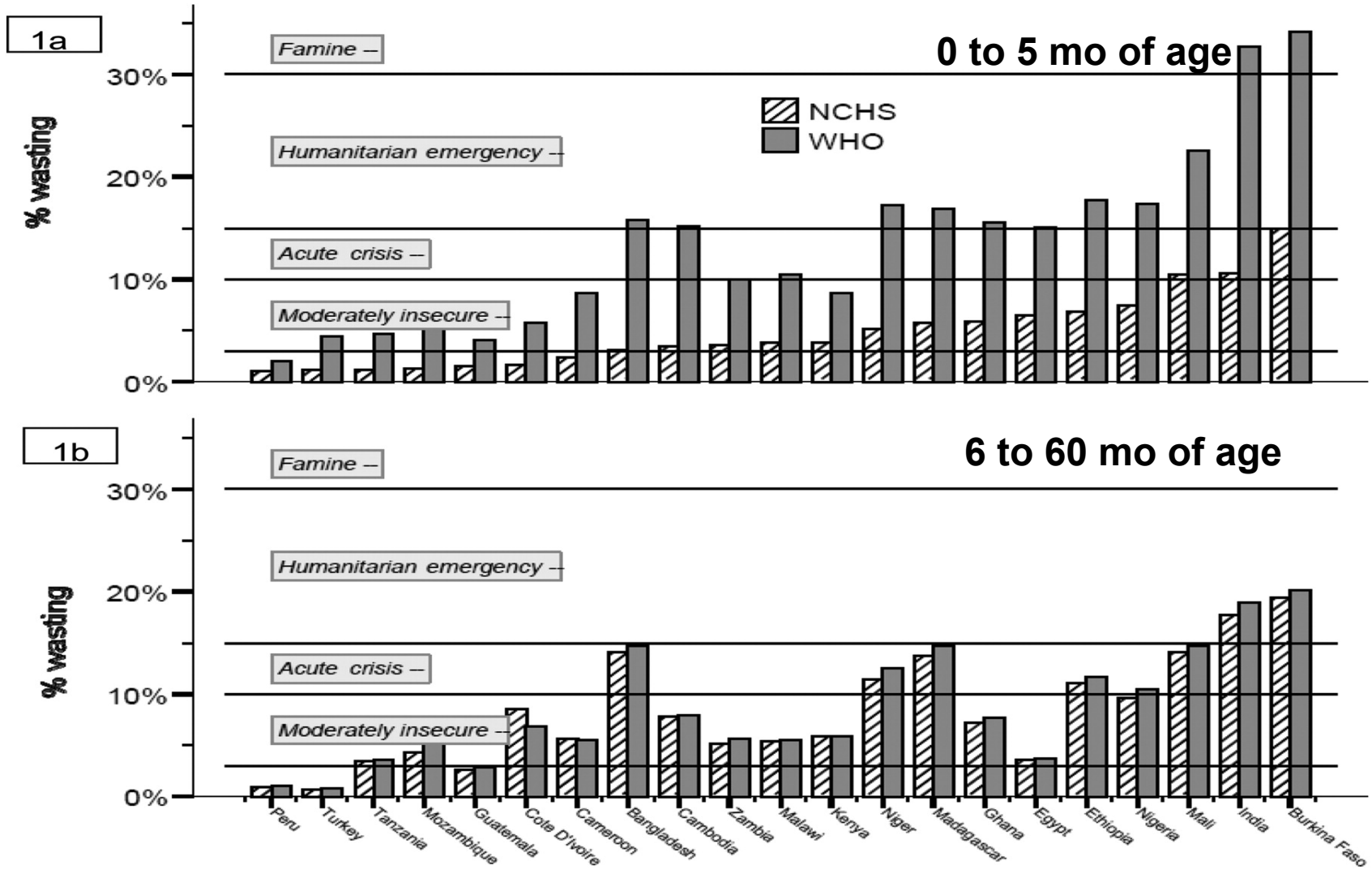


FIG.1. Change in overall prevalence with the adoption of the new WHO standards (percentage points). The box plots summarize the data from the 41 countries, showing medians, 25th and 75th percentiles, lower and upper adjacent values, and outside values

Urgo et al. Food Nutr Bull 2009

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

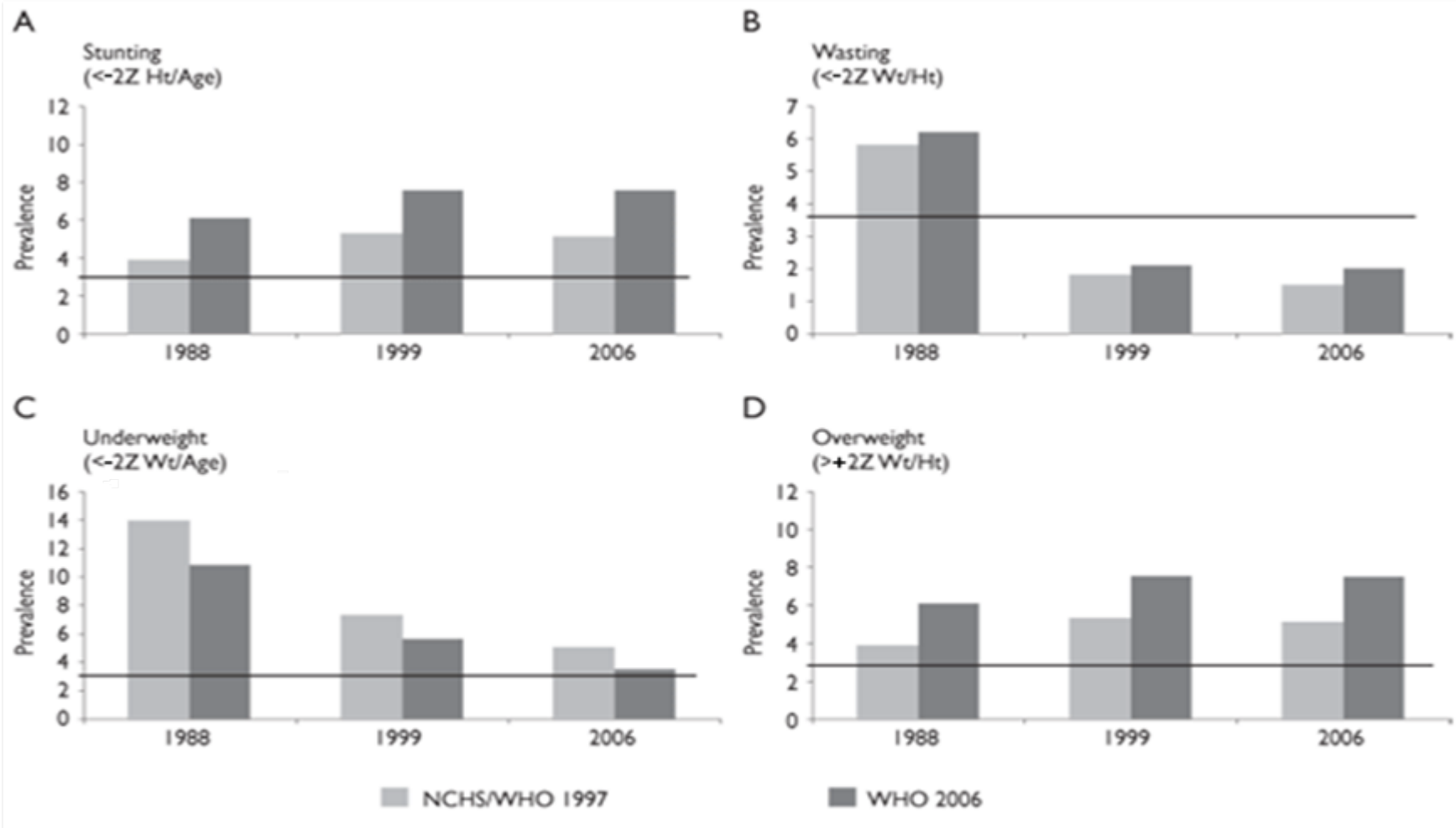


FIGURE 1. PREVALENCE OF MALNUTRITION IN MEXICAN CHILDREN IN 1988, 1999 AND 2006 USING THE NCHS/WHO REFERENCES AND THE WHO-2006 GROWTH STANDARDS

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

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.

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)

Golden MH. 1988, 1991

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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

Golden MH. 1988, 1991

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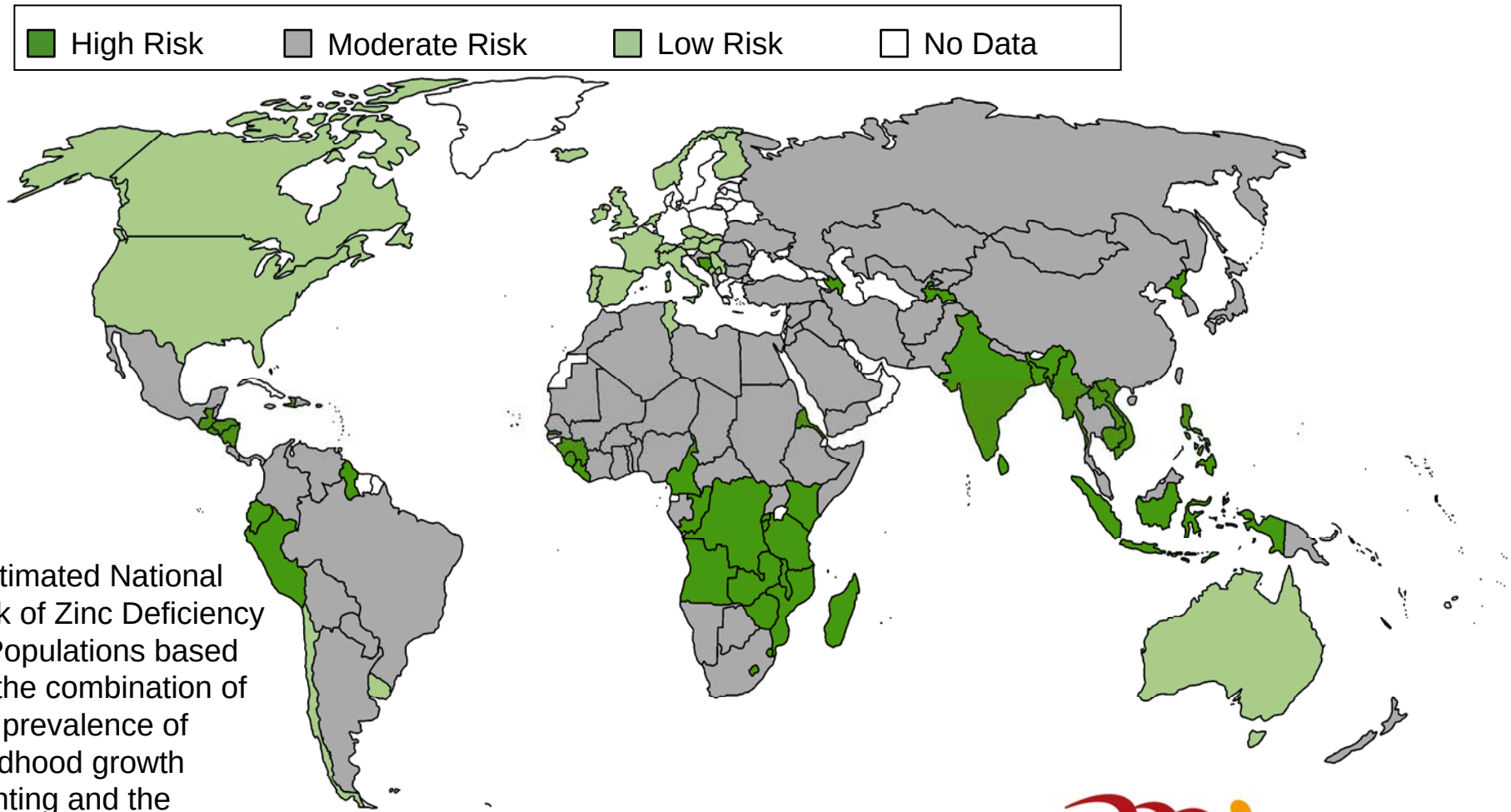
Estimate of risk of zinc deficiency* in populations (children 6 mo to 5 yr of age)



*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.

Source: IZiNCG Technical Document #1: Ch 2 Assessment of the Risk of Zinc Deficiency in Populations. C Hotz and K.H. Brown. Food and Nutrition Bulletin 25(1) 2004.

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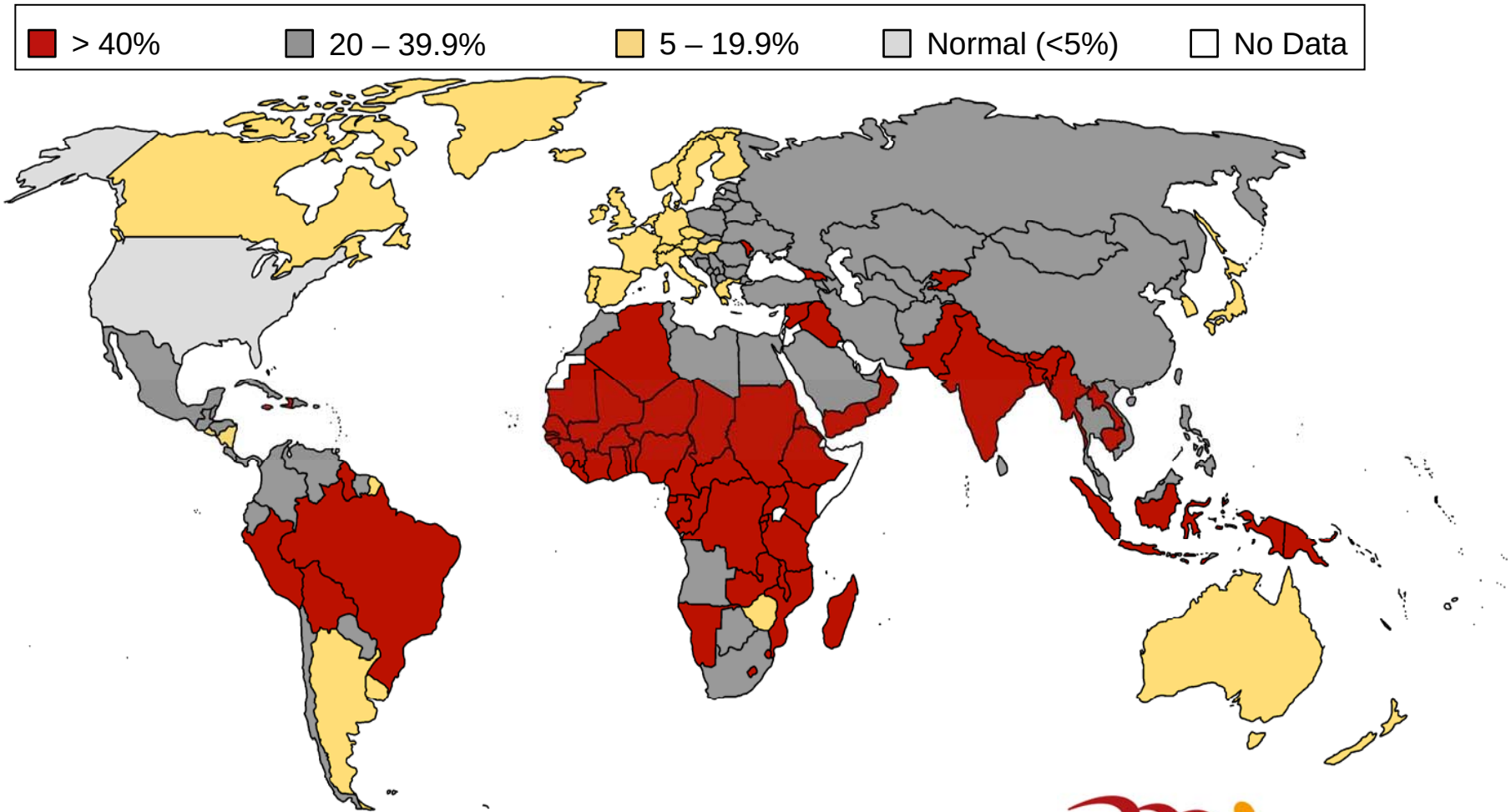
Type of indicator	Measurement	Reflects	Requirements
VITAMIN A – Immune function, vision, normal cell development			
Clinical sign	Xerophthalmia	Function (individuals)	Expertise in identification
	Night Blindness	Function (individuals and population)	Surveys, local terminology
Biomarker	Serum Retinol	Status (population)	Venous blood samples, laboratory
	Retinol binding protein	Status (population)	Venous or cap blood, equiptment, laboratory
IODINE – Thyroid hormones, growth, fetal devel., cognitive devel.			
Clinical sign	Goiter	Function (individuals)	Expertise in identification (expect severe cases)
Biomarker	Urinary Iodine	Exposure(population)	Urine; equipment; laboratory
	Thyroglobulin	Status (Individuals, population)	Venous or capillary sample; equipment; laboratory

Type of indicator	Measurement	Reflects	Requirements
ZINC – Immune function, enzyme function, growth, many biological roles			
Clinical sign	Dietary intake	Exposure (population)	Together with other
	Stunting	Function (population)	Combined w/ other indicators; not specific to Zn
Biomarker	Serum Zinc	Status (population)	Venous sample; equipment; laboratory
IRON – Hb production (oxygen transport), immune function			
Biomarker	Zinc protoporphyrin	Status (Individuals, population)	Venous or cap sample; equipment; laboratory
	Serum Ferritin	Status (Individuals, population)	Venous (or cap) sample; equipment; laboratory; elevated in infection
	Transferrin Receptor	Status (Individuals, population)	Venous sample, equip, laboratory, ref values
	Serum Iron, TIBC	Status (Individuals, population)	Venous or cap sample; equipment, laboratory

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

www.micronutrient.org

Source: WHO, CDC. Worldwide prevalence of anaemia 1993-2005. WHO global database on anaemia. Geneva, World Health Organization, 2008.

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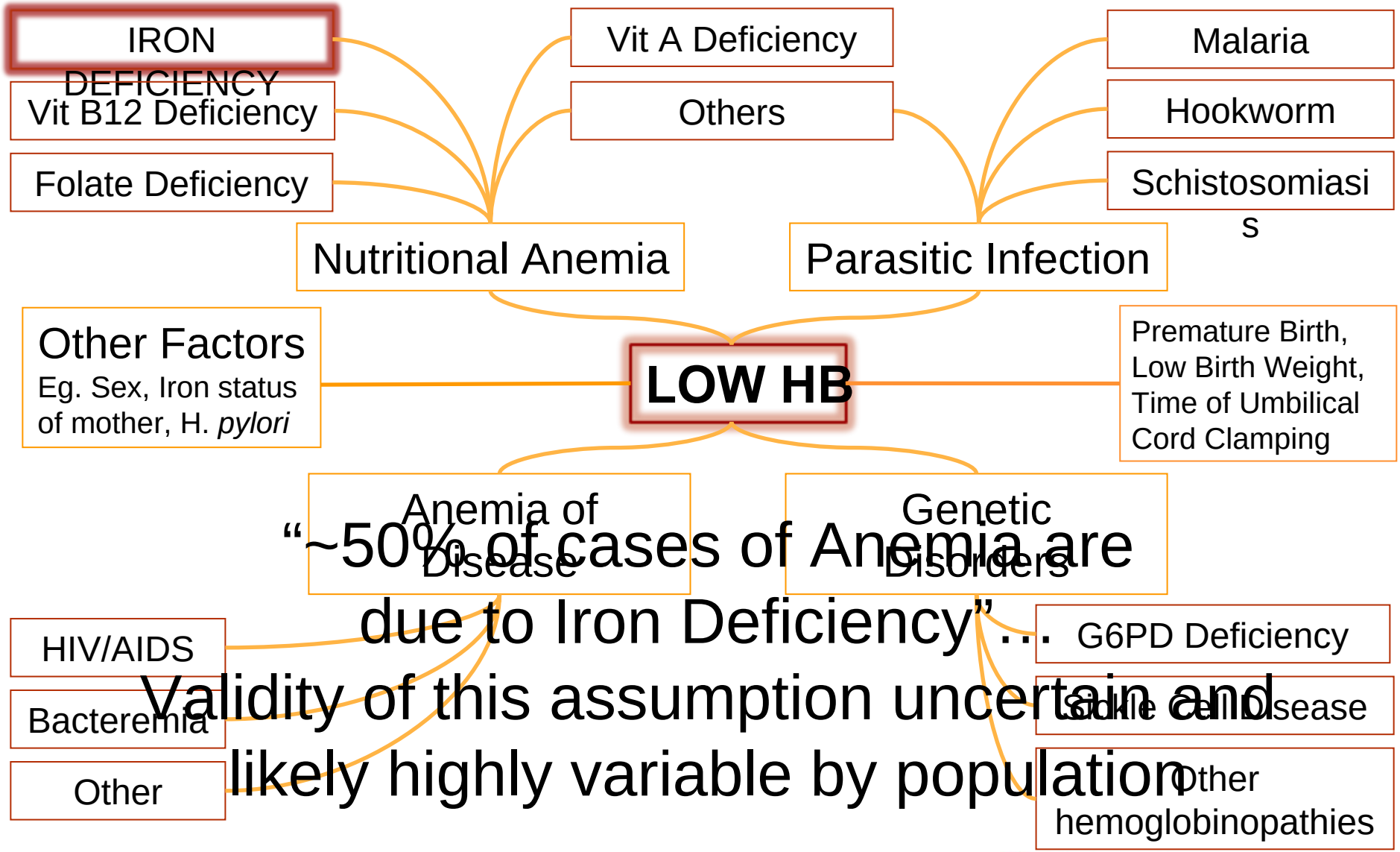
Is anemia an appropriate proxy for micronutrient deficiency?



"~50% of cases of Anemia are due to Iron Deficiency"…

Validity of this assumption uncertain and likely highly variable by population

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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 …

http://www.who.int/vmnis/database/vmnis_upgrade/en/index.html

Adds another layer of complexity

Weight → / Height ↓	Low		Adequate		High	
	Micro-nutrient sufficient	MN deficient	MN sufficient	MN deficient	MN sufficient	MN deficient
Low	Stunted Wasted	Stunted Wasted	Stunted Adequate weight	Stunted Adequate weight	Stunted Over weight	Stunted Over weight
Adequate	Adequate height Wasted	Adequate height Wasted	Adequate height Adequate weight	Adequate height Adequate weight	Adequate height Over weight	Adequate height Over weight

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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