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# Protein quality, amino acids and growth

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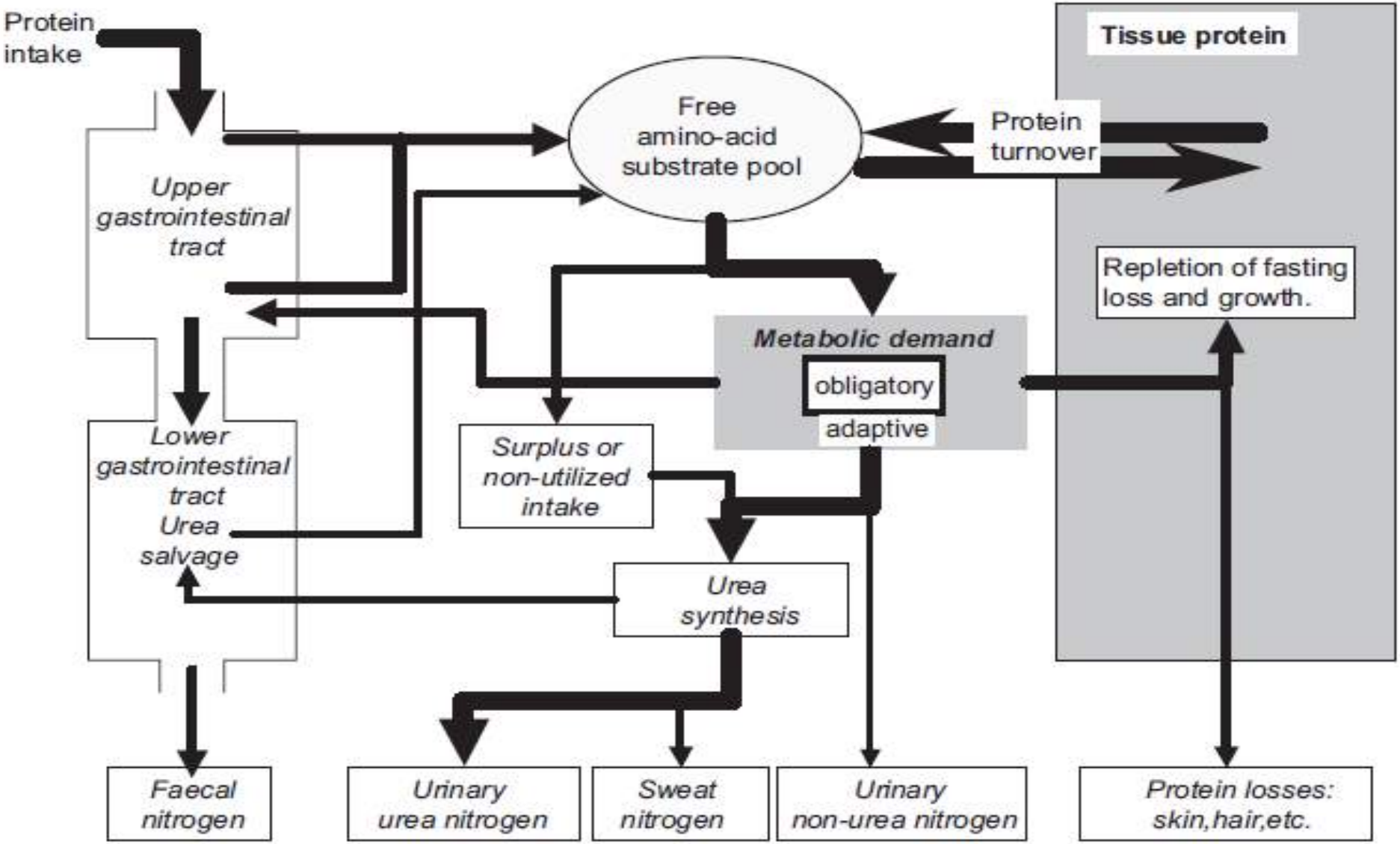
# Protein Quality Related Metabolic Outcomes



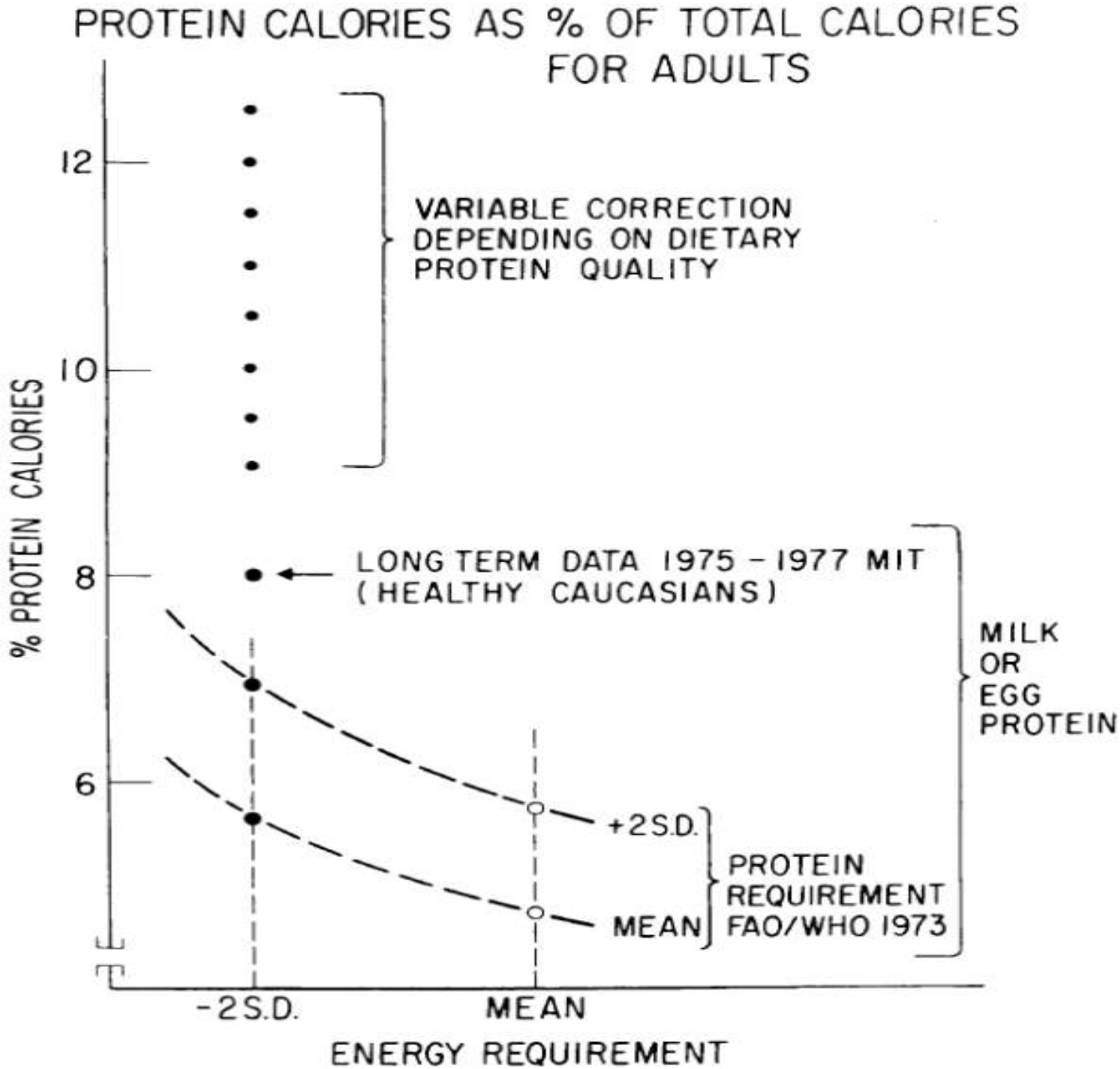
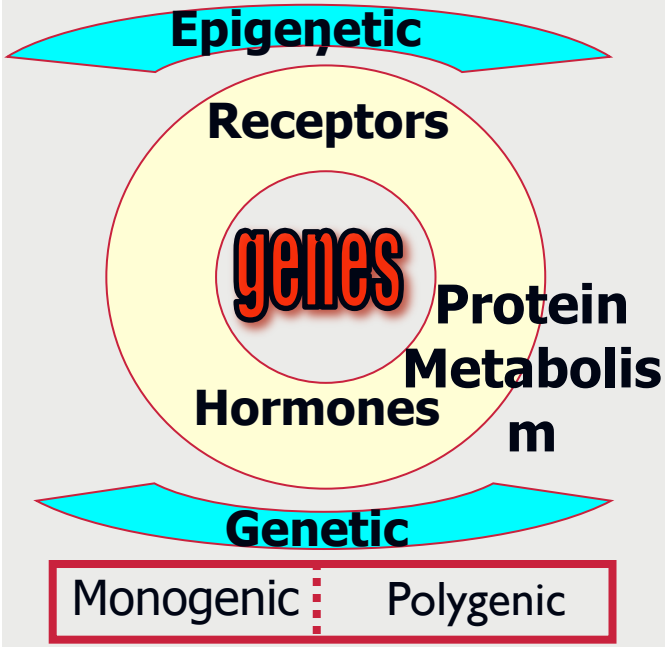

PROTEIN CALORIES AS % OF TOTAL CALORIES
FOR ADULTS
% PROTEIN CALORIES
12
10
8
6
VARIABLE CORRECTION
DEPENDING ON DIETARY
PROTEIN QUALITY
LONG TERM DATA 1975 - 1977 MIT
(HEALTHY CAUCASIANS)
MILK
OR
EGG
PROTEIN
+2S.D.
MEAN
PROTEIN
REQUIREMENT
FAO/WHO 1973
-2S.D.
MEAN
ENERGY REQUIREMENT

FIG. 1

# Protein Quality Related Health Outcomes

## Physiologic/MetabolicResponses

Absorption-Digestibility
Metabolic Utilization
Nitrogen Balance
Lean mass/Muscle/Bone
Tissue turnover
Secretory Proteins
Host defenses/Immunity
Growth & Maturation
Tissue Repair




## Short term outcomes

Growth and tissue repair (wasting and stunting)

Immune function and host defense system(prevalence and severity of infection)

Muscle and skeletal Mass (capacity for physical work and athletic performance)

Mental performance, mood, sleep patterns ?

Detoxification of chemical agents and antioxidant systems

## Long Term Outcomes

Life course events, linear growth , menarche, aging

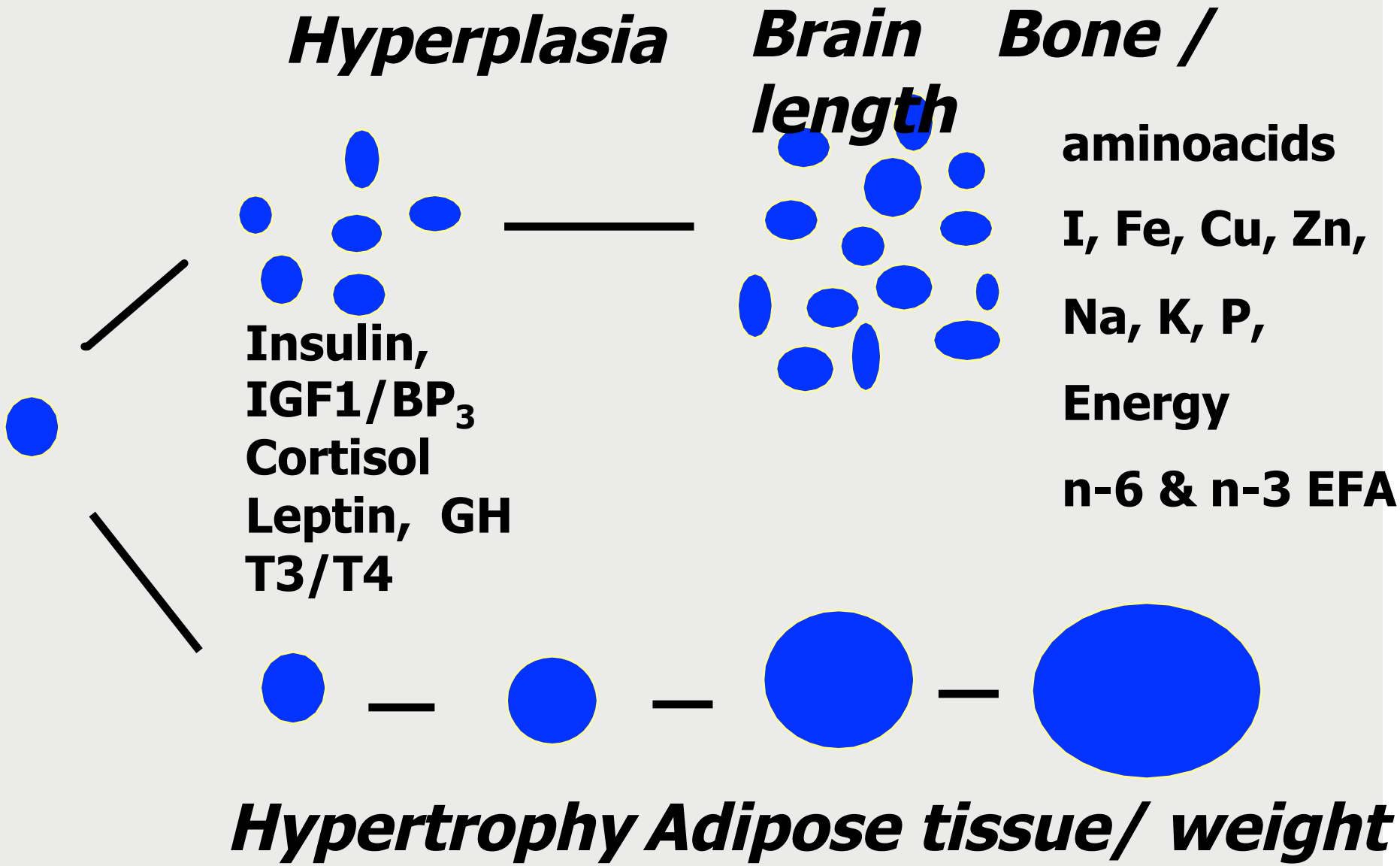
Age related functional losses: muscle, bone strength, immunity, cognitive decline

Nutrition related chronic diseases: CVDs, Cancer, Hypertension, oxidative damage, repair systems

present efforts

future efforts

# Nutrient/Hormones Effects on Growth



Present efforts in infant/child nutrition should “not only” improve survival (**avoid low weight for age**) but must also aim that **all children** have the opportunity to **be educated**, **be healthy and productive as adults**, extending life and preventing disability beyond the reproductive cycle (**marked by length and BMI for age**).

**We should aim for “longer” , “healthier” and “happier” lives while preventing functional losses.**

**These goals are essential for human, economic and social development as well as for global peace.**

# Nutrient Effects on Growth

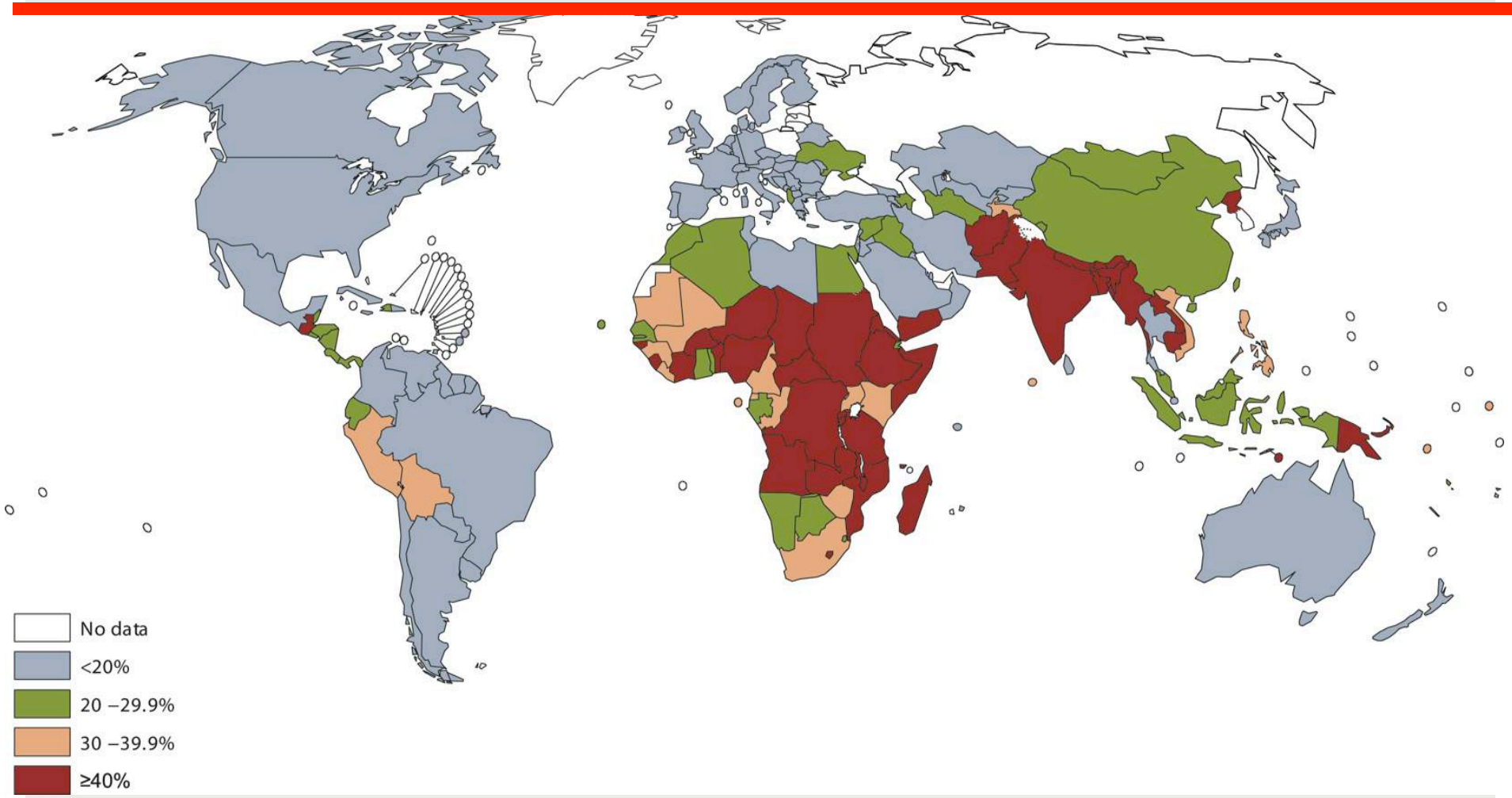
- Any essential nutrient can condition abnormal embryonic & organ growth and development (Folate, I, Vit A, E, Fe, Zn, EFA, EAA Pr/Energy)

- Timing of nutrient deficit or excess is crucial in effect: cell replication/migration/apoptosis/maturation

- Genetic polymorphism affecting nutrient metabolism transport or tissue levels can modulate effects.

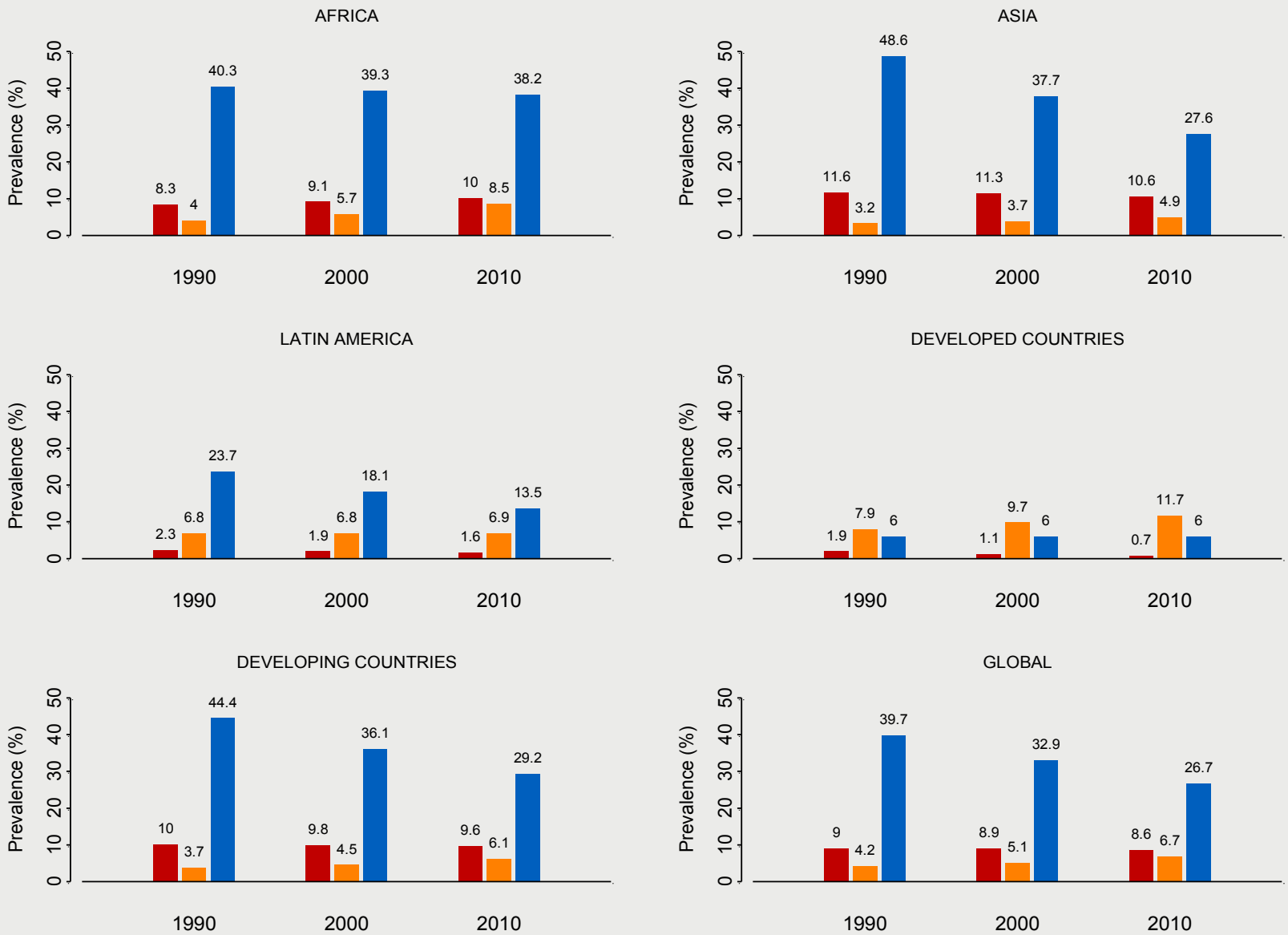
- Nutrients & toxicants (retinoic acid, Pb, Zn, folate) interact in defining normal or abnormal growth.

# 171 million children under 5 are stunted



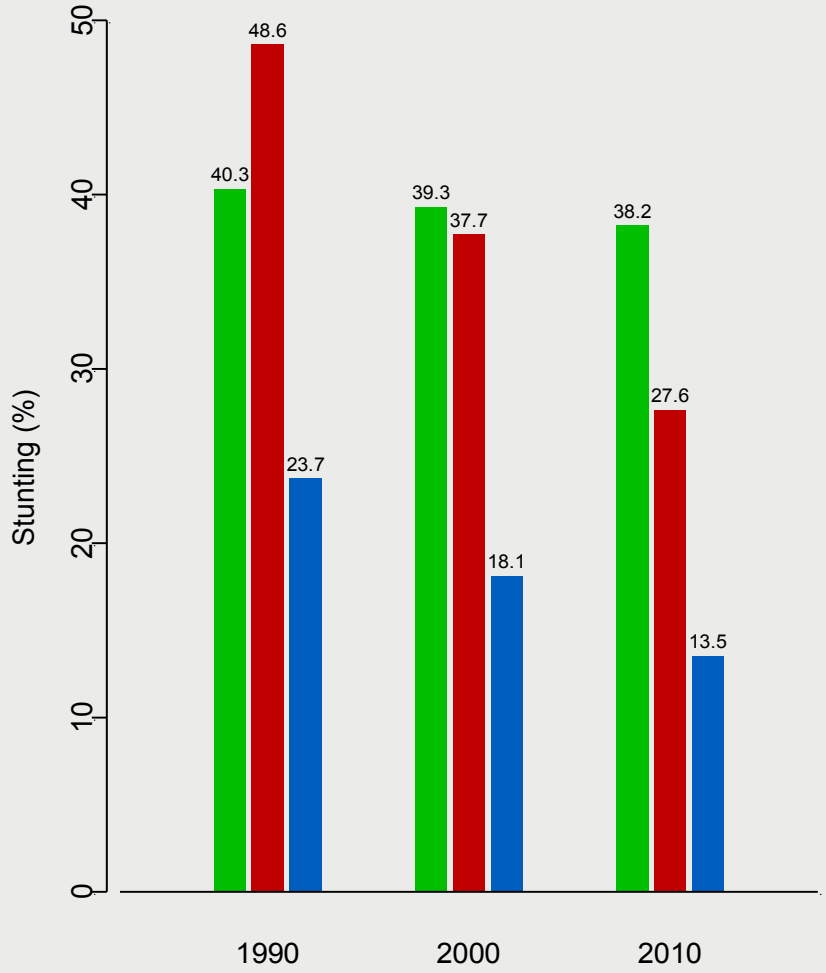

Source: WHO Global Database on Child Growth and Malnutrition, May 2009

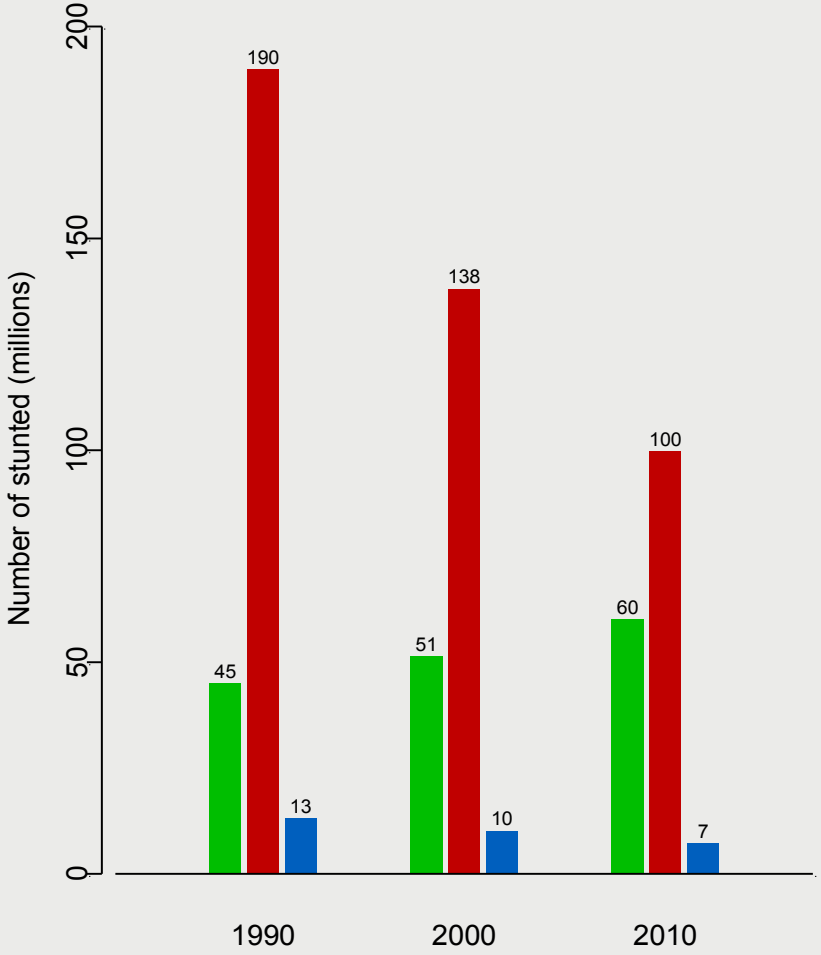
# Global and regional prevalences of stunting, wasting and overweight




Source: Department of Nutrition, World Health Organization

# Stunting prevalence and number affected in developing countries

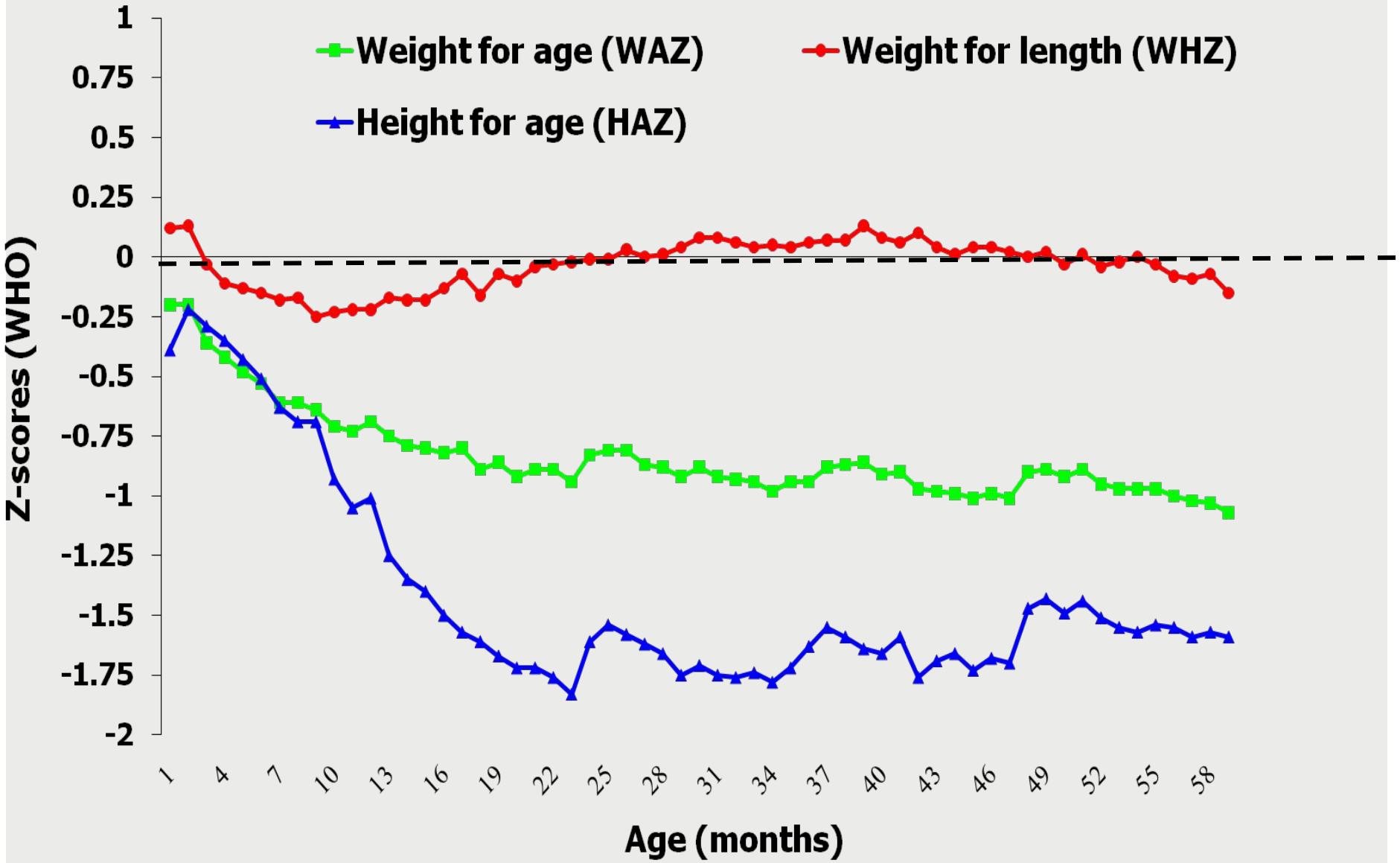



Source: Department of Nutrition, World Health Organization

AFRICA ASIA LATIN AMERICA

# Mean *z*-scores for age all 54 studies, relative to the WHO standard




Source: Victora CG, de Onis M, Hallal PC, Blössner M, Shrimpton R. Worldwide timing of growth faltering: revisiting implications for interventions using the World Health Organization growth standards. Pediatrics,

# Milk/Animal source foods interventions improve linear growth

**1930s UK: Boyd Orr:** feeding trials of surplus milk disposal to school children: significant increase in height, improvement in "general appearance" .

**India:** Aykroyd and Krishnan (1937) skimmed milk supplemented school children grew faster in height

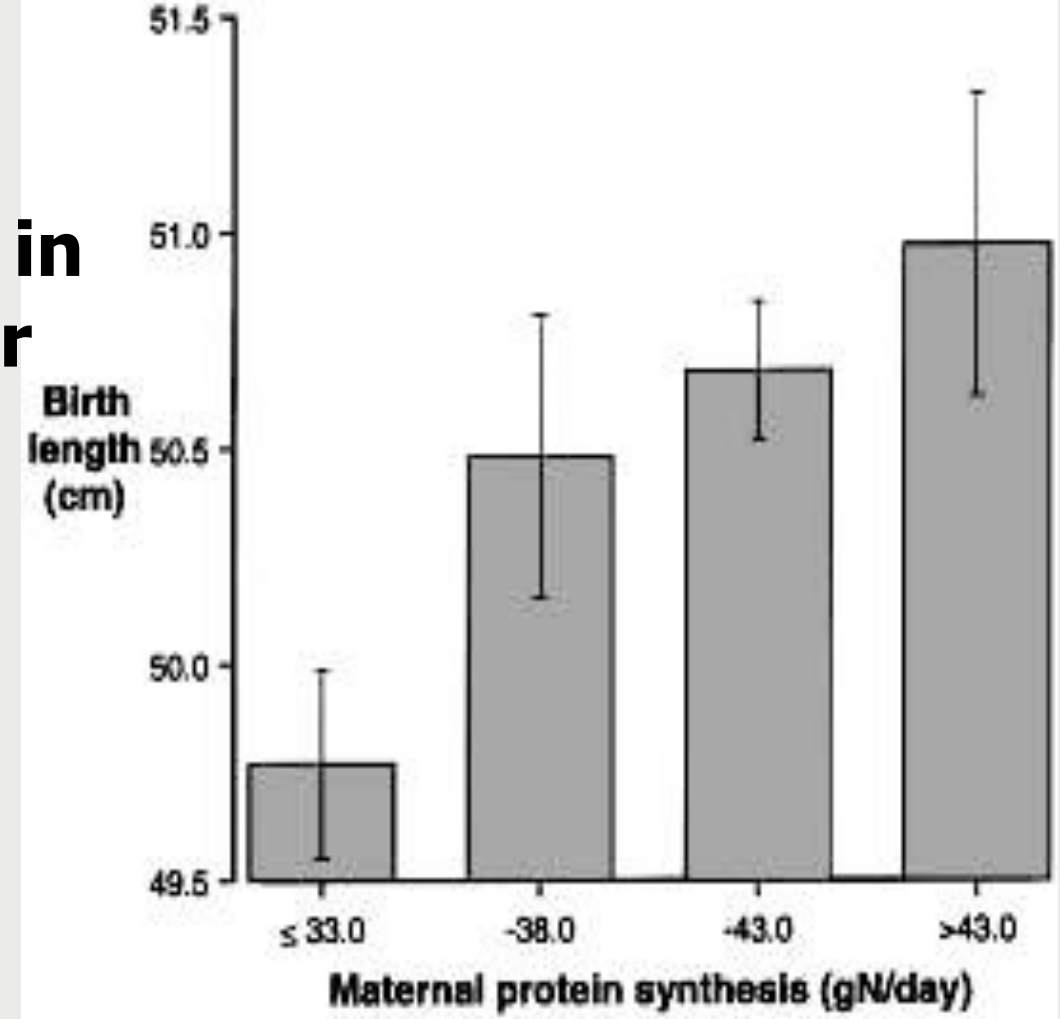
**New Guinea:** Malcolm (1971) & Lampl *et al* (1978): skimmed milk supplement increased height of stunted, low protein fed children

**US**: Fomon *et al.* (1977): skimmed milk (low energy, high protein)-fed infants showed same length growth but less weight gain than high energy formula.

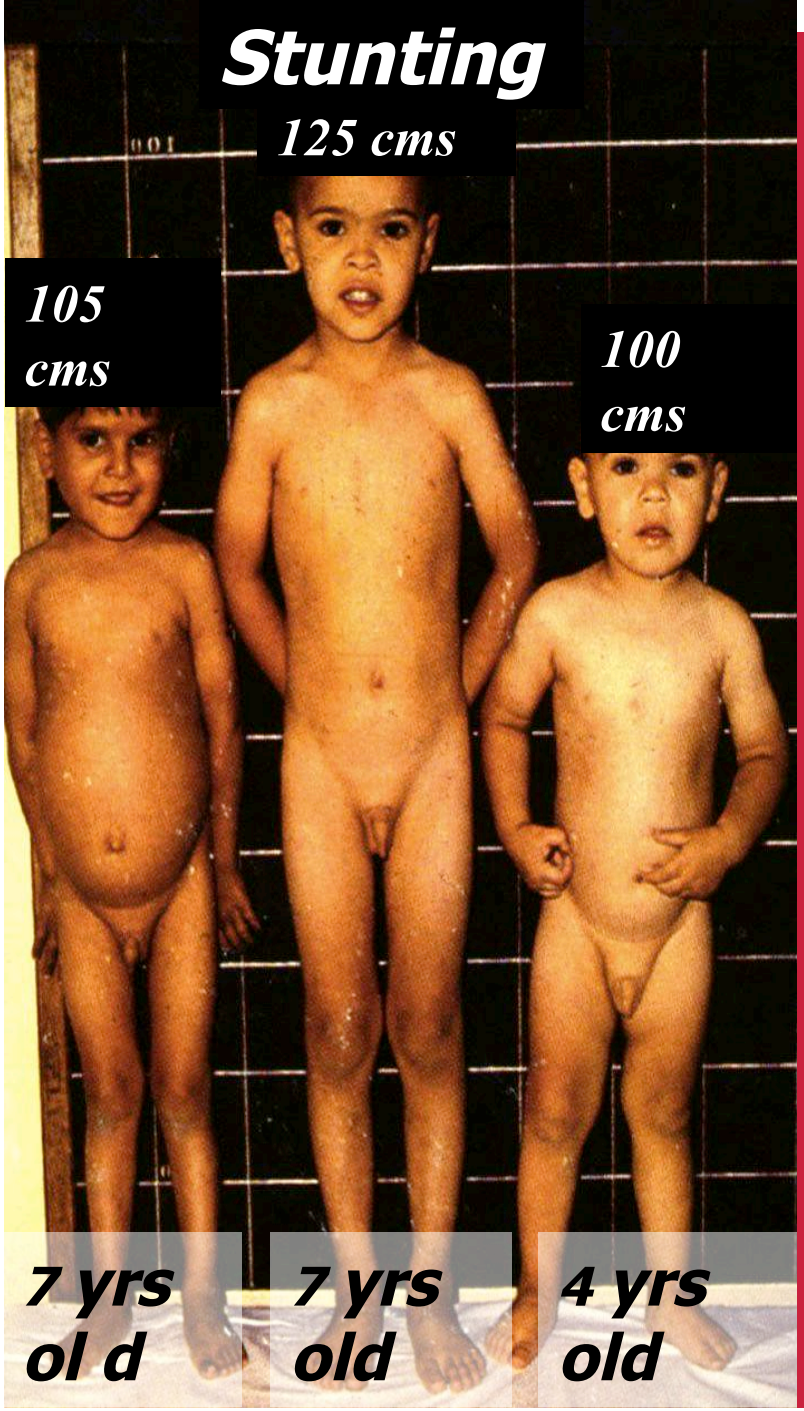
**Bangladesh:** Kabir *et al (*1992/3): ASF protein at 15% energy increases IGF-1 and linear growth cf 7.5% protein in children recovering from shigellosis

# Maternal protein flux and neonatal Length

**Length of the newborn at birth and maternal protein synthesis in mid pregnancy for 26 women**




**Sarah L. DUGGLEBY* and Alan A. JACKSON**
**Clinical Science (2001) 101, 65–72**




# Stunting

**Most common form of undernutrition (**PE/micronutrients)

**Affects infants before and early after birth**

**Linked to maternal size, nutrition during pregnancy & fetal growth**

**Length that is lost early on is rarely recovered**

**Stunted have less lean body mass (lower RMR per kg bw)**

# Nutrition and height growth: specific nutrients

**Protein ⇨:** strong experimental evidence in animals
Good indirect data in humans

**Zinc ⇨:** Good experimental evidence in animals
Good meta analysis data in humans (weak effect)

**Calcium & Phosphate:** Length growth not thought to be limited by mineral supply in general

**Other micronutrients:**
I, Fe, Mn, Ca, vitamin A, Vit D all potentially involved but specific deficiency signs & symptoms would be observed.

**Infection/stress:** Good experimental and epidemiological evidence mediated by pro inflammatory cytokines & cortisol

# Mechanisms by which nutrition conditions linear growth

- Gene Expression (transcription factors,  single or multiple genes)

- Hormones receptors, binding proteins and signal transduction

- Cell growth and turnover during critical periods

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# Assessment of protein adequacy in developing countries: quality matters

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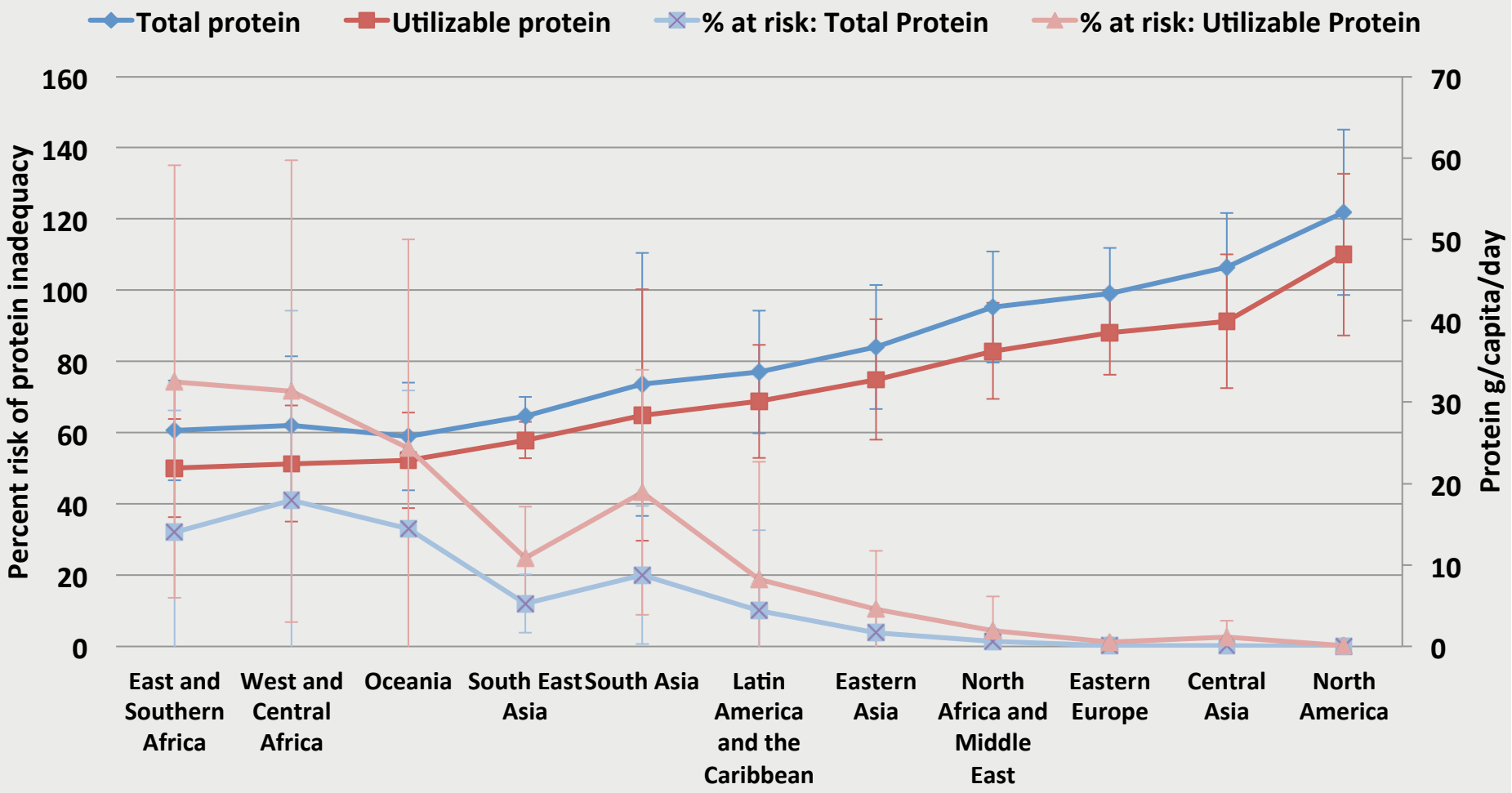
# Data Sources

- Food balance sheet data for 180 countries (FAO STAT)- year 2005
  - For each country FBS provides amount of listed commodity available fro food consumption
- Stunting data from UNICEF for 116 countries – year 2005
  - "Moderate to Severe Stunting" (referred to as "stunting") is defined by UNICEF as the percentage of children under five years of age in a particular country who fall below -2 and -3 standard deviations for height-for-age z-score.
- Data on Gross Domestic Product (GDP) from UNDP Human Development report
- Nutrient database developed on basis of USDA food composition tables
- Protein digestibility data from FAO/WHO 1991 protein quality evaluation and literature

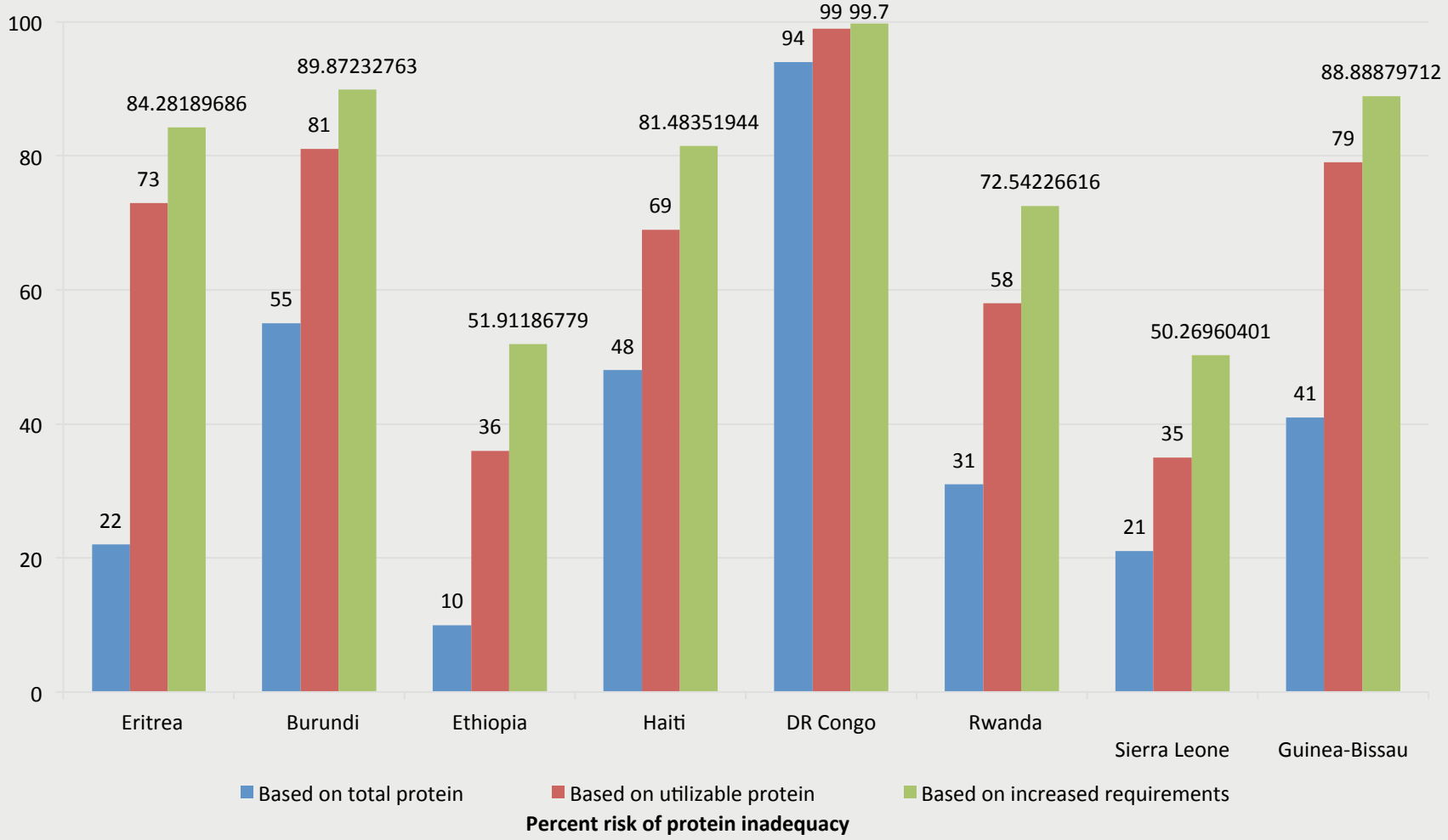
# Data calculations

- Estimation of nutrient availability from FBS commodity data
- Calculation of PDCAAS for each country (diet) using WHO prescribed methodology and utilizable protein
- Estimation of prevalence of inadequacy
  - Adult protein requirement 0.66 g/kg body weight, 60 kg
  - 2525 kcal total energy calculated for a moderately actively adult (PAL 1.75, average for moderately active adult male and female
  - Amino acid reference pattern for lysine (30 mg/kg body weight/ day), tryptophan (4 mg/kg body weight/day), SAA (15 mg/kg body weight/day) and threonine (15 mg/kg body weight/day) (1, 26).
  - Country level availability as mean protein availability, intake distribution based on CV 25%
  - Energy deficit- 10% increased need in protein requirement
  - Increased need for protein during and after 8 episodes per year illness (recovery), 10% for total days ill and recovery weighted over year

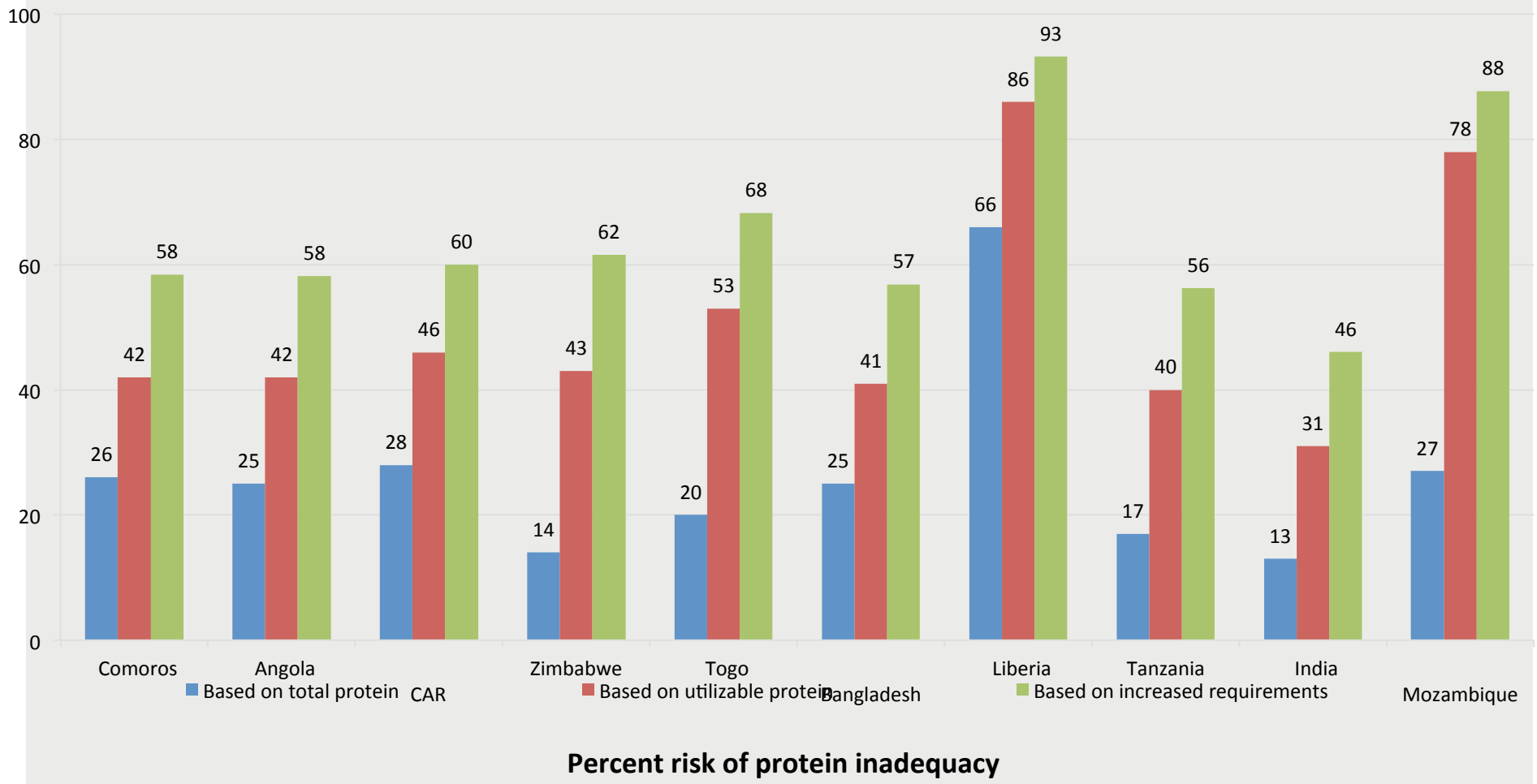
# Comparison of total protein to utilizable protein by region (g/capita/day and prevalence of inadequacy)



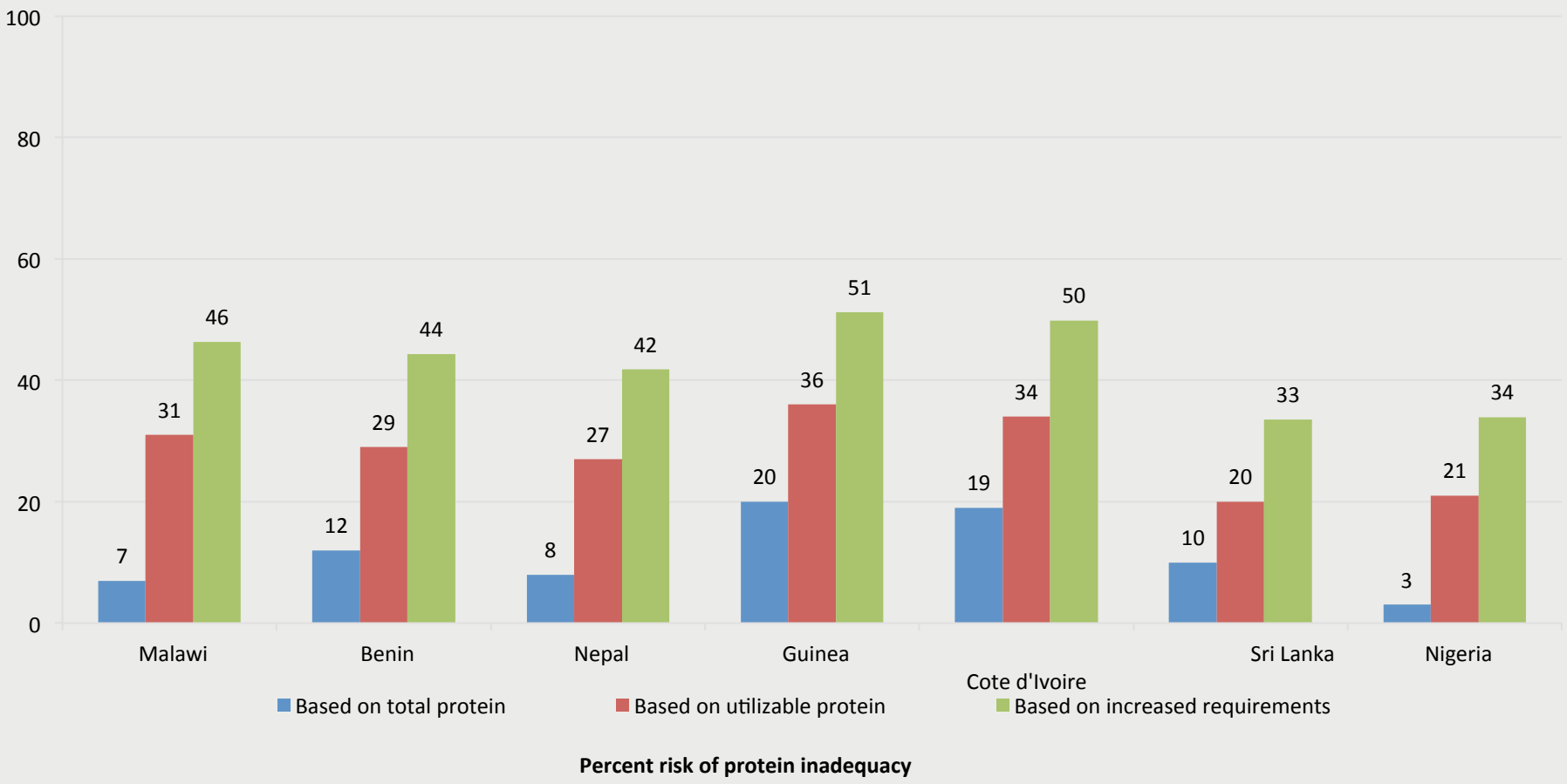
# Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with under 2000 kcal/capita/day



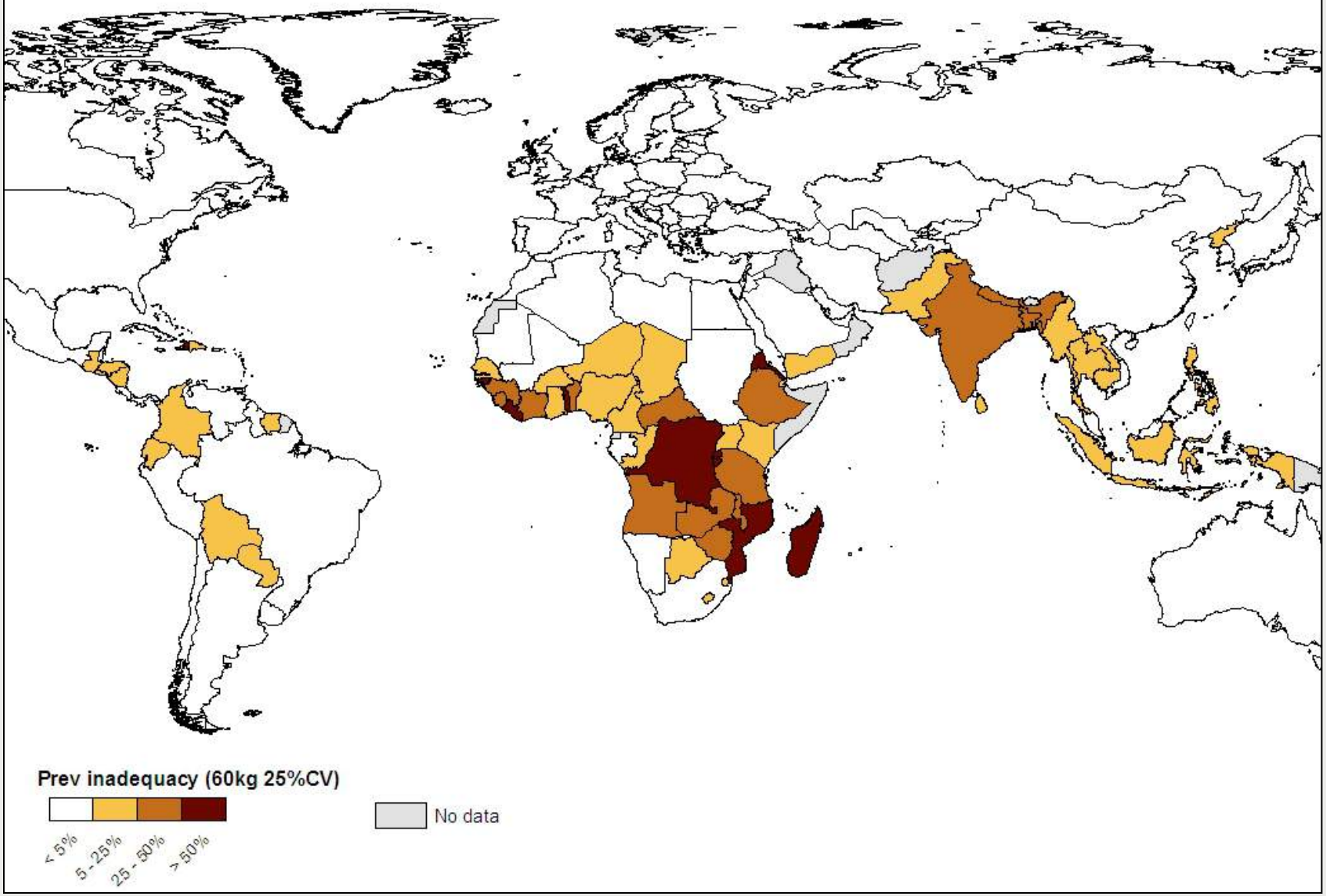
# Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with between 2000-2500 kcal/ capita/day



# Percent risk of protein inadequacy calculated from total and utilizable protein, and with increased requirements based on low energy availability and infection in countries with over 2500 kcal/capita/day



# Percent risk of protein inadequacy, by country in 2005



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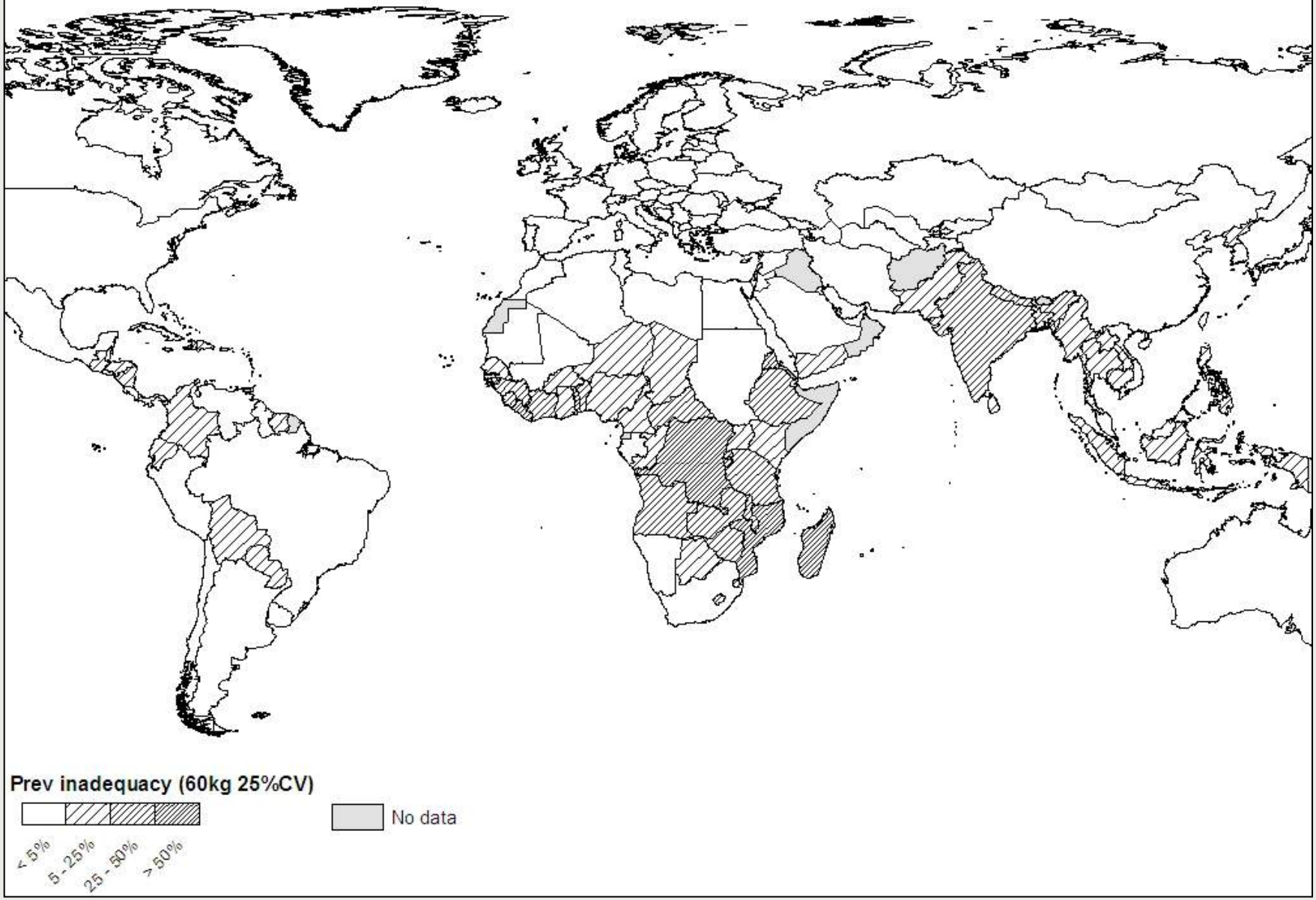
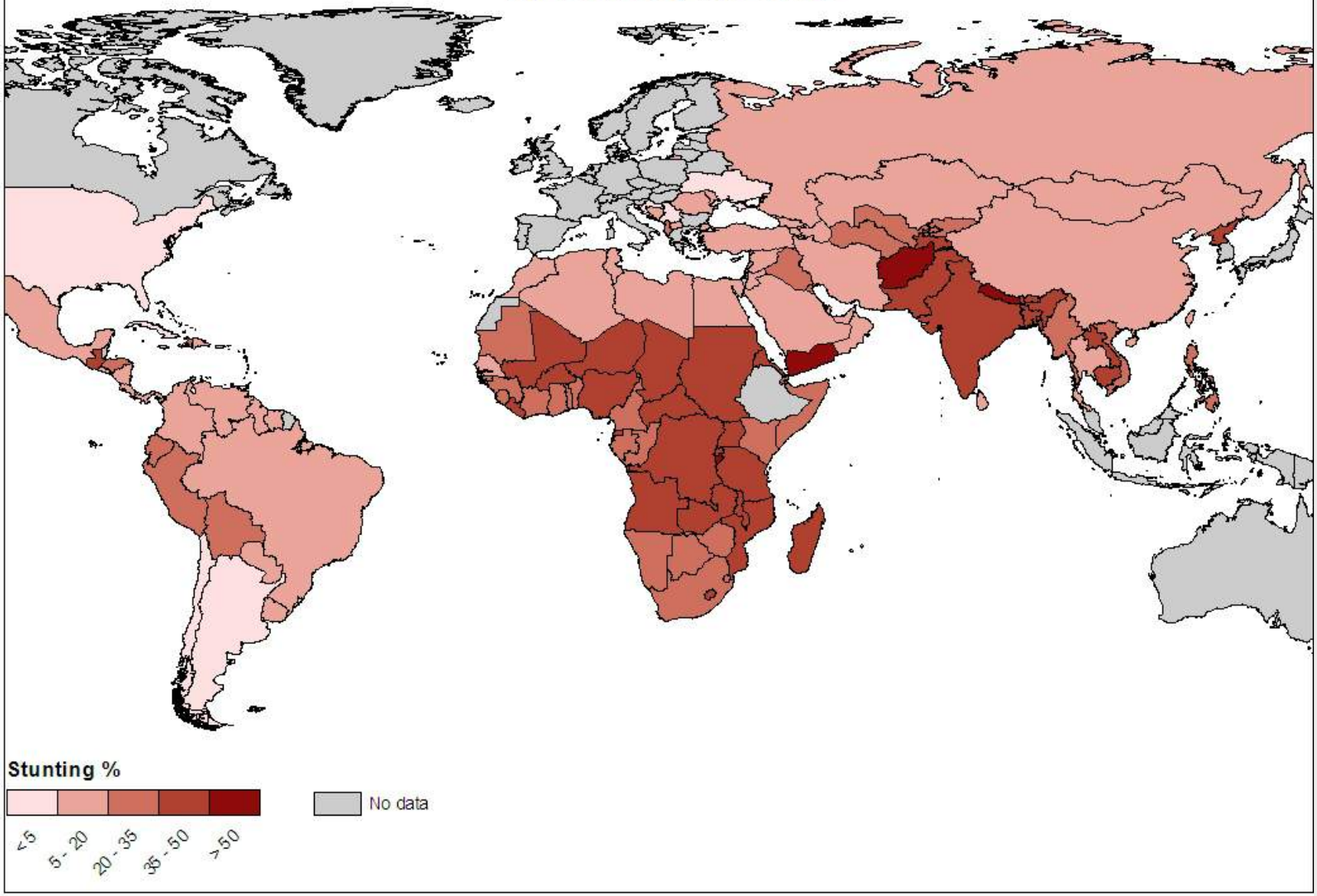
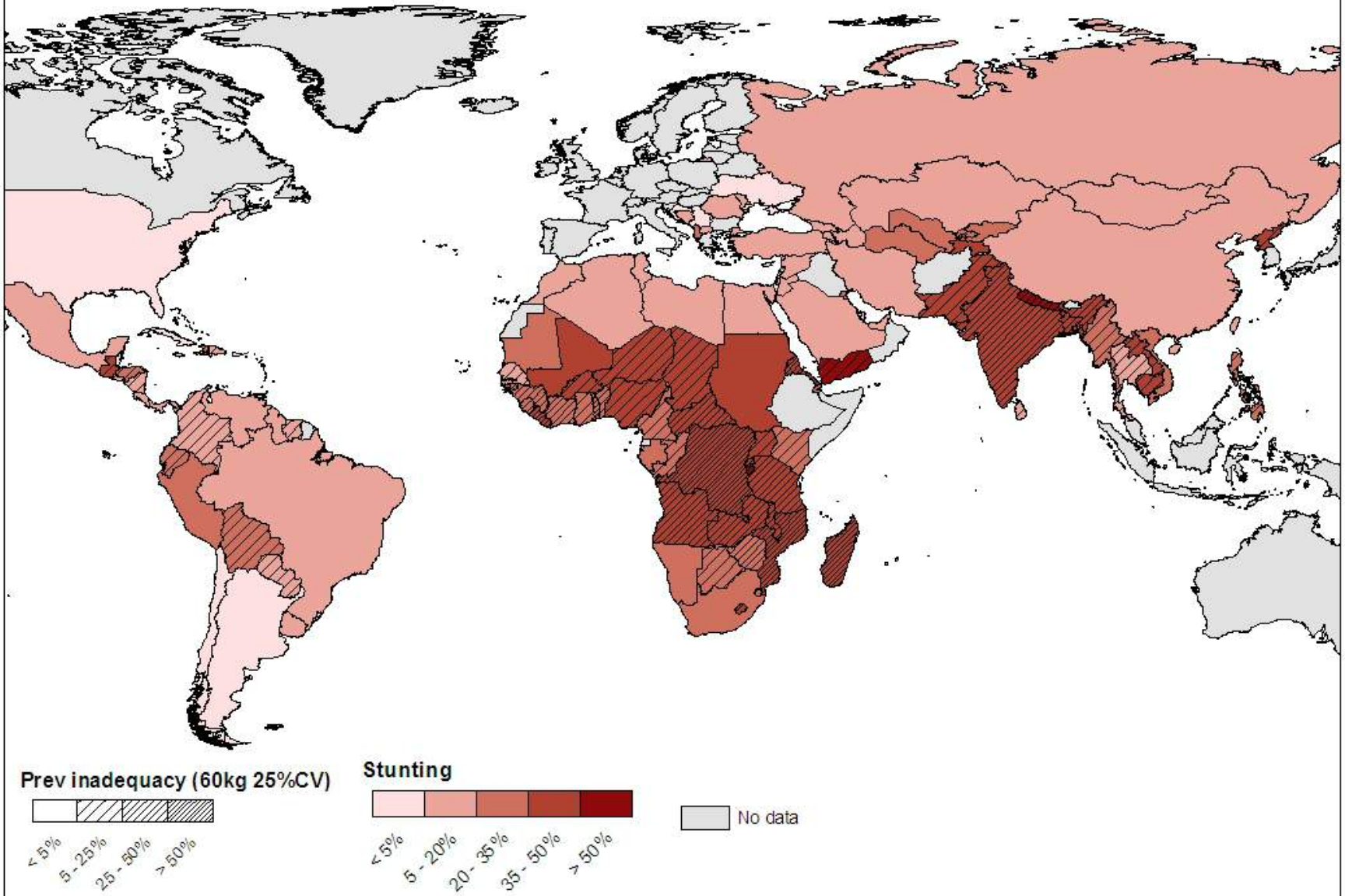


# Percent of children under 5 that are moderately and severely stunted by country in 2005



# Percent risk of protein inadequacy and percent of children under 5 who are stunted by country in 2005



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