Maternal, infant, and young child nutrition: a global perspective

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PICN 2012

Overview of presentation

- General concepts – what is “international nutrition”?
  - Characteristics of lower income countries – demography, disease patterns, food supply
  - Public health approach to nutritional problems

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  - Dietary energy supply
  - Childhood stunting and wasting
  - Micronutrient deficiencies
  - Overweight, obesity

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  - Micronutrient deficiencies
  - Overweight, obesity
- Intervention strategies to control undernutrition

World Bank classification of countries by per capita income

Level of income	2011 GNI per capita
Low income	$1,025
Lower middle income	$1,026 - $4,035
Upper middle income	$4,036 - $12,475
High income	$12,476

The demographic, health, food, and nutrition transitions from LIC to UIC

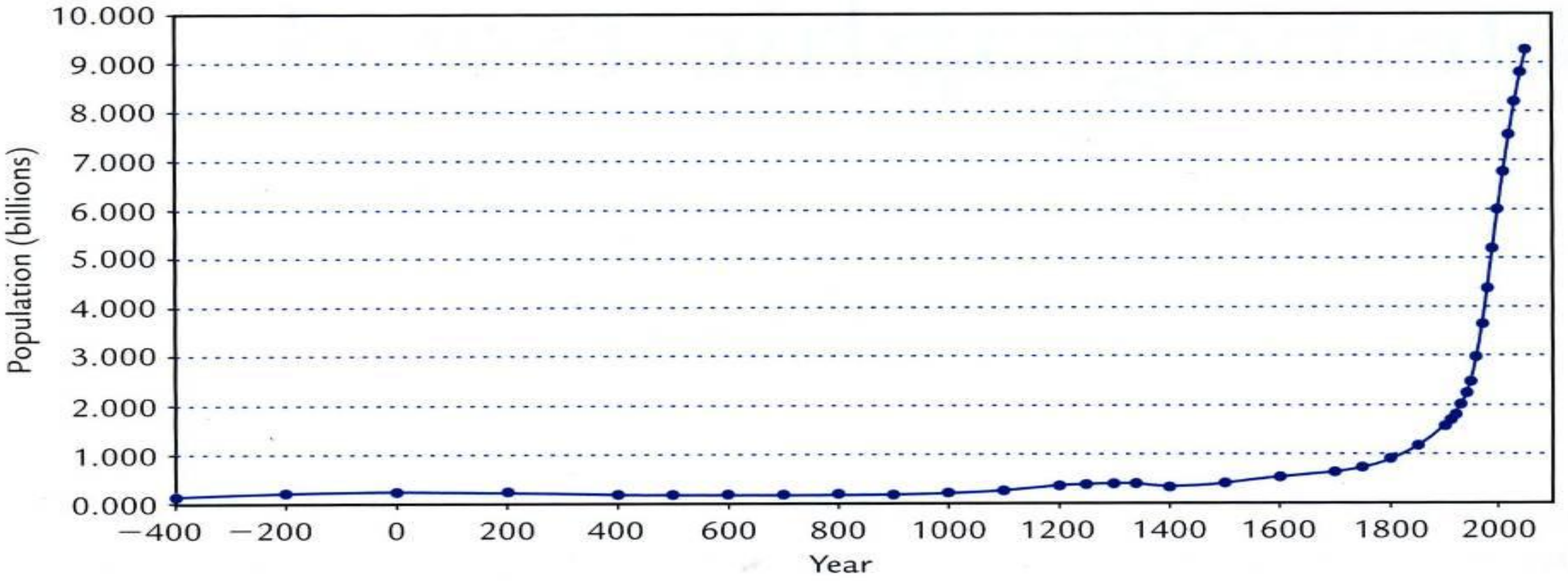
- Population growth rates
- Disease patterns
- Food supply and consumption patterns
- Nutritional status – under- and over-nutrition

~7,039,546,464*

*As of Sept 15, 2012

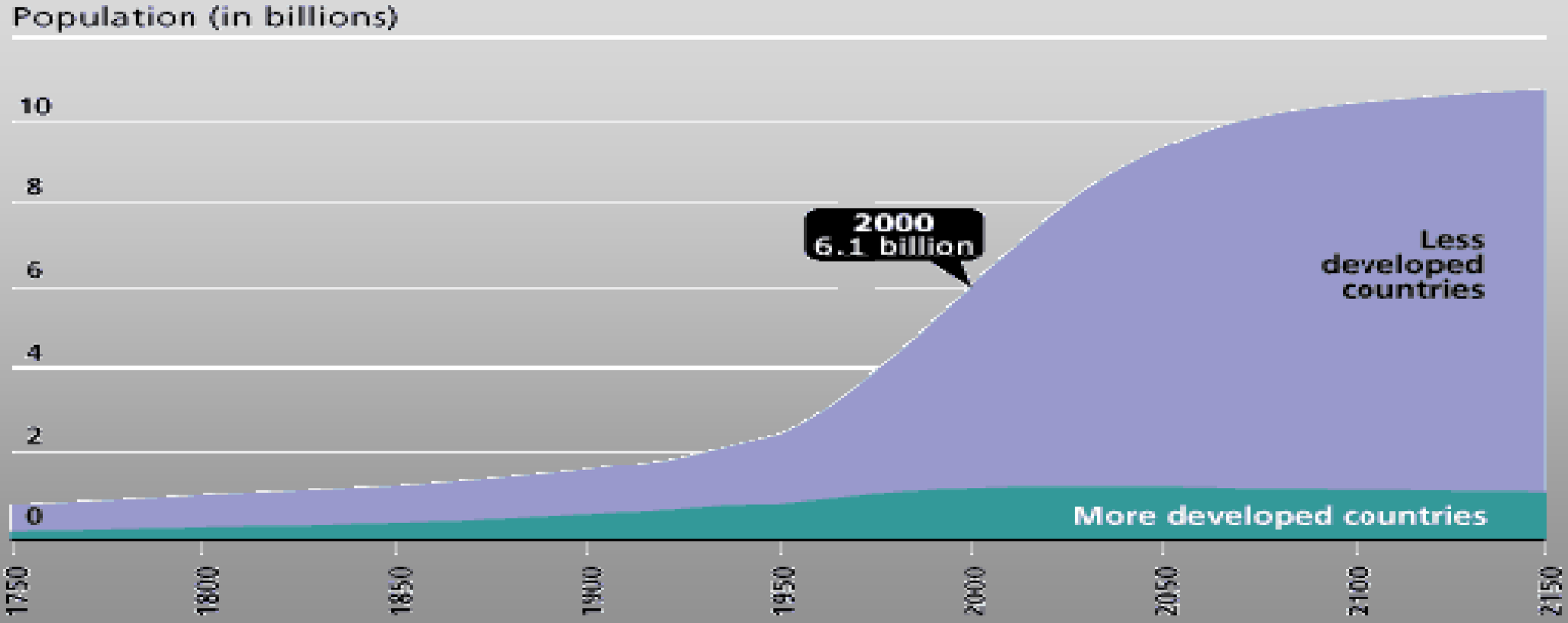
http://www.census.gov/main/www/popclock.html

Long-term population increase, 400 B.C. to 2000 A.D.



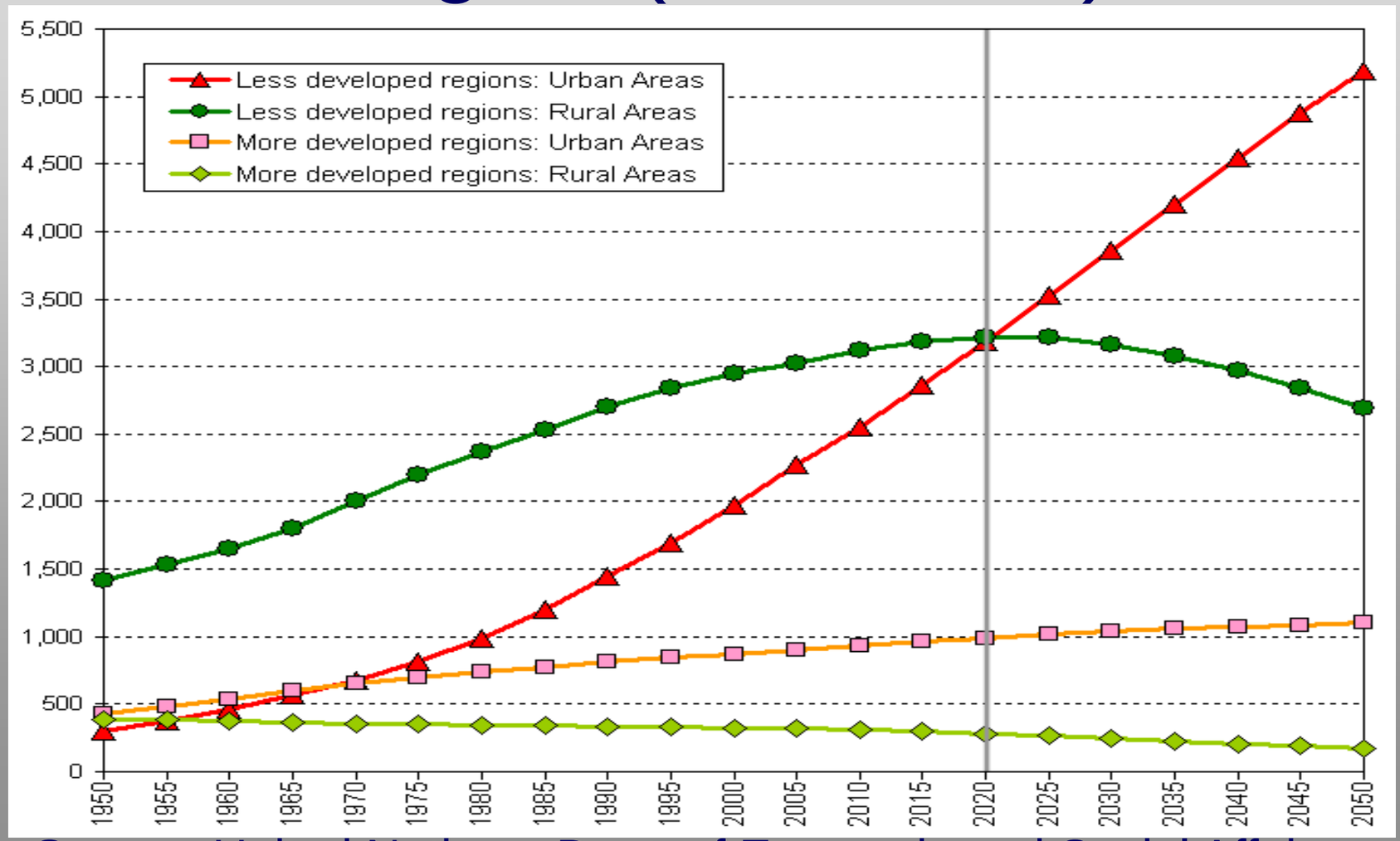
Source: Nutrition Transition, eds Caballero, B and Popkin, BM, pg 72, 2002

Expected population growth



Population Reference Bureau,
estimated from the United Nations World Population Prospects 1998 Revision

Urban and rural populations by development region (in millions)



Source: United Nations, Dept. of Economic and Social Affairs (http://esa.un.org/unpd/wup/Fig_3.htm ; accessed Dec 23, 2010)

The Millennium Development Goals Report

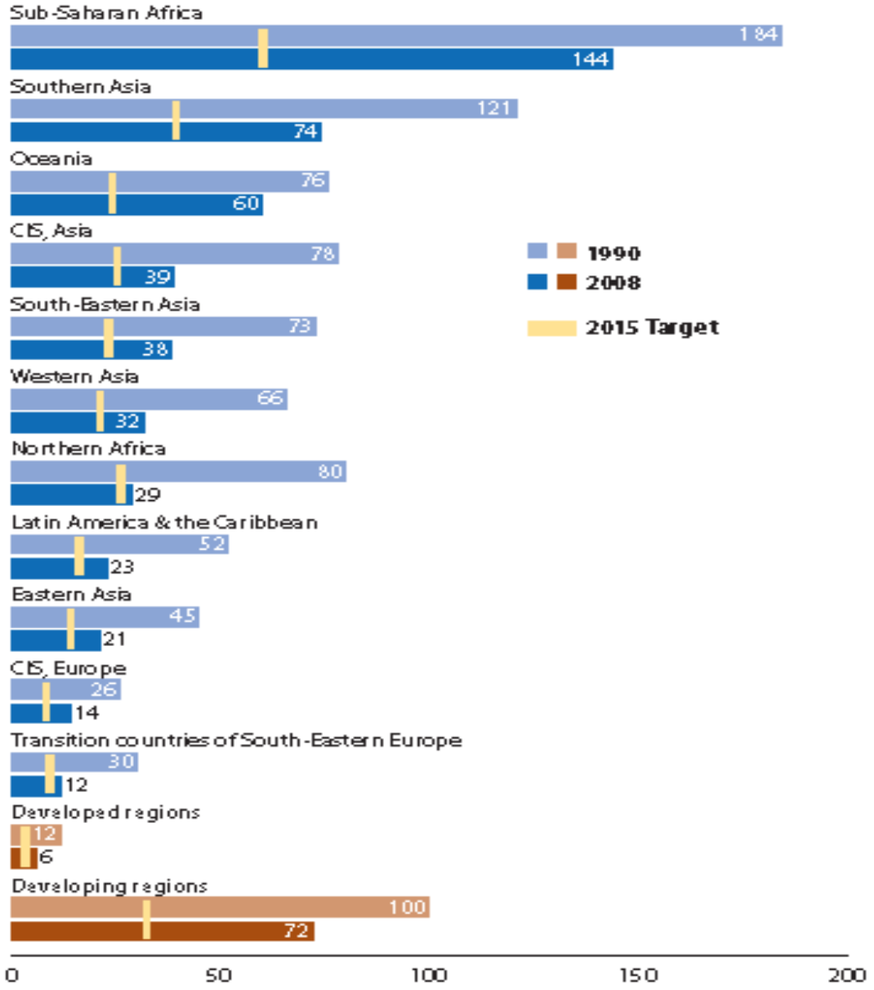
2010

UNITED NATIONS

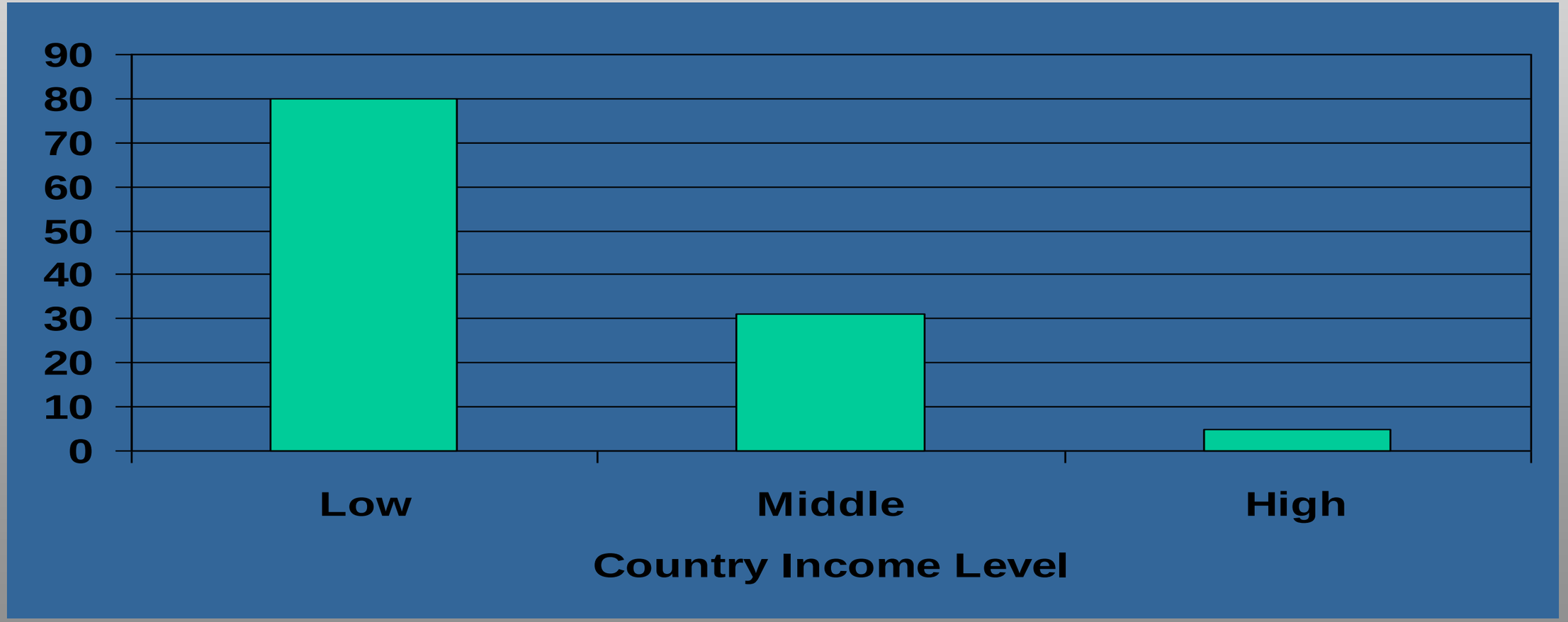
TARGET
Reduce by two thirds, between 1990 and 2015, the under-five mortality rate

Child deaths are falling, but not quickly enough to reach the target

Under-five mortality rate per 1,000 live births, 1990 and 2008

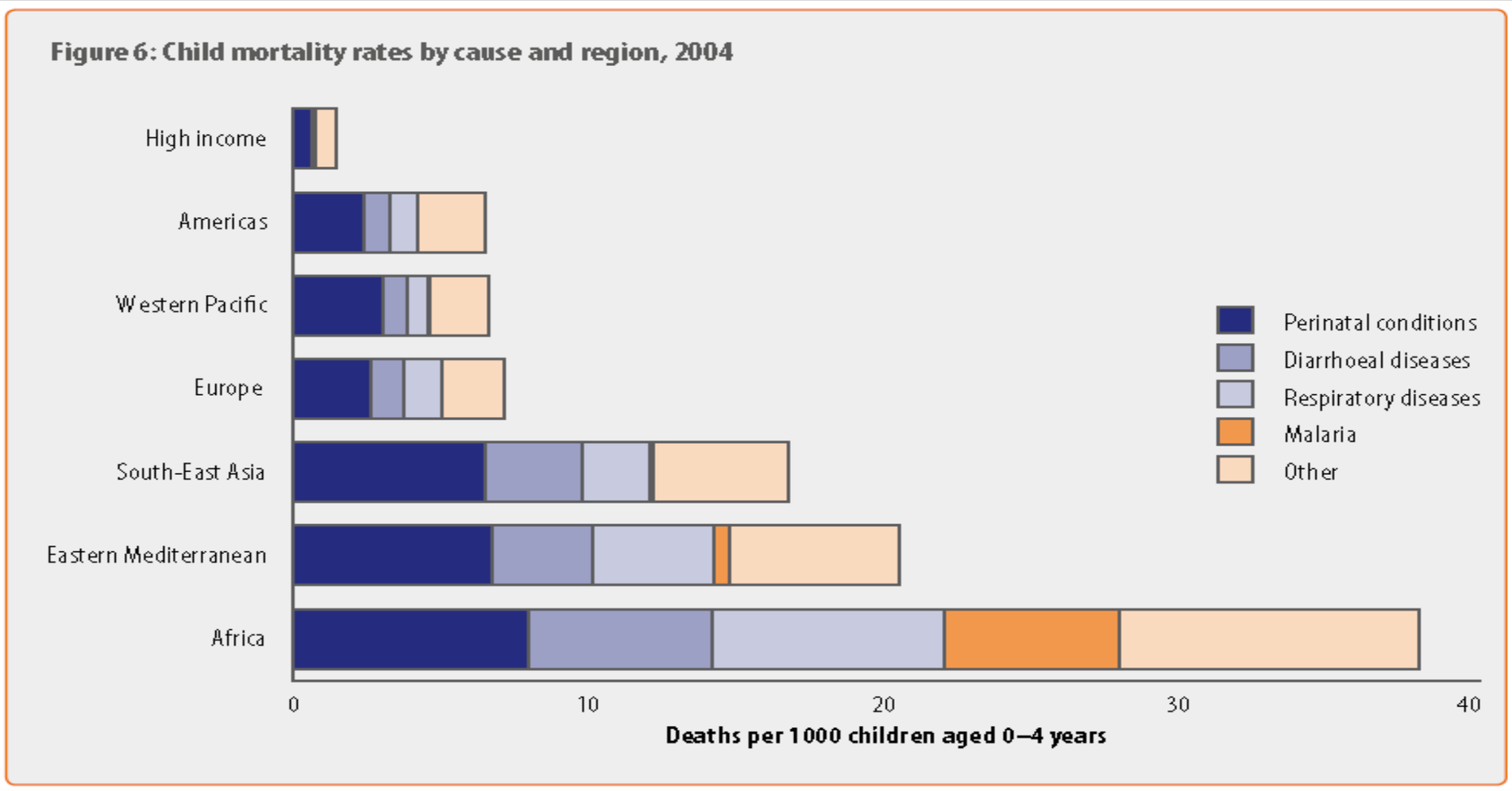


Infant mortality rate per 1,000 births



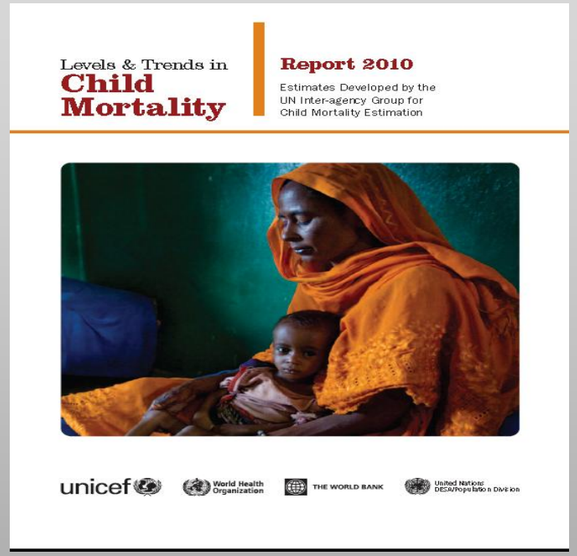
http://www.undp.org/hdr2003/indicator/indic_289.html

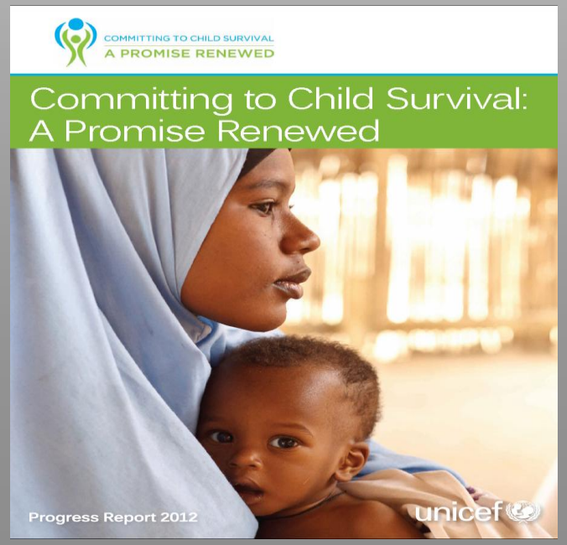
The global burden of disease: Under-5 mortality by region and cause of death

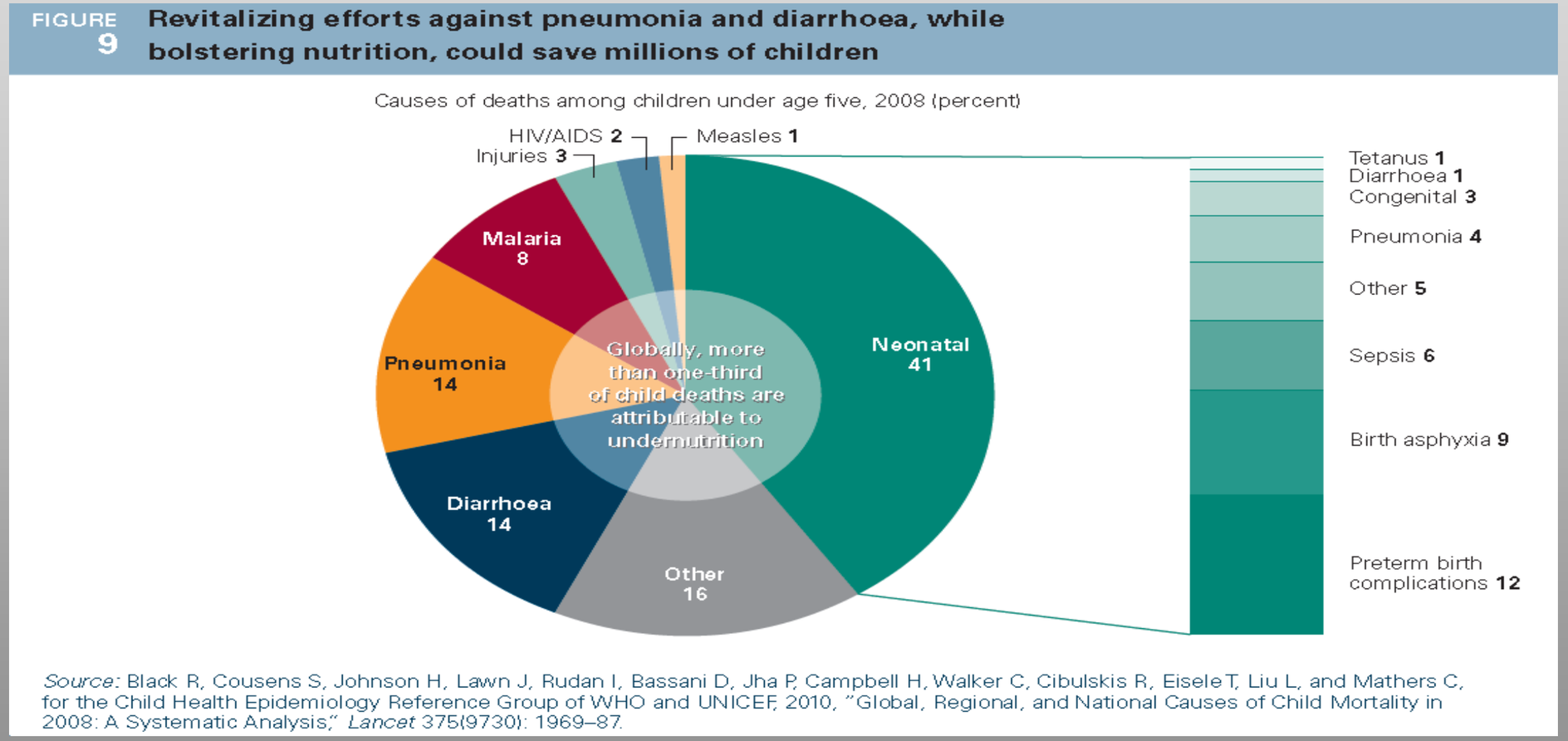


WHO Global Burden of Disease Project, 2008

Major causes of death among children under five worldwide, 2008

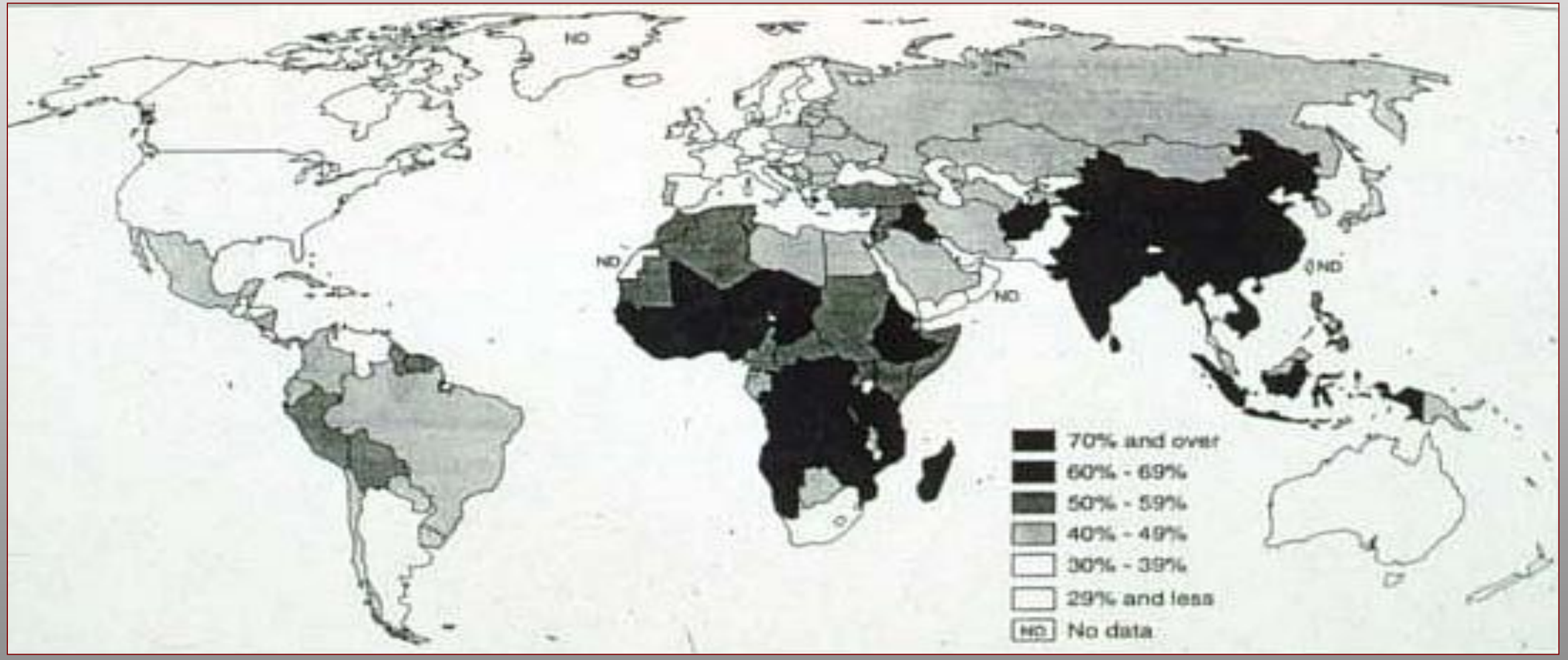






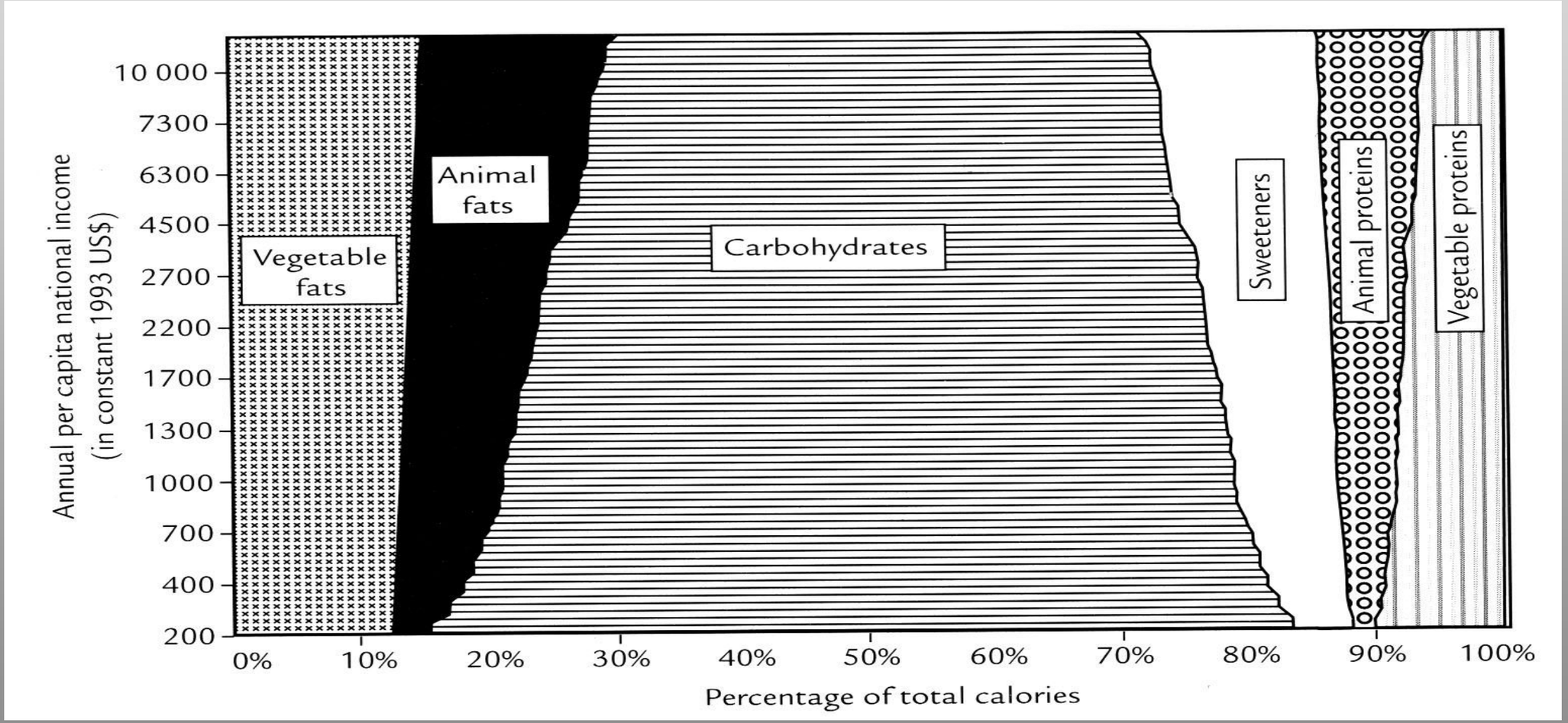
Source: UN Inter-Agency Group for Child Mortality Estimation. Levels and trends in child mortality, 2010.

Energy from the dominant starch staples, 1990-1992



Source: Reproduced with permission from the Geographical Association (20)

Relationship between GNP per capita and the proportion of energy from each food source, 1990



Source: FAO Food Balance Sheets.

Demographic transition

Trad

- High fertility
- High IMR
- Young, rural population

Mod

- Low fertility
- Low IMR
- Aging, urban population

Trends in worldwide population and health

Demographic transition	→	Health transition

Trad

- High fertility
- High IMR
- Young, rural population

Infectious diseases

Mod

- Low fertility
- Low IMR
- Aging, urban population

Non-communic.diseases (CVD, cancer)

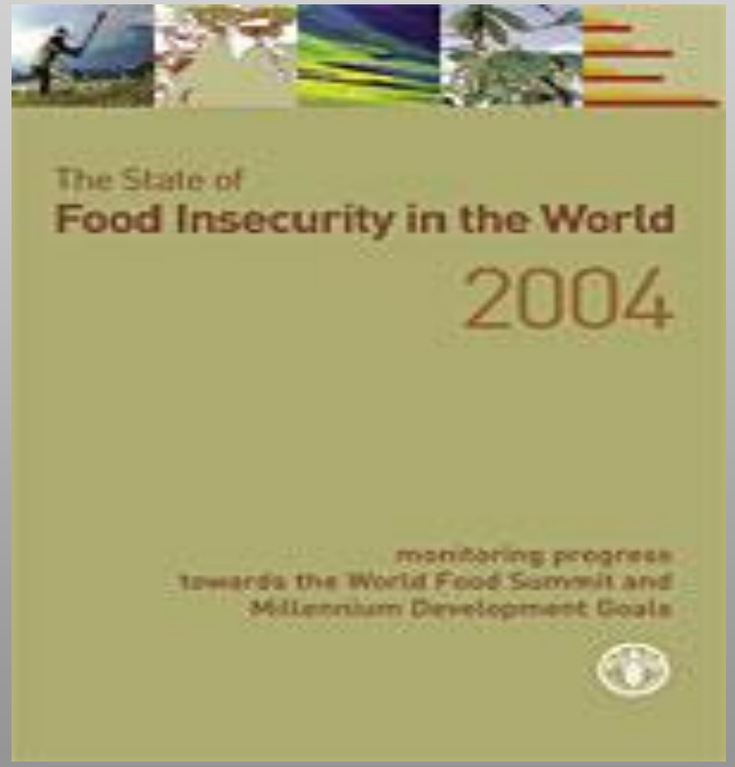
Trends in worldwide population and health

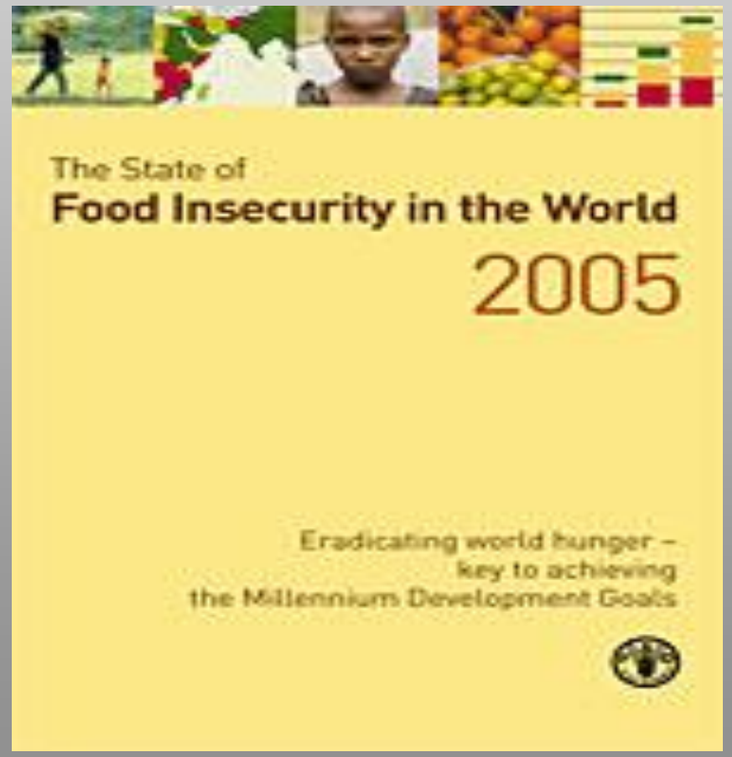
Demographic transition	Health transition	Dietary transition
Trad		
High fertility High IMR Young, rural population	Infectious diseases	Starchy staples Low fat Few ASFs
Mod		
Low fertility Low IMR Aging, urban population	Non-communic.diseases (CVD, cancer)	Refined cereals, sugars High fat ASFs

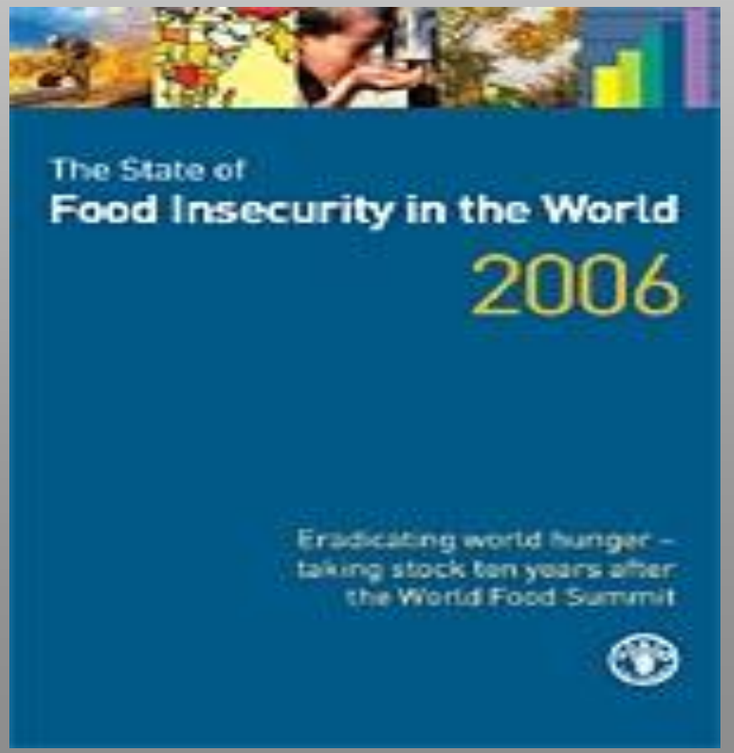
Trends in worldwide population and health

	Demographic transition	Health transition	Dietary transition	Nutrition transition
Trad	High fertility High IMR Young, rural population	Infectious diseases	Starchy staples Low fat Few ASFs	Under-nutrition/ famine Physical labor
Mod	Low fertility Low IMR Aging, urban population	Non-communic.diseases (CVD, cancer)	Refined cereals, sugars High fat ASFs	Over-nutrition Sedentary labor (TV) Obesity

FAO annual publication on global food security

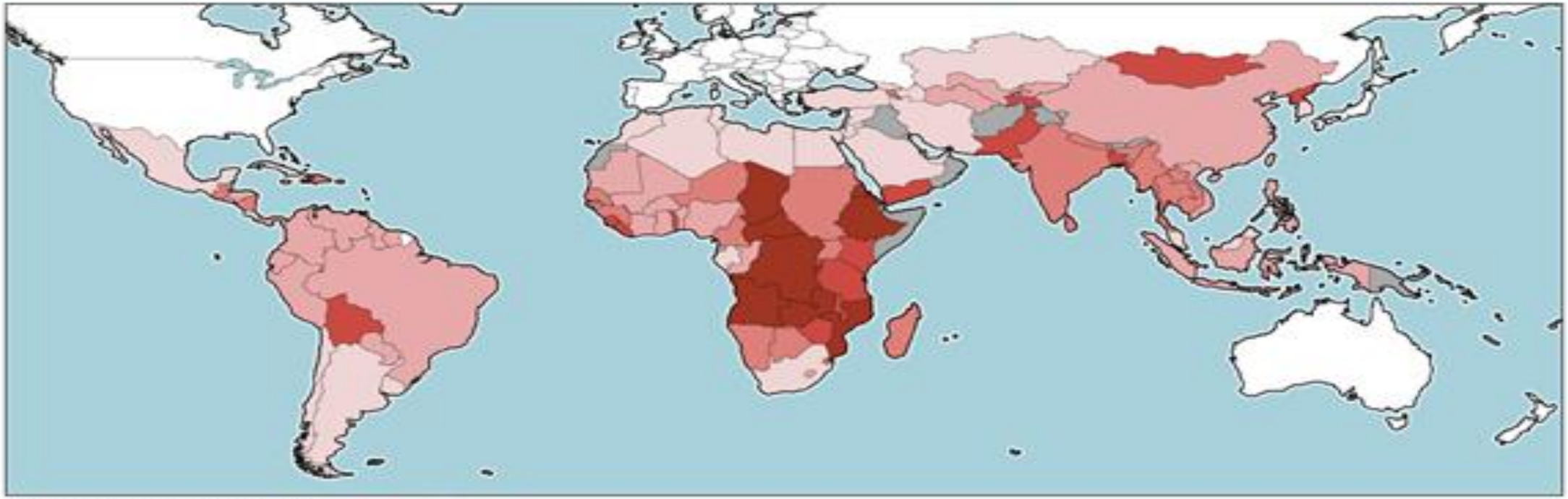






FAO Hunger Map 2010

Prevalence of undernourishment in developing countries



Source: FAOSTAT 2010 (www.fao.org/hunger)

Note: The map shows the prevalence of undernourishment in the total population of developing countries as of 2005-7 – the most recent period for which complete data are available. Undernourishment exists when caloric intake is below the minimum dietary energy requirement (MDER). The MDER is the amount of energy needed for light activity and a minimum acceptable weight for attained height, and it varies by country and from year to year depending on the gender and age structure of the population.

The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

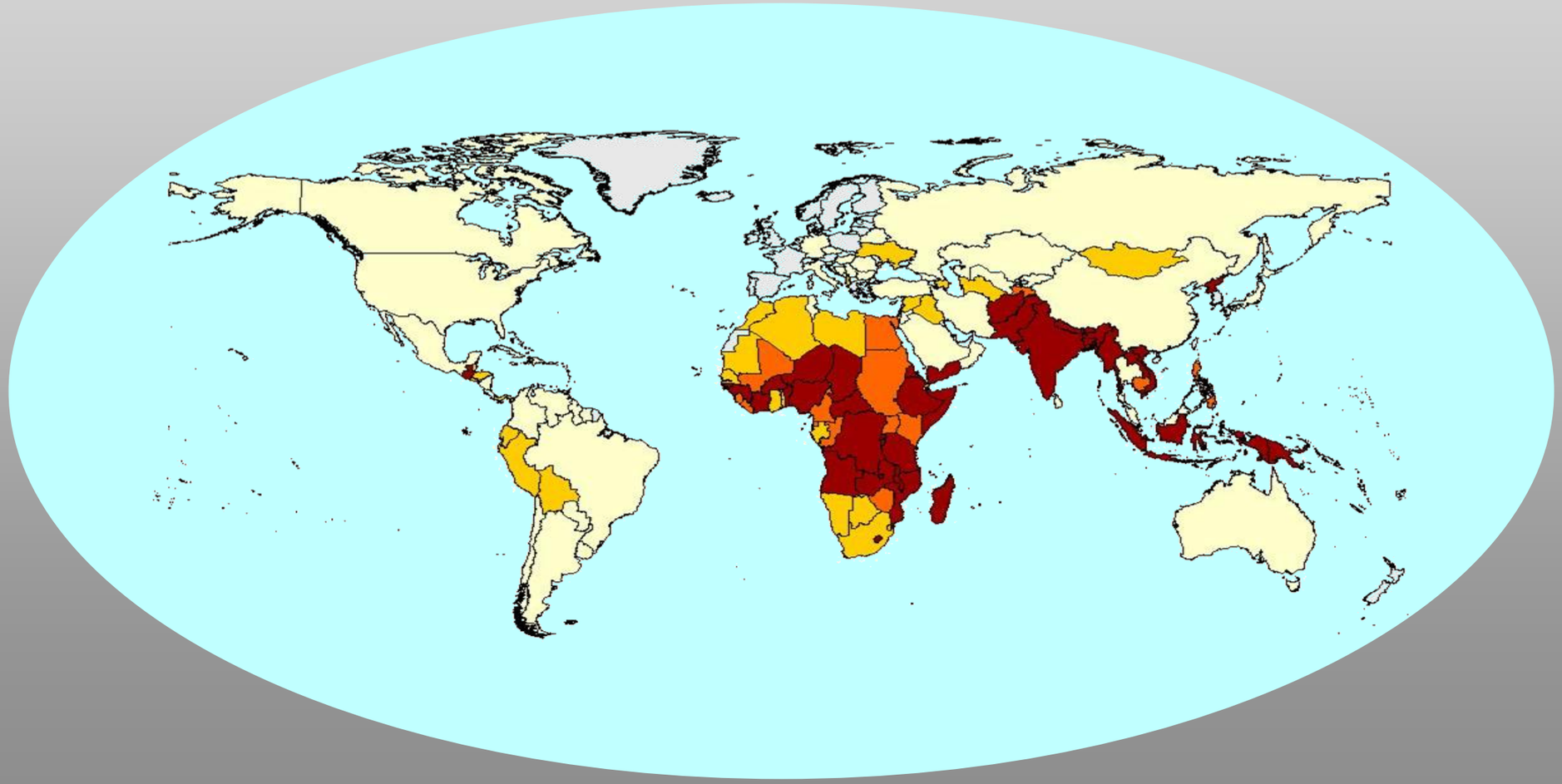
Prevalence of undernourishment in developing countries (2005-07)

- Very high (undernourishment 35% and above)
- High (undernourishment 25-34%)
- Moderately high (undernourishment 15-24%)
- Moderately low (undernourishment 5-14%)
- Very low (undernourishment below 5%)
- Missing or insufficient data

*Defined as % of population for whom food availability is less than amount needed to satisfy energy requirements

From: http://www.fao.org/economic/ess/food-security-statistics/fao-hunger-map/en/

Prevalence of nutritional stunting (HAZ <-2 SD) among pre-school children (Dec 2010)



< 20 %

20-30 %

30-40%

≥ 40 %

Data derived from WHO or most recent Demographic Health Surveys

Trends in young child height-for-age and weight-for-age, by region

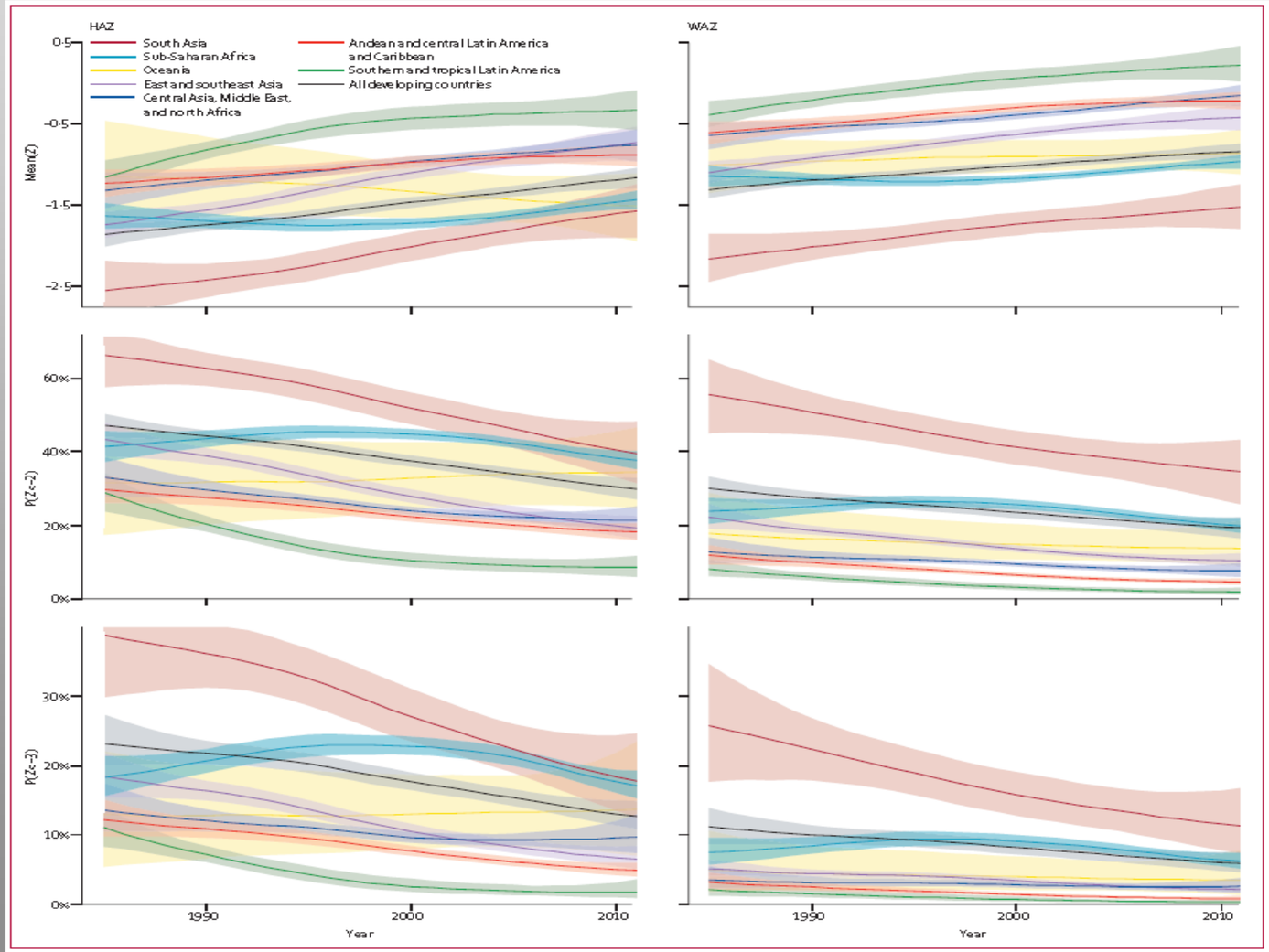
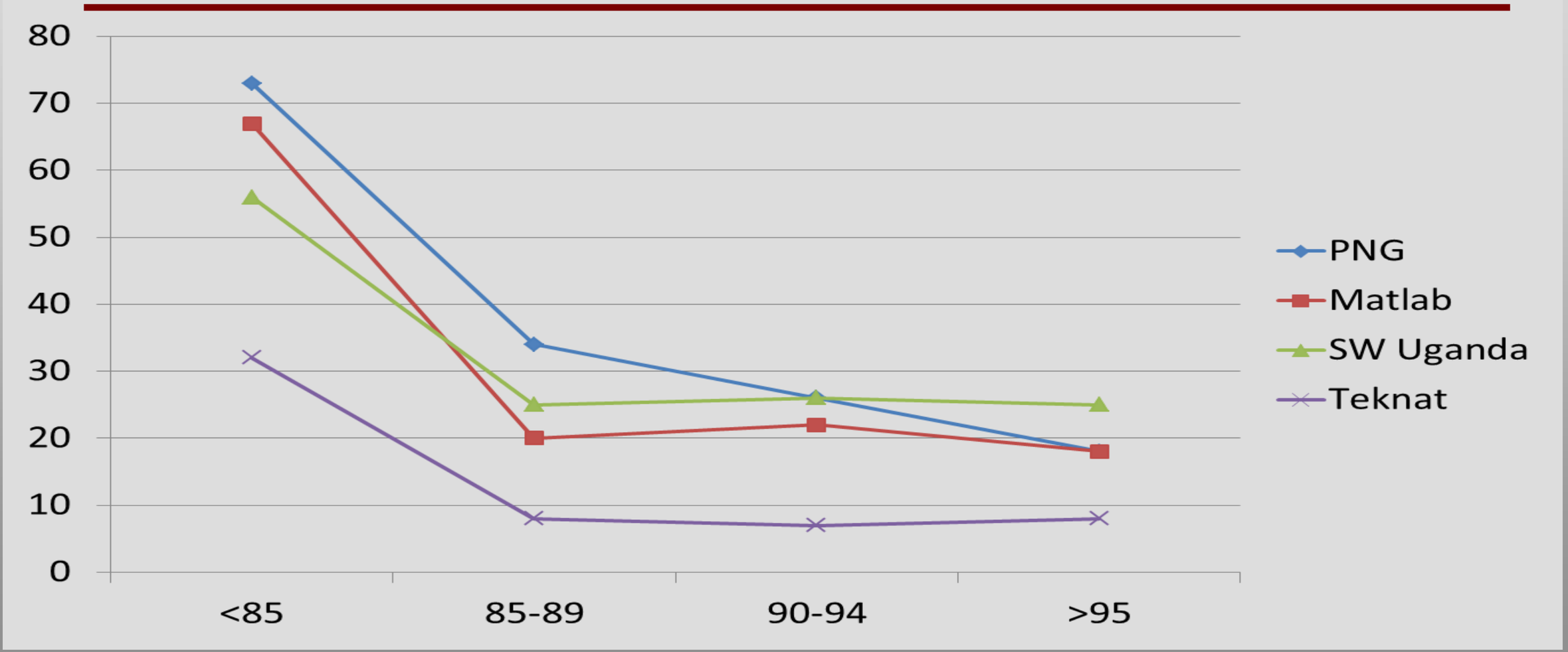


Figure 3: Trends in HAZ and WAZ means and prevalences by region between 1985 and 2011
Shaded regions show the uncertainty interval. We present the trends by country in the appendix (pp 90–231). Prevalence of children with Z scores below –2 includes all children below this cutoff, including those with Z scores below –3. HAZ=height-for-age Z score. WAZ=weight-for-age Z score.

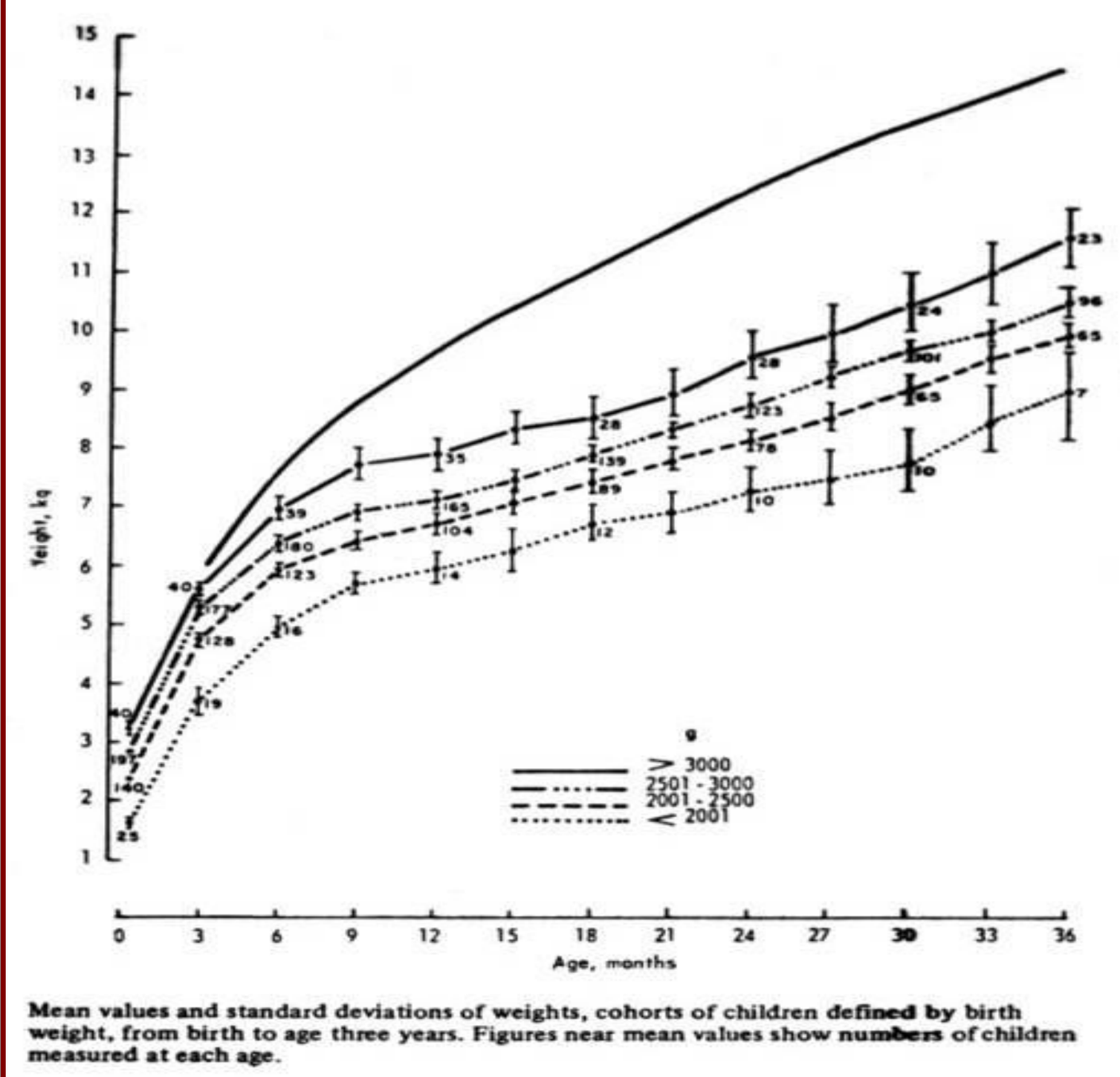
Stevens GA et al (NIMS). Lancet, 2012.

Relationship between height-for-age and child mortality



Results are percentages of international median, as estimated from graph.
Data from Pelletier DL, J Nutr 1994

Mean weight-for-age, by age and birth weight



Mean values and standard deviations of weights, cohorts of children defined by birth weight, from birth to age three years. Figures near mean values show numbers of children measured at each age.

Mata LJ. The Children of Santa Maria Cauque. MIT Press, 1978.

Risk of LBW by maternal pre-pregnancy BMI

Study or subgroup	log(RIsk ratIo)	SE	Weight (%)	Risk ratio (95% CI) IV, Random
Barton *et al.*[46]	0.05	0.17	12.5	1.05 (0.75–1.47)
Bhattacharya *et al.*[48]	0.48	0.12	16.5	1.62 (1.28–2.04)
Frederick *et al.*[29]	0.43	0.2	10.5	1.54 (1.04–2.28)
Hoa 1996	0.97	0.25	7.9	2.64 (1.62–4.31)
Lumme *et al.*[59]	0.39	0.16	13.2	1.48 (1.08–2.02)
Rasmussen and Borup[33]	1.39	1.11	0.6	4.01 (0.46–35.36)
Ronnenberg *et al.*[63]	0.43	0.2	10.5	1.54 (1.04–2.28)
Tsukamoto *et al.*[24]	0.5	0.18	11.8	1.65 (1.16–2.35)
Wolfe 1991	0.74	0.12	16.5	2.10 (1.66–2.65)
Total (95% CI)			**100.0**	**1.64 (1.38–1.94)**

Heterogeneity: $\tau^2 = 0.03$; $\chi^2 = 15.93$, df = 8 ($P = 0.04$); $I^2 = 50\%$

Test for overall effect: $Z = 5.75$ ($P < 0.00001$)

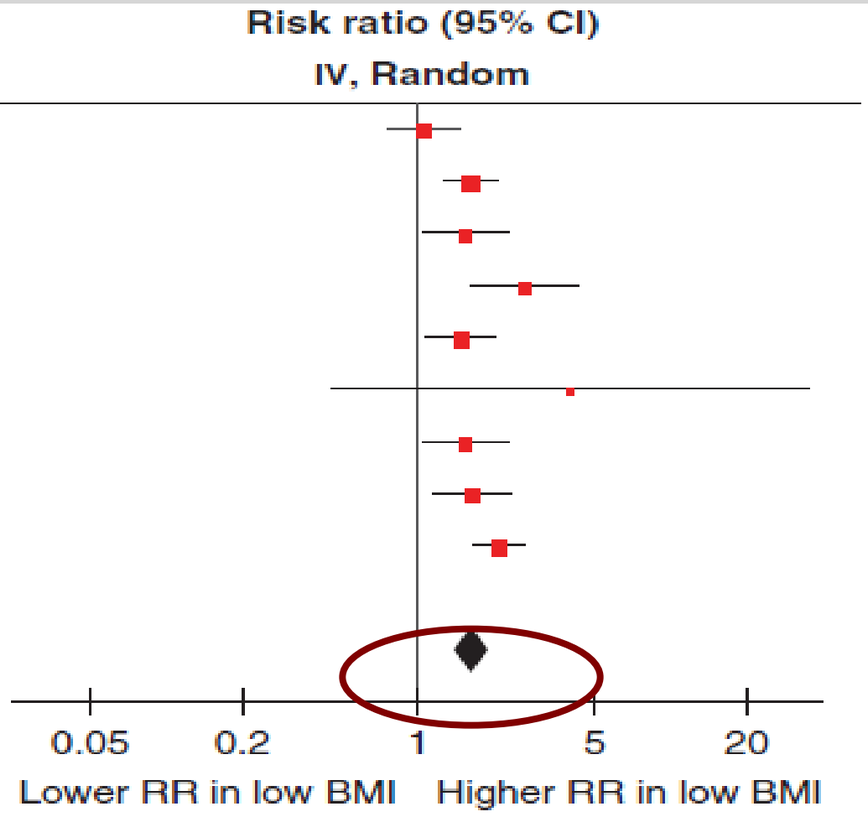
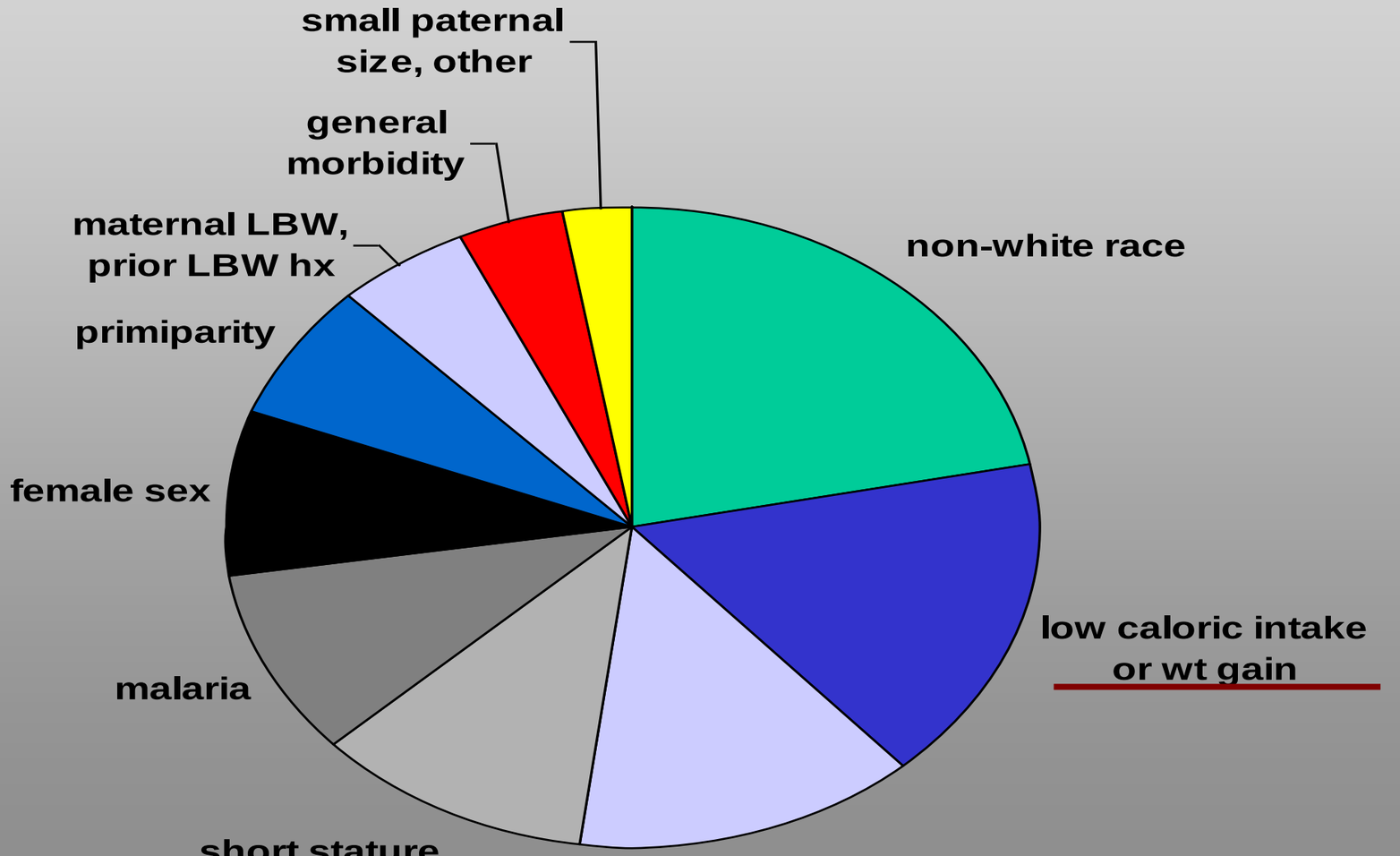


Figure 5 Fores… weight women compared with norma… weight in adju… 37 weeks' gestation. Sizes of data markers indicat… the weights of … ndom effects model was used for statistical poolin…

Evidence for the inter-generational cycle of malnutrition

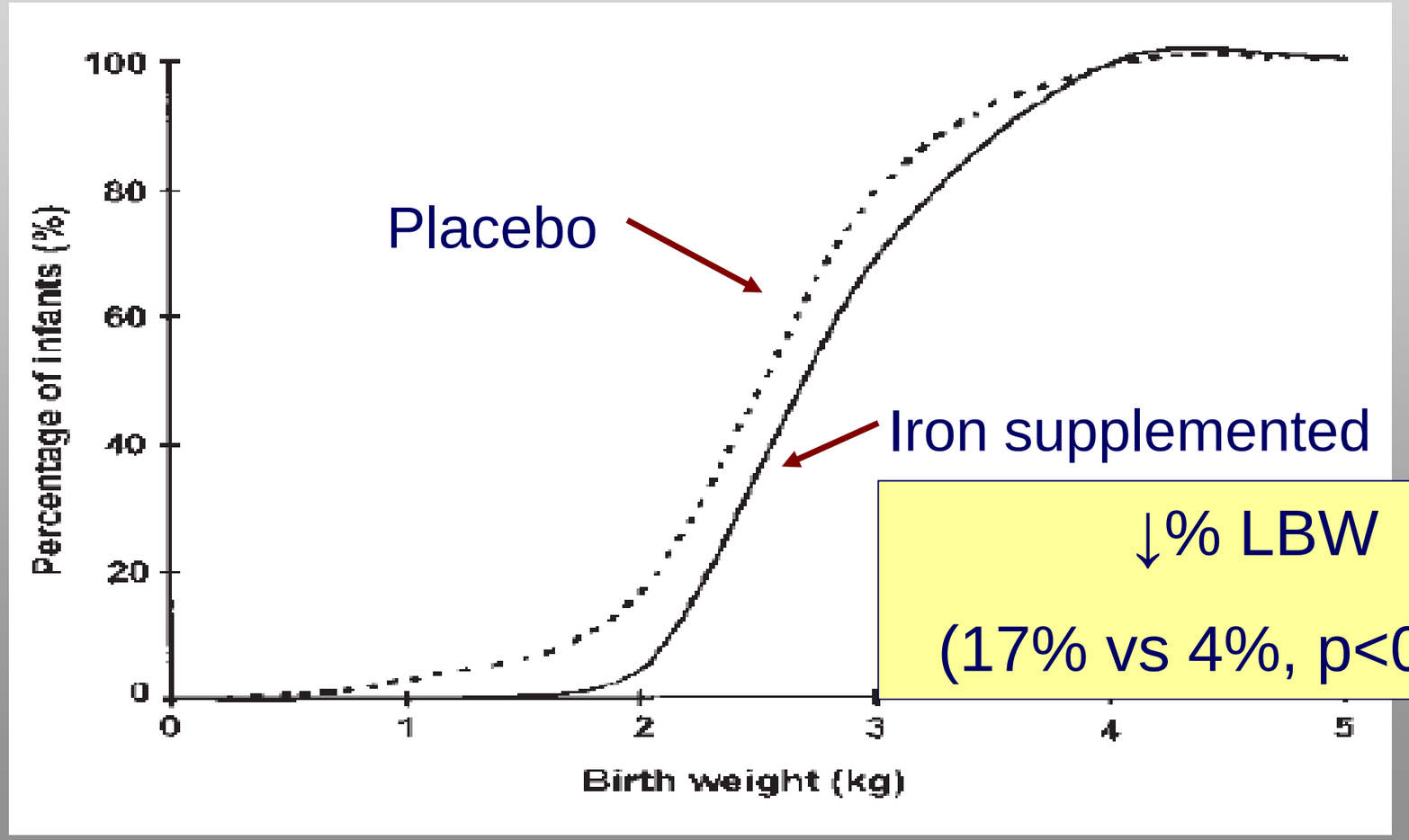
Relative importance of established factors with direct causal impacts on intrauterine growth restriction (IUGR) in rural developing countries



~45% of attributable risk due to maternal undernutrition

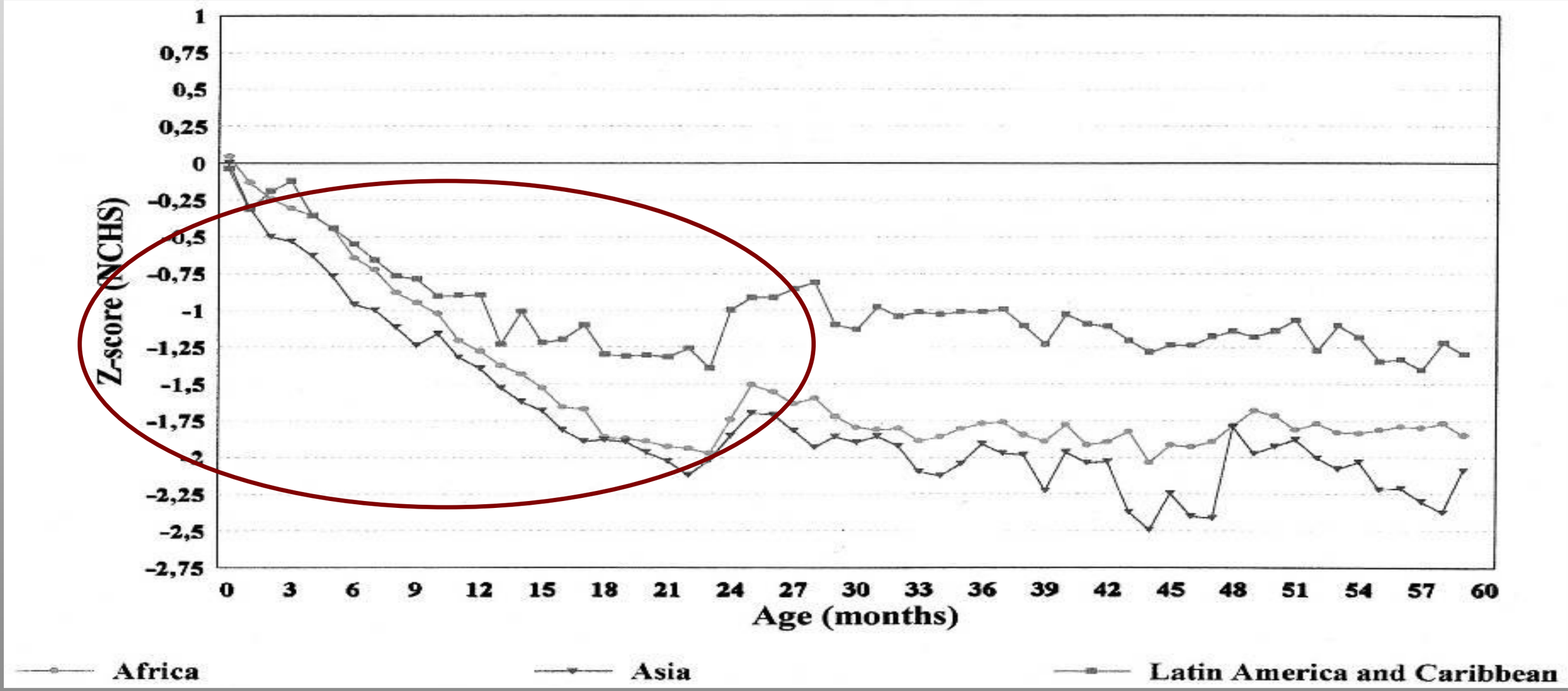
Source: Kramer, 1987

Effect of maternal iron supplementation during pregnancy on infant birth weight*



* Data from: Cogswell ME et al. Am J Clin Nutr, 2003. Study of iron-replete US women

Mean length-for-age Z-scores, by age and region



Data from: Shrimpton et al. Pediatrics 107: e75; 2001

Relationships between nutrition and infection

Decreased dietary intake

Malabsorption

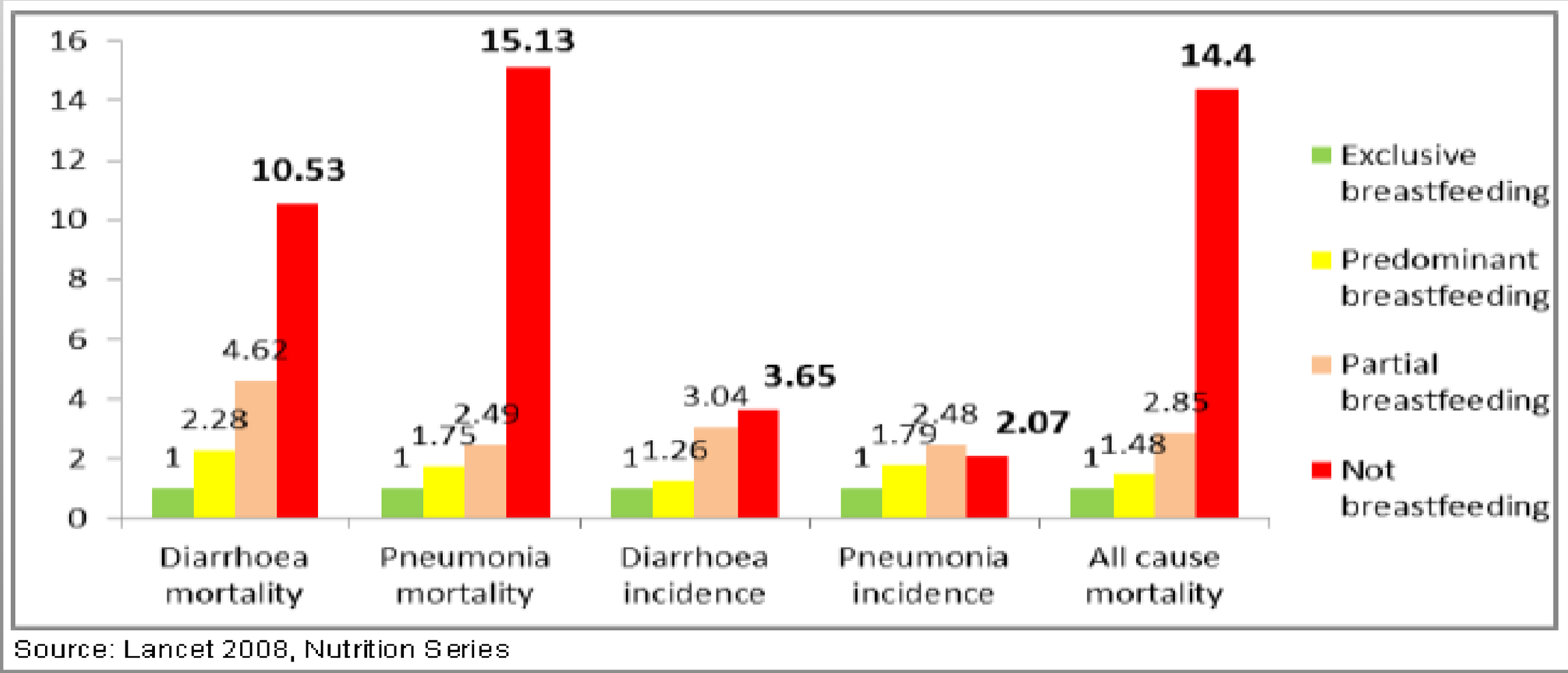
Increased catabolism

Nutrient sequestration

Impaired immune function

Decreased barrier protection

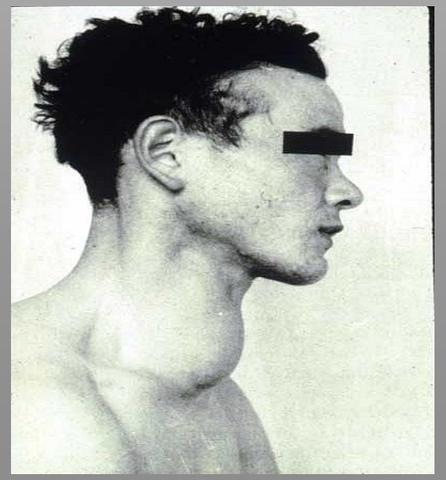
Relationship between breast feeding intensity and risk of morbidity and mortality, infants <6 mo



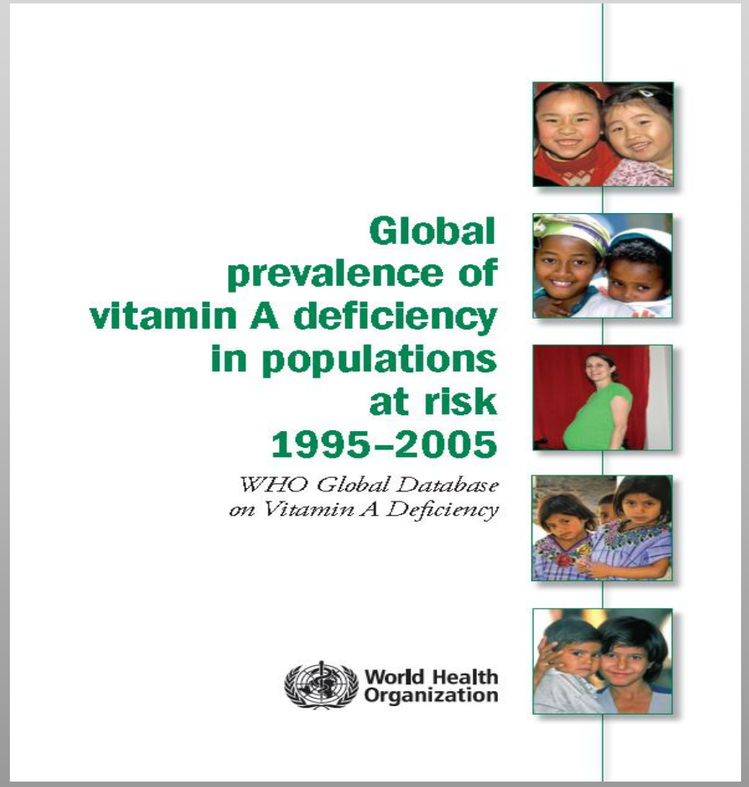
Source: Lancet 2008, Nutrition Series

Major MN deficiencies of public health importance in lower income countries

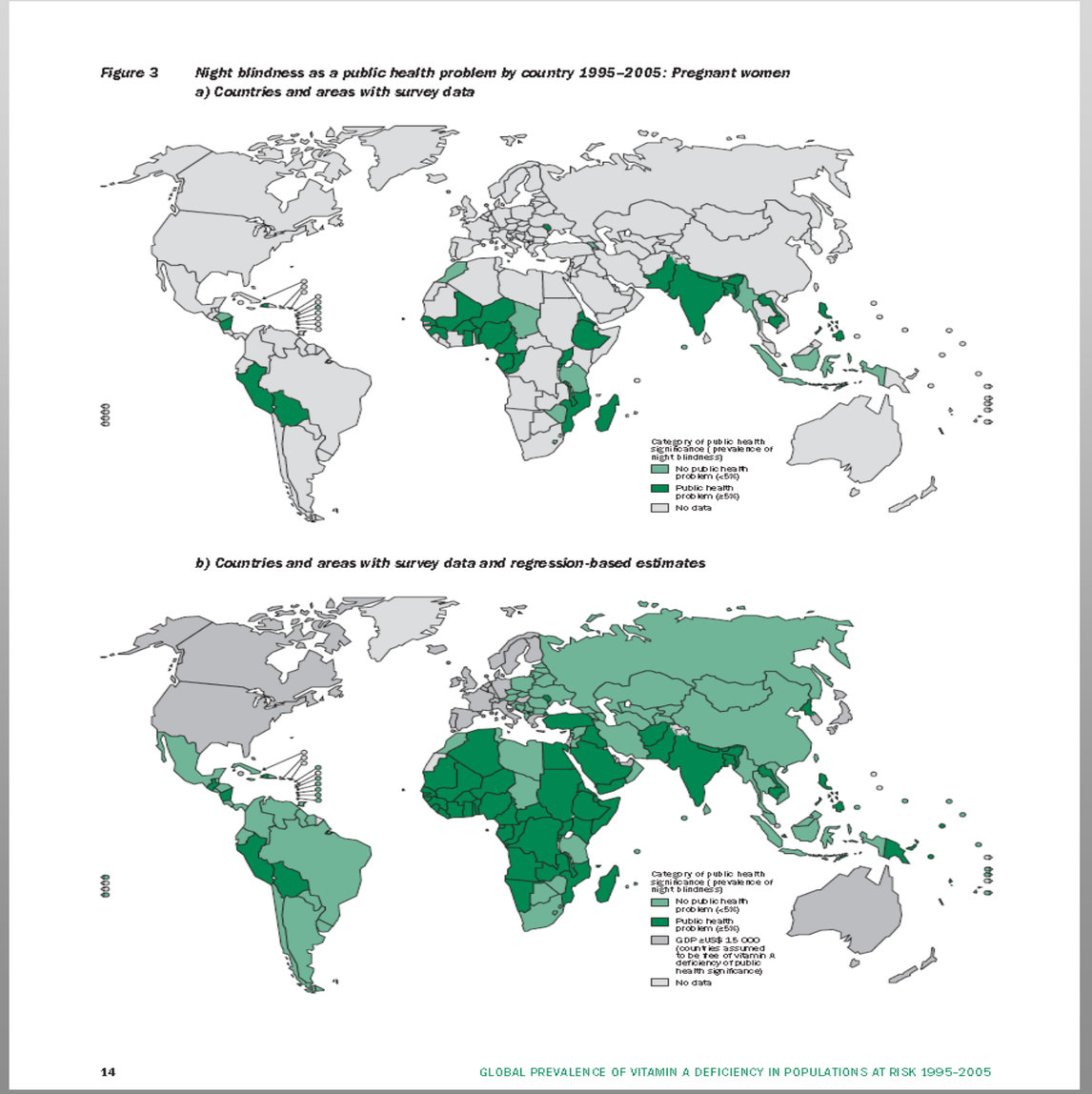
- Vitamin A
- Zinc
- Iron
- Iodine
- Others?



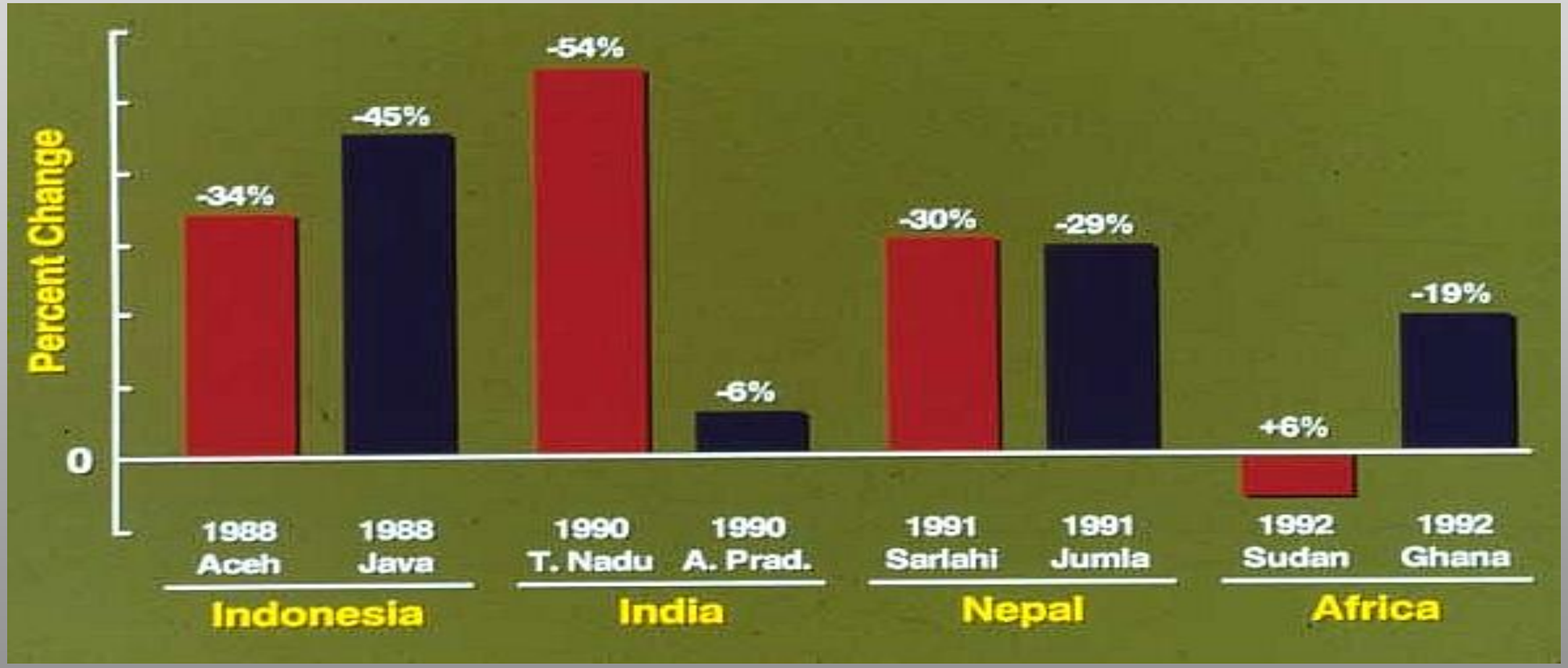
Global prevalence of vitamin A deficiency



Available at: http://www.who.int/nutrition/publications/micronutrients/vitamin_a_deficiency/9789241598019/en/index.html

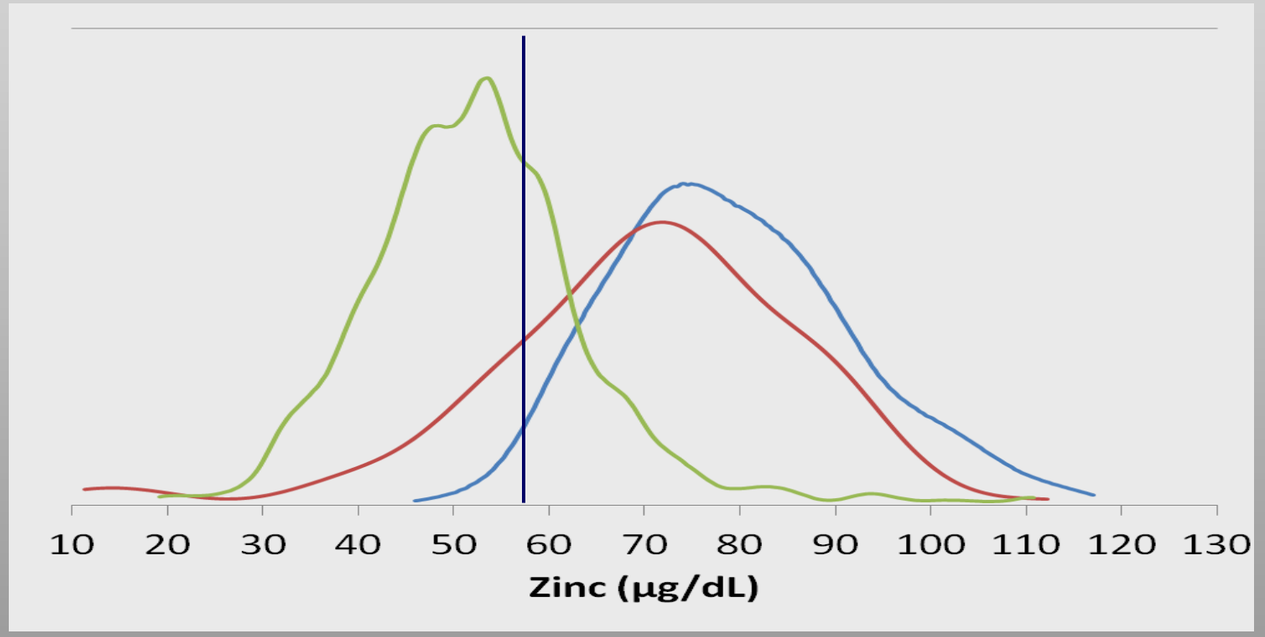


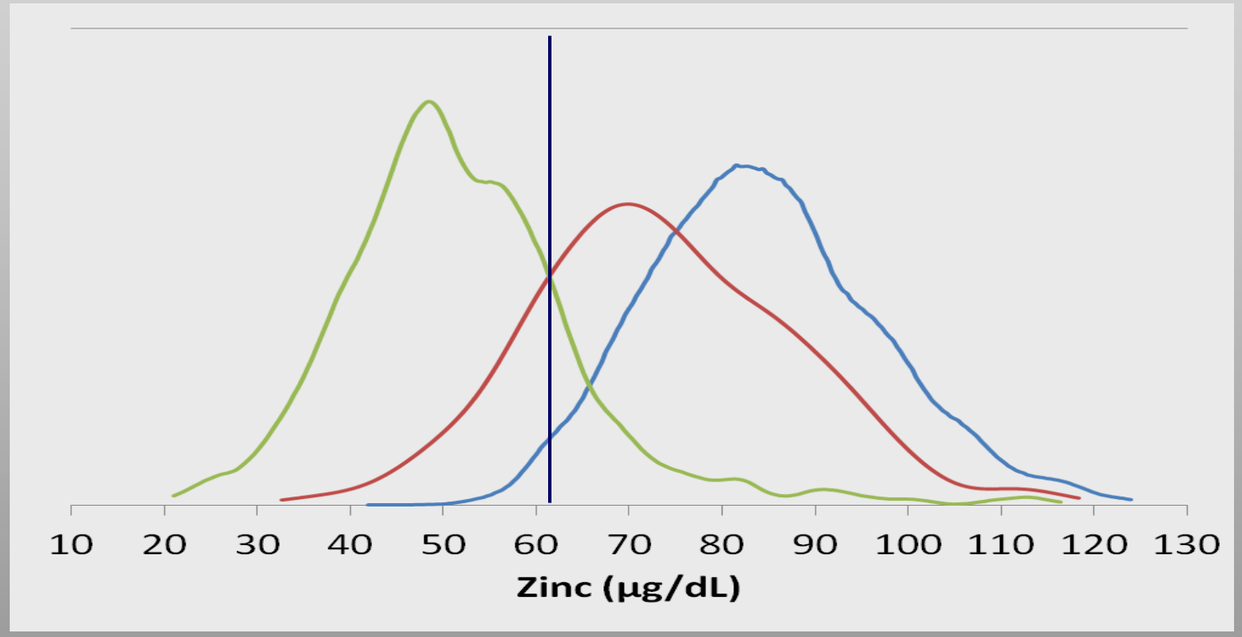
Vitamin A supplementation and child mortality



23% reduction in all-cause mortality;
RR 0.77 (CI 0.71-0.94)

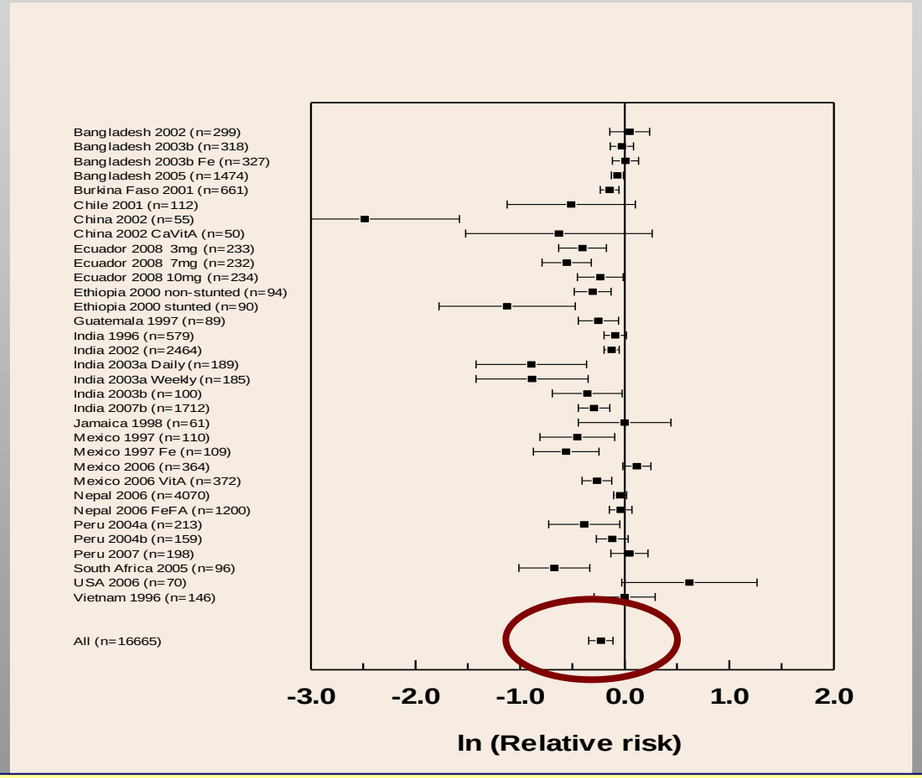
Distribution of plasma zinc concentration: children <5 and women 15-49 yr, 3 countries

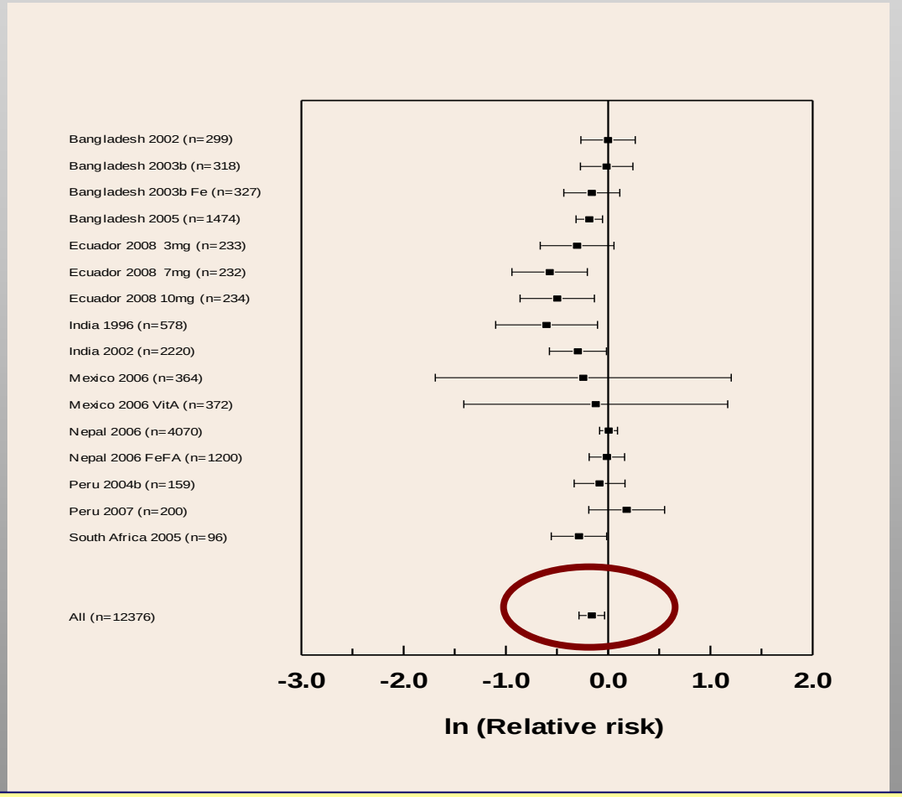




NHANES 1976-80
Mexico 1999
Cameroon 2010

Effect of preventive zinc supplementation on the incidence of diarrhea and ALRI



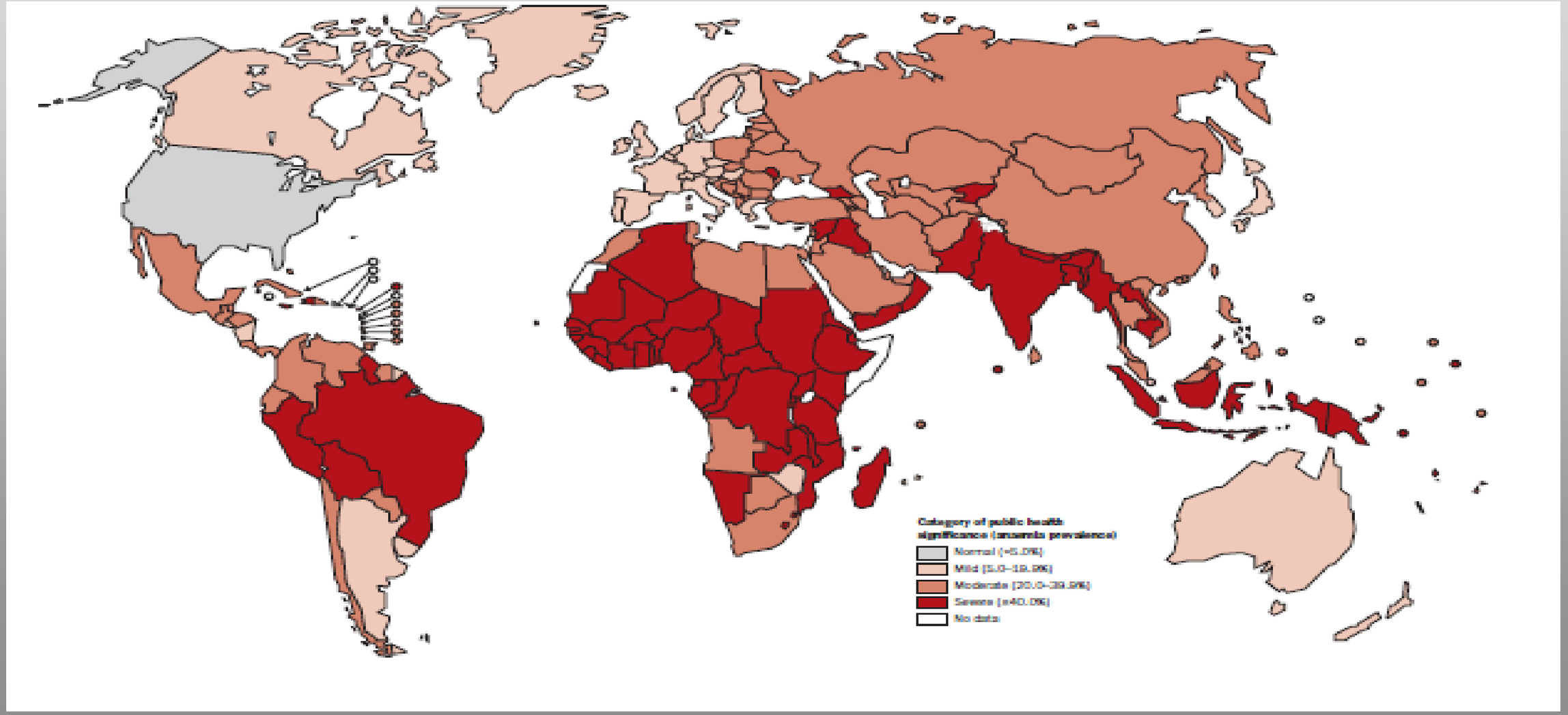


Preventive zinc supplementation reduces diarrhea incidence by ~20%

Preventive zinc supplementation reduces ALRI incidence by ~15%

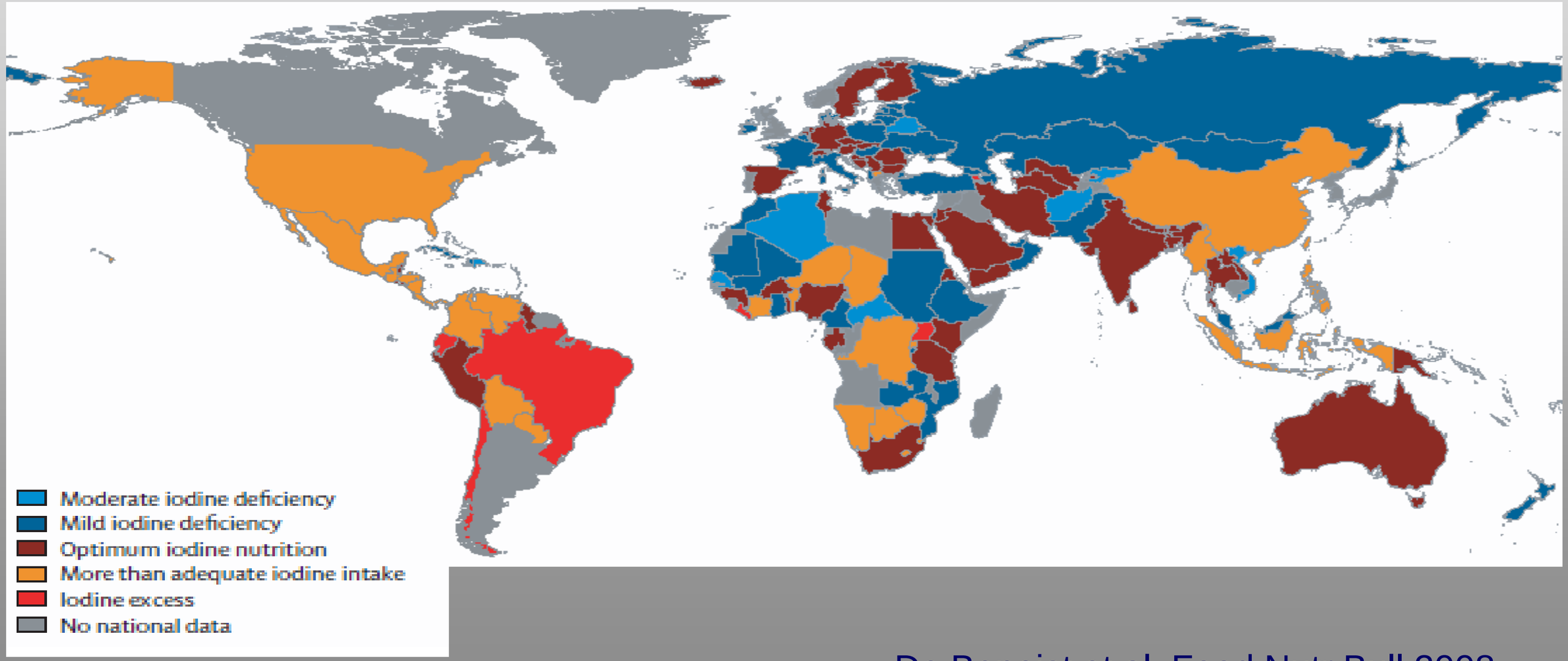
Brown KH et al, Food Nutr Bulletin, 2009

Prevalence of anemia in pre-school children



WHO, Worldwide prevalence of anemia 1993-2005, 2008

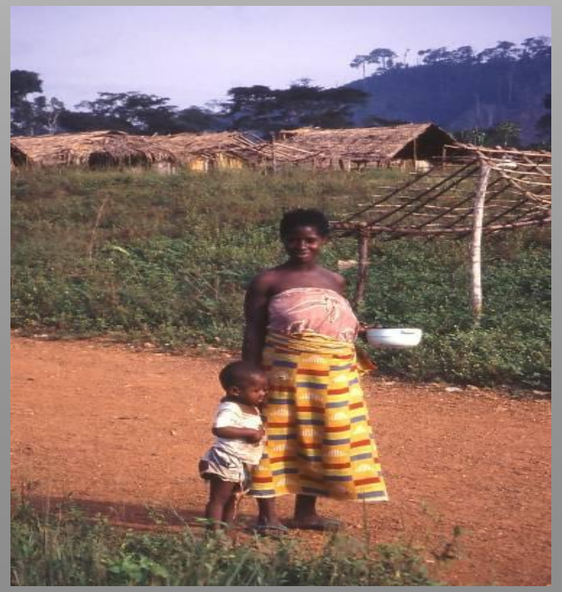
Prevalence of iodine deficiency based on median urinary iodine concentration



De Benoist et al, Food Nutr Bull 2008

Dietary diversification / modification

- Exclusive breast feeding (first 6 mo)
- Appropriate complementary feeding
- Use of animal source foods
- Agricultural interventions



Intervention strategies to control MN deficiencies

Supplementation

- Preventive – daily, weekly, intermittent
- Therapeutic – diarrhea, PEM

Food fortification

- Mass (cereal)
- Targeted (infant foods, therapeutic foods)

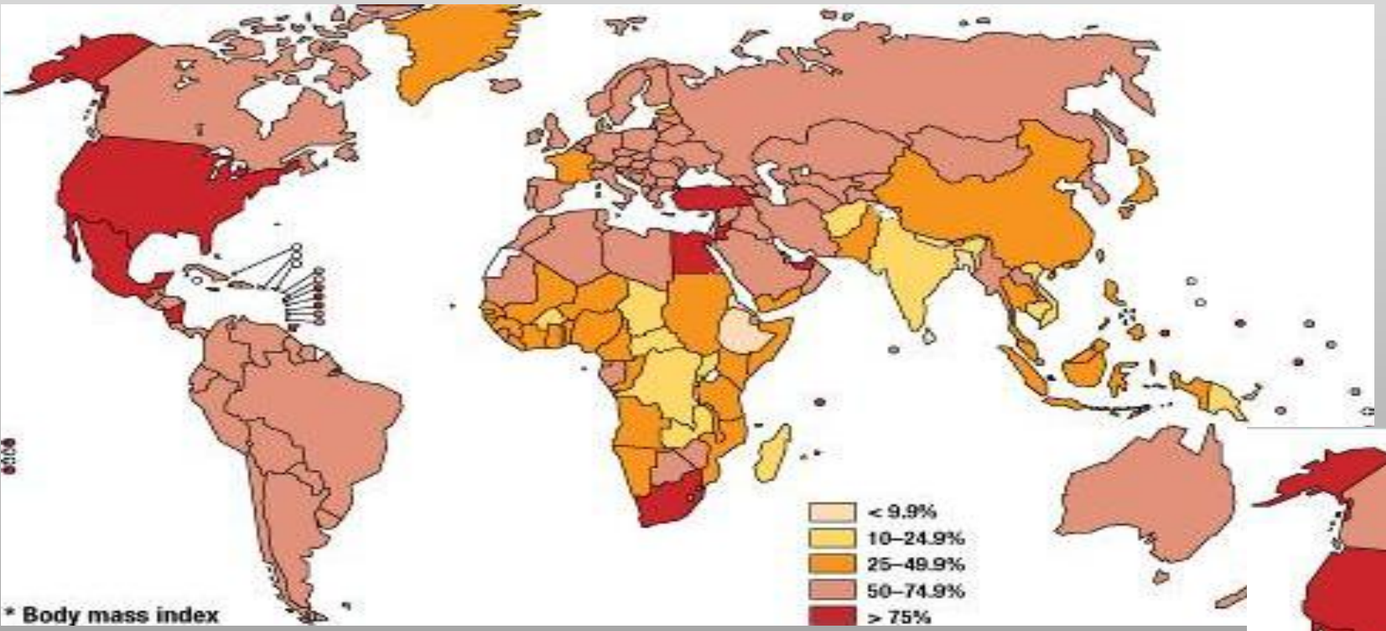
Public health

- Infection control (e.g., hygiene & sanitation, bednets and malaria prevention; deworming)

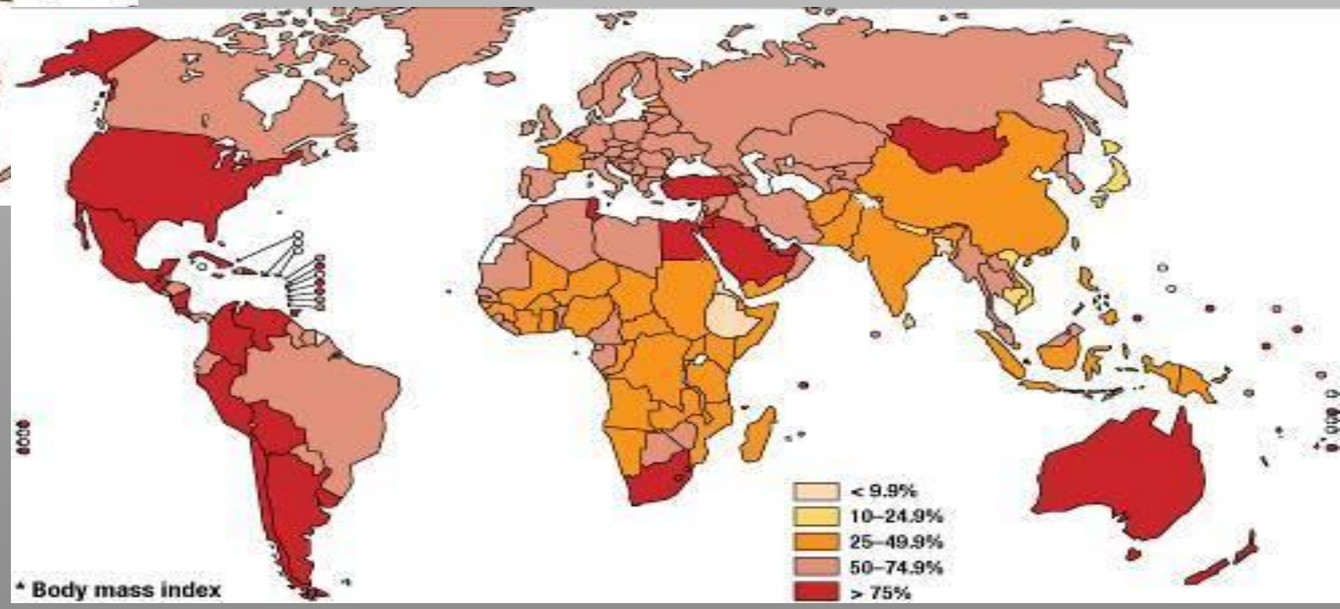
Screening for acute malnutrition

Dietary counseling and child feeding
Mali-MMAM Study

Projected prevalence of overweight (BMI >25 kg/M^2) among women ≥30 yr, 2005 and 2015



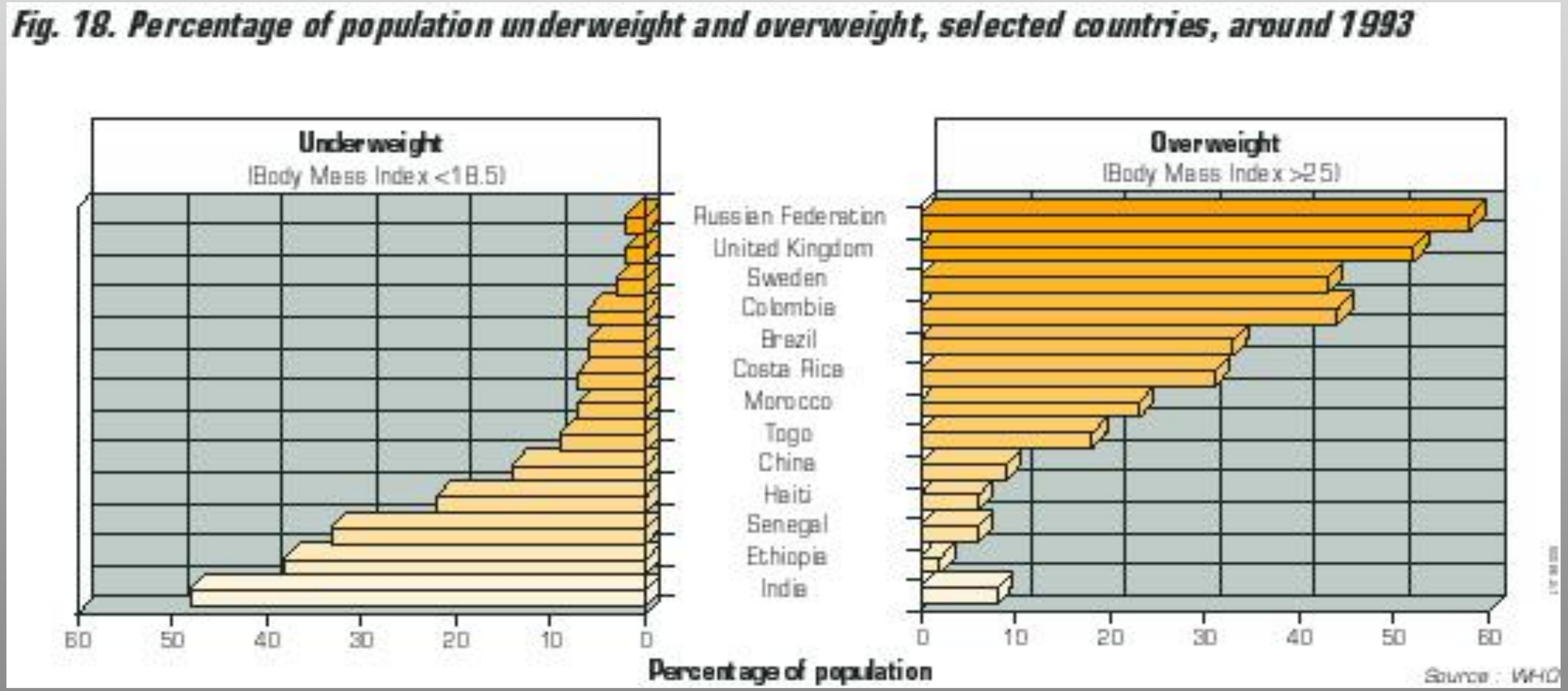
2005



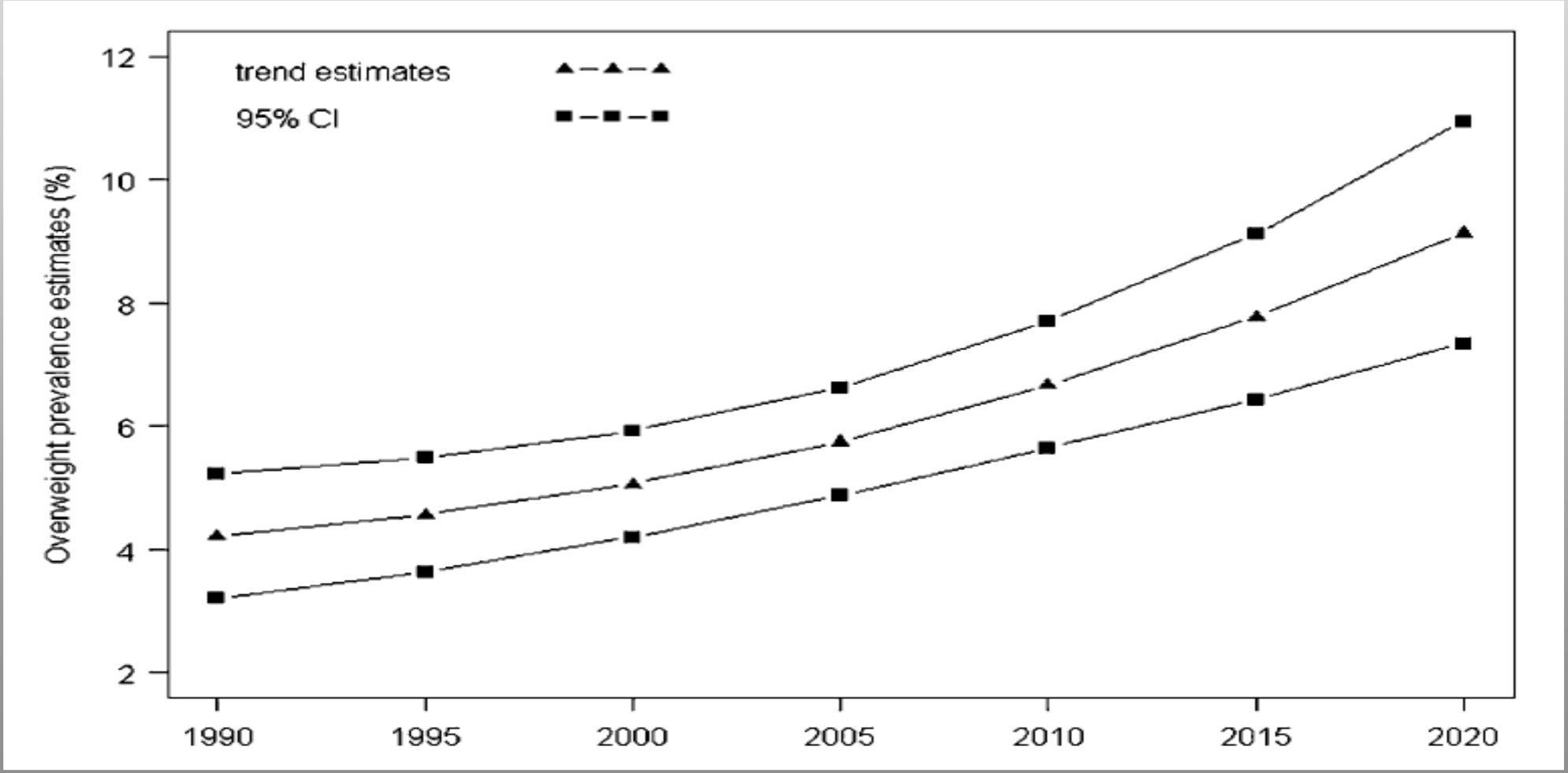
2015

Figure from: WHO. Preventing chronic diseases: a vital investment, 2005

% Population under- and over-weight, 1993

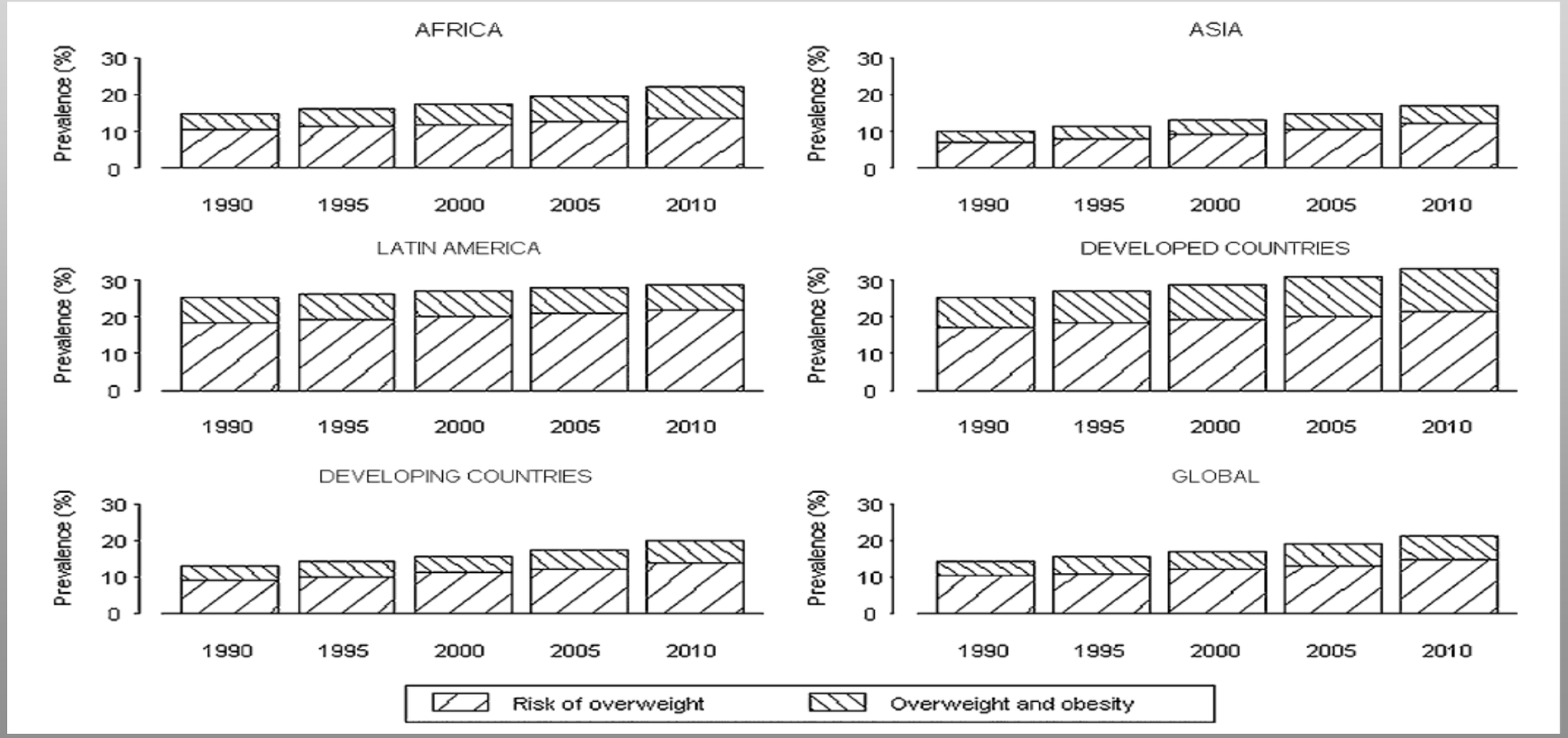


Global prevalence & trends in overweight and obesity, pre-school children



De Onis et al.. Am J Clin Nutr, 2010.

Prevalence & trends in overweight and obesity, pre-school children, by UN region



De Onis et al.. Am J Clin Nutr, 2010.

Conclusions

- Most of the world's population resides in LICs, where the major nutrition problems are still related to undernutrition (LBW, poor IYCF practices, stunting, wasting, and MN deficiencies), with greatest risk among women and young children (first 1000 d)
  - Effective, public health interventions are available to ameliorate these problems, but they are not being implemented at scale
- With increased income and changing food supply and life styles, overweight and obesity are beginning to emerge as public health problems, even in LICs


Thanks!

Poverty

Income, Food,
Education,
Environment,
Health services

Malnutrition

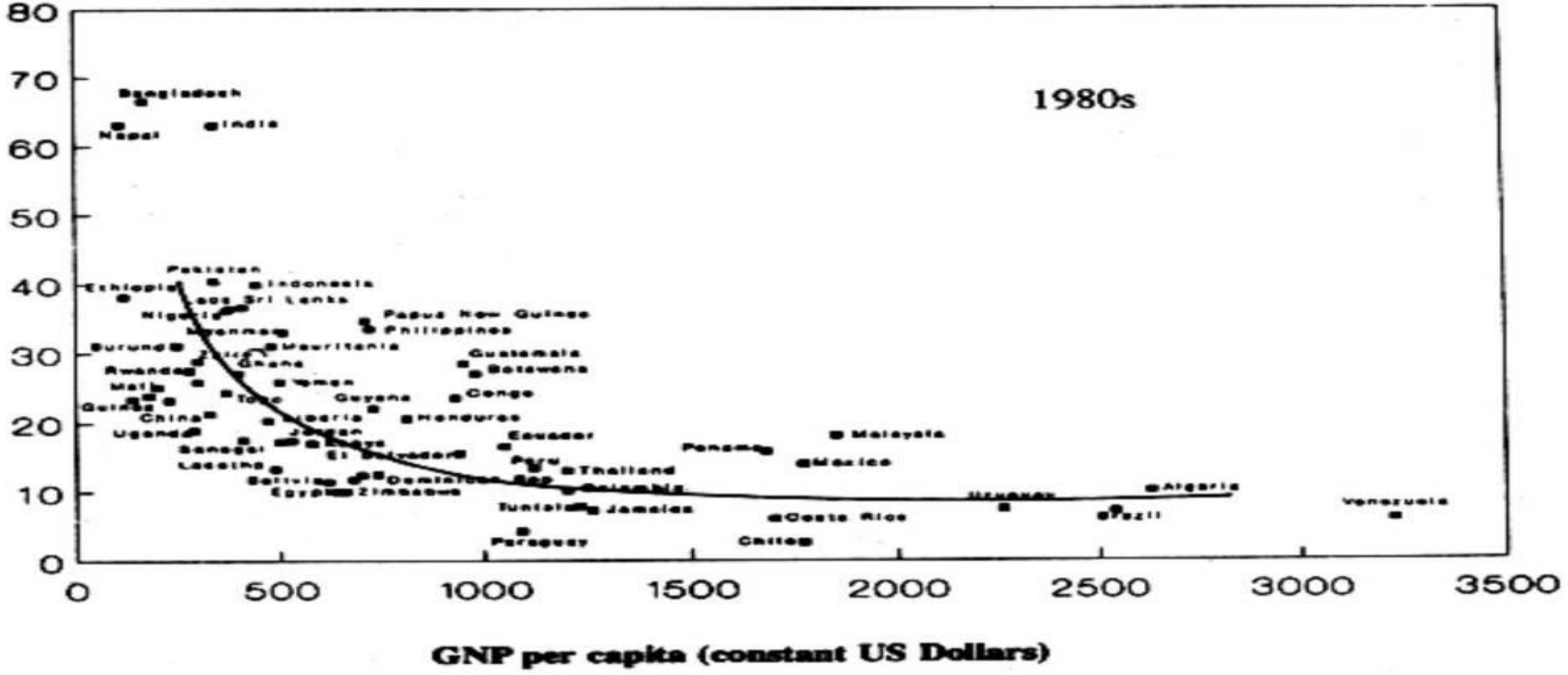
Malnutrition

Educational inefficiency,
Physical capacity,
Susceptibility to infection

Poverty


Poverty
Malnutrition

GNP vs. % underweight (<-2SD W/A)



- MDG #1: Reduce extreme poverty and hunger (measured as proportion of people with insufficient food, percent children underweight)

- MDG #4: Reduce child mortality

The Millennium Development Goals Report

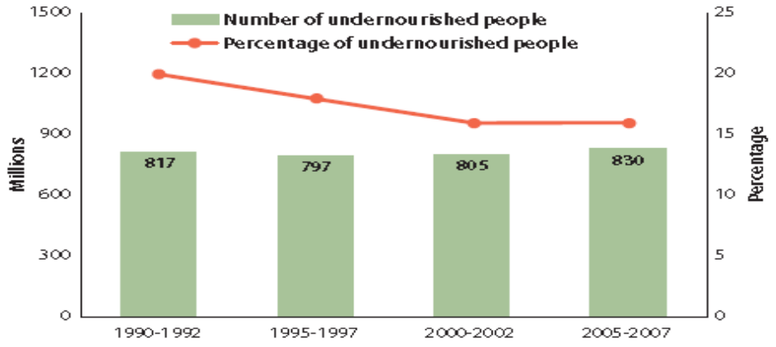
2010

UNITED NATIONS

TARGET
Halve, between 1990 and 2015, the proportion of people who suffer from hunger

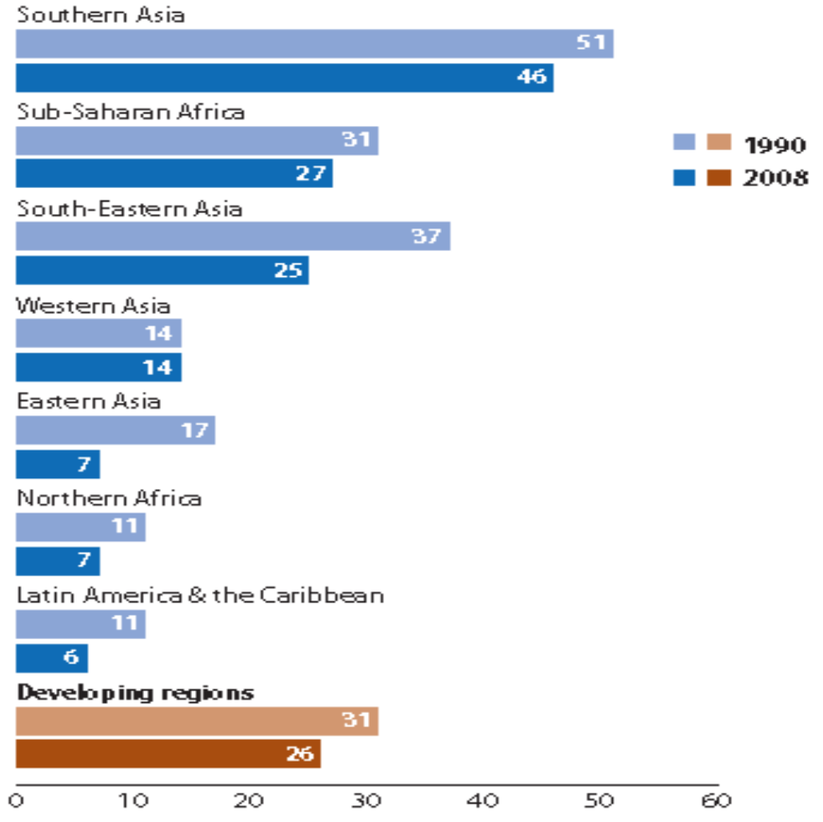
Hunger may have spiked in 2009, one of the many dire consequences of the global food and financial crises

Proportion of people who are undernourished in the developing regions (Percentage) and number of undernourished people (Millions), 1990-1992, 1995-1997, 2000-2002 and 2005-2007

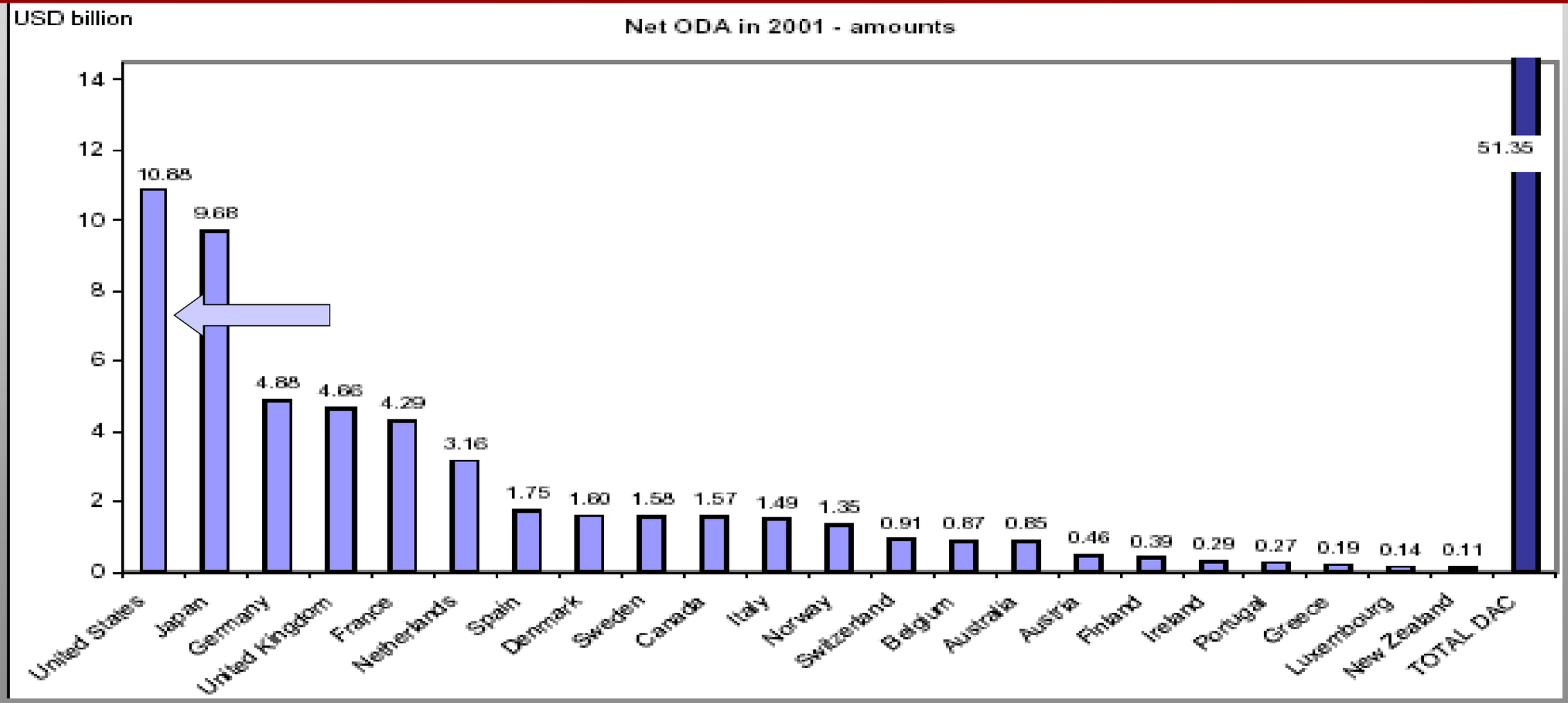


Despite some progress, one in four children in the developing world are still underweight

Proportion of children under age five who are underweight, 1990 and 2008 (Percentage)

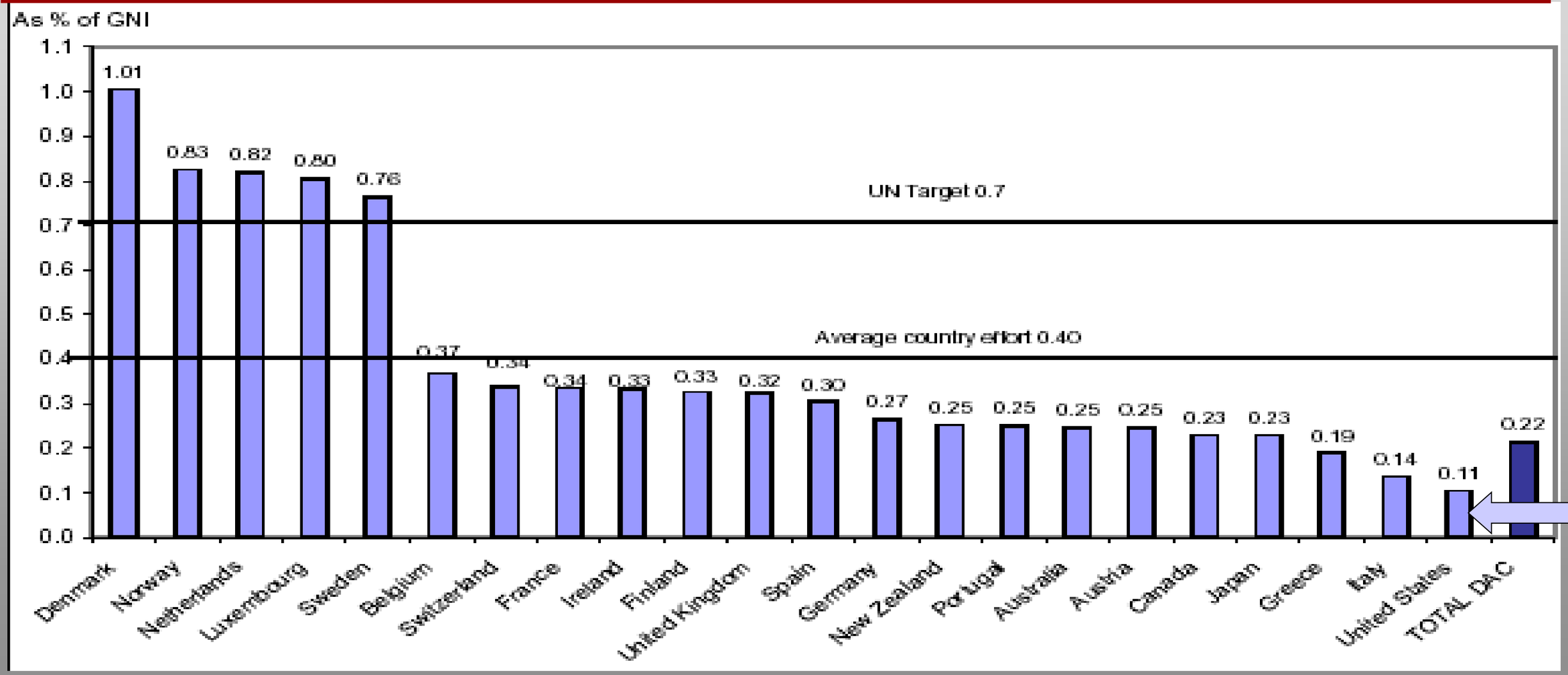


Assistance from DAC member countries (2001) in USD billions



Source: www.oecd.org, “A Mixed picture of Official Development Assistance in 2001”

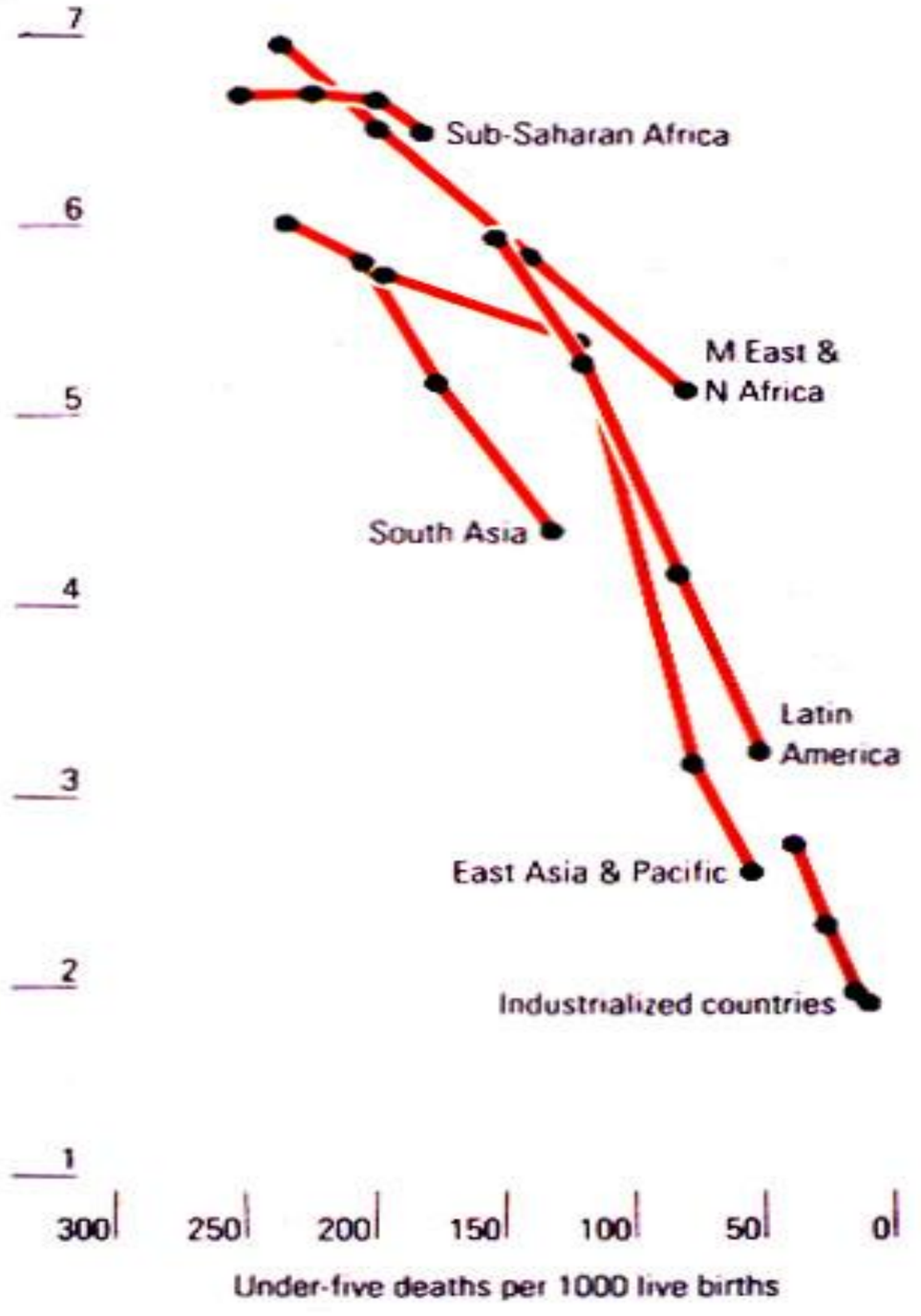
Assistance from DAC member countries (2001) as % GNI



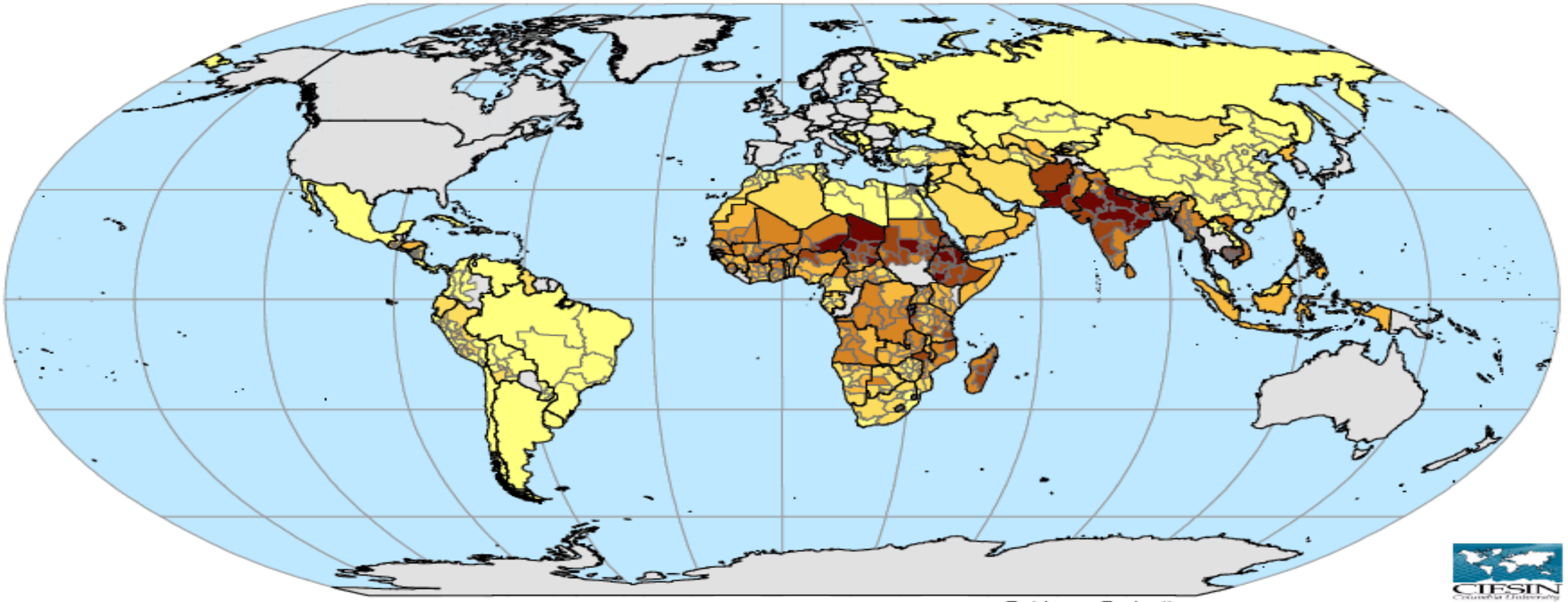
Source: www.oecd.org, “A Mixed picture of Official Development Assistance in 2001”

Child deaths and births

Changes in the total fertility rate (average number of births per woman) compared with changes in under-five mortality rates. For each region, the points on the graph show the situation in 1960, 1970, 1980 and 1990.



Prevalence of Child Malnutrition



Robinson Projection

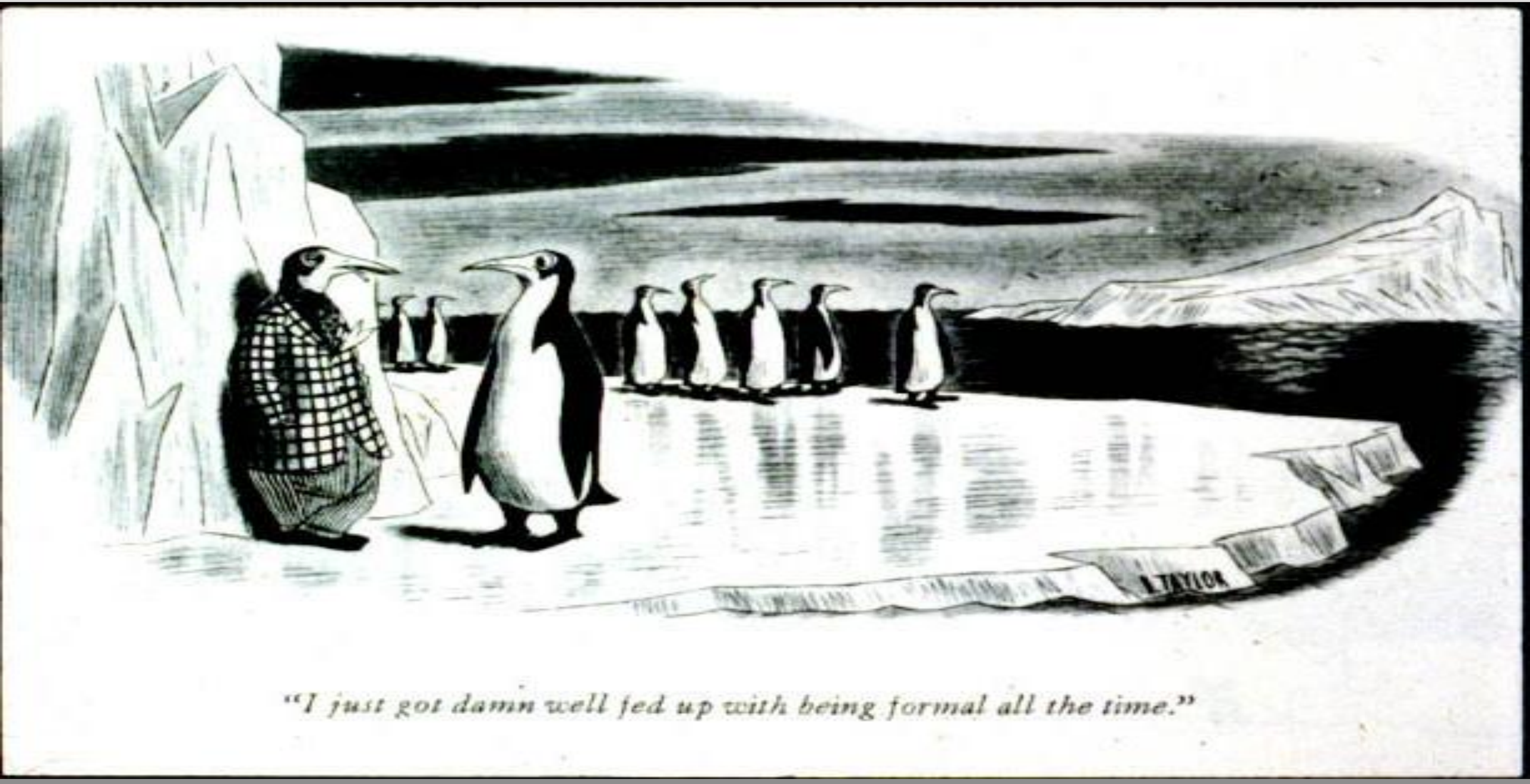
Percent of children underweight

- less than 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- more than 50
- no data
- national borders

Children are defined as underweight if their weight-for-age z-scores are more than two standard deviations (2 SD) below the median of the NCHS/CDC/ WHO International Reference Population.

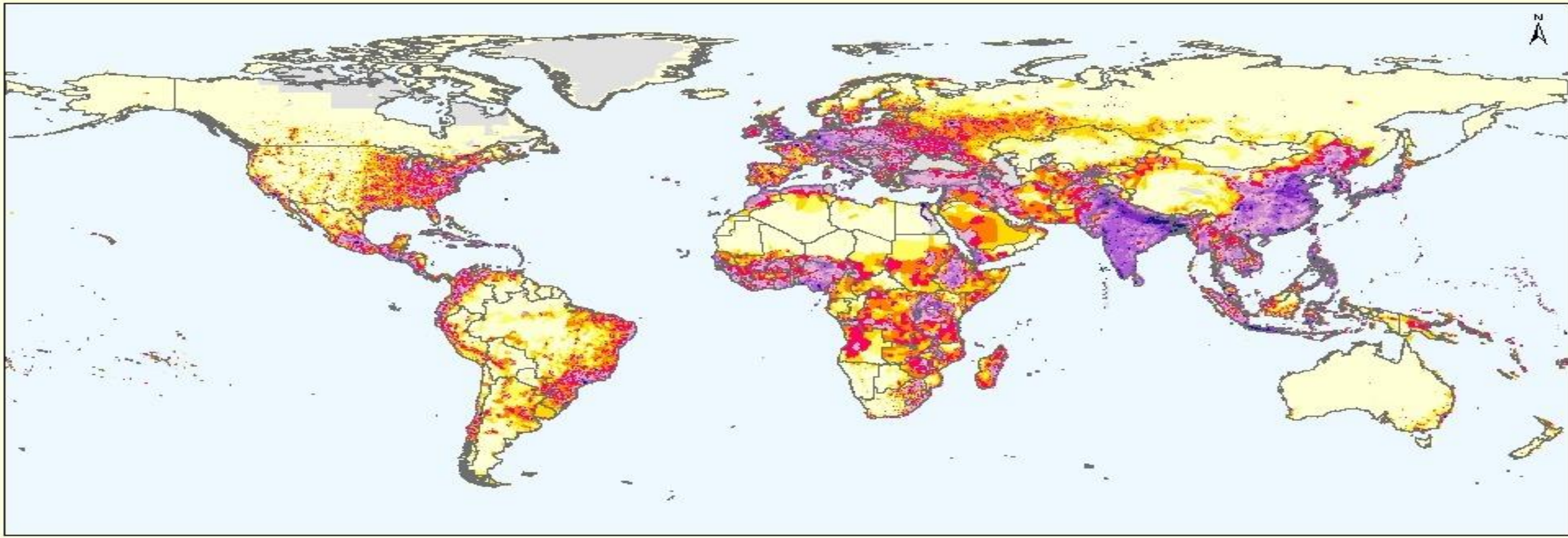
Data Summary	Count-ries	Data units	Avg. units/ country	% of world Population	% of non-OECD Population
National data only	41	41	1.0	16	18
Subnational data	74	640	8.6	65	78
Total	115	681	5.9	81	96

Sources: UNICEF, Demographic and Health Surveys (DHS), National Human Development Reports (nHDR), African Nutrition Database Initiative (ANDI). Data for 96% of countries are from 1995 or later. All data are from 1990 or later.



"I just got damn well fed up with being formal all the time."

Global Population Density projected for 2015



Geographic Projection (Lat/Long)

Persons per Km²

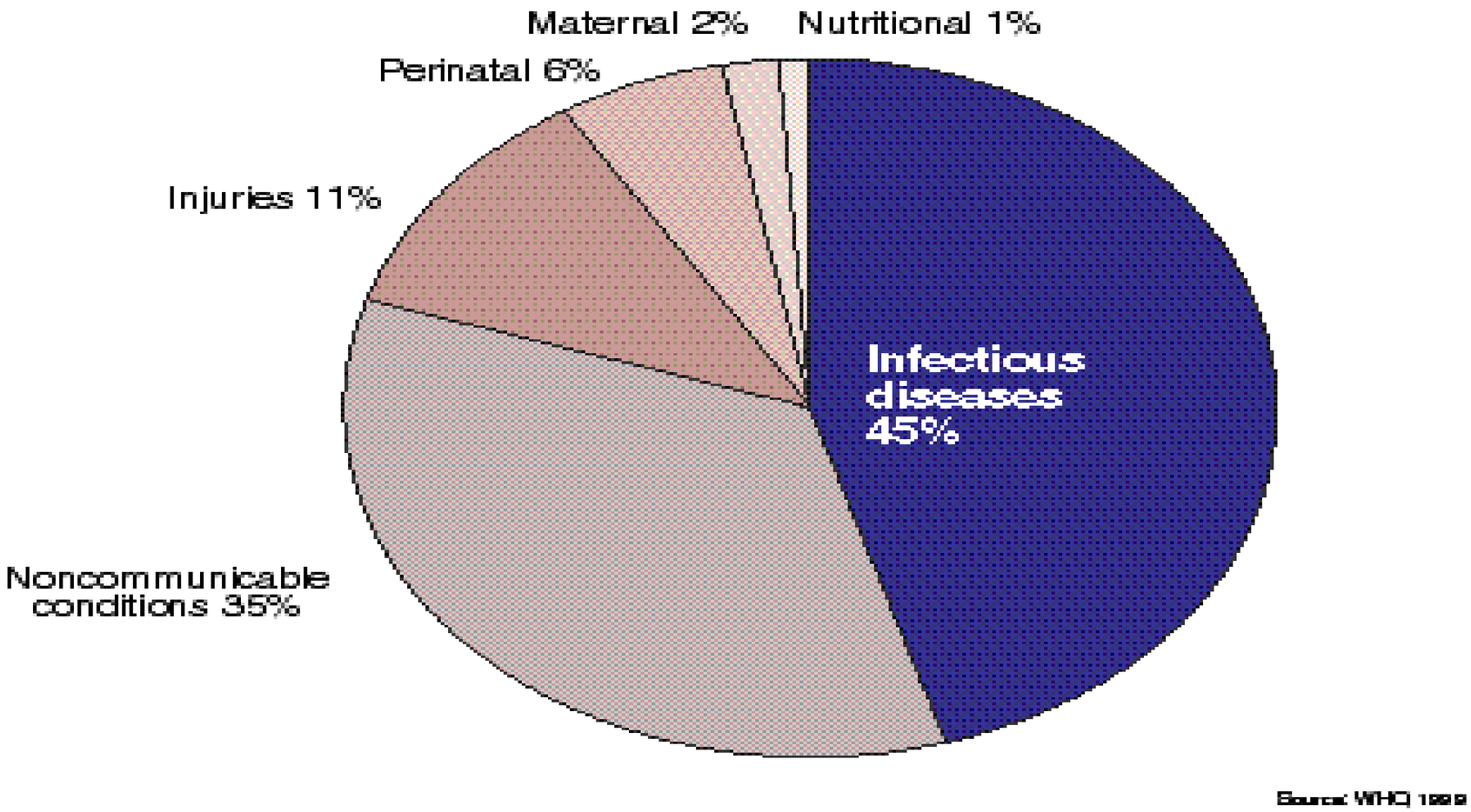
	0		2 - 5		10 - 20		50 - 100		200 - 500		> 1,000
	0 - 2		5 - 10		20 - 50		100 - 200		500 - 1,000		

Source: Poverty Mapping Urban Rural (PMUR) Database
Date: 2005

Food and Agriculture Organization of the United Nations
http://www.fao.org/geonetwork

Main causes of death in low-income countries

In South-East Asia and Africa
Estimates for 1998

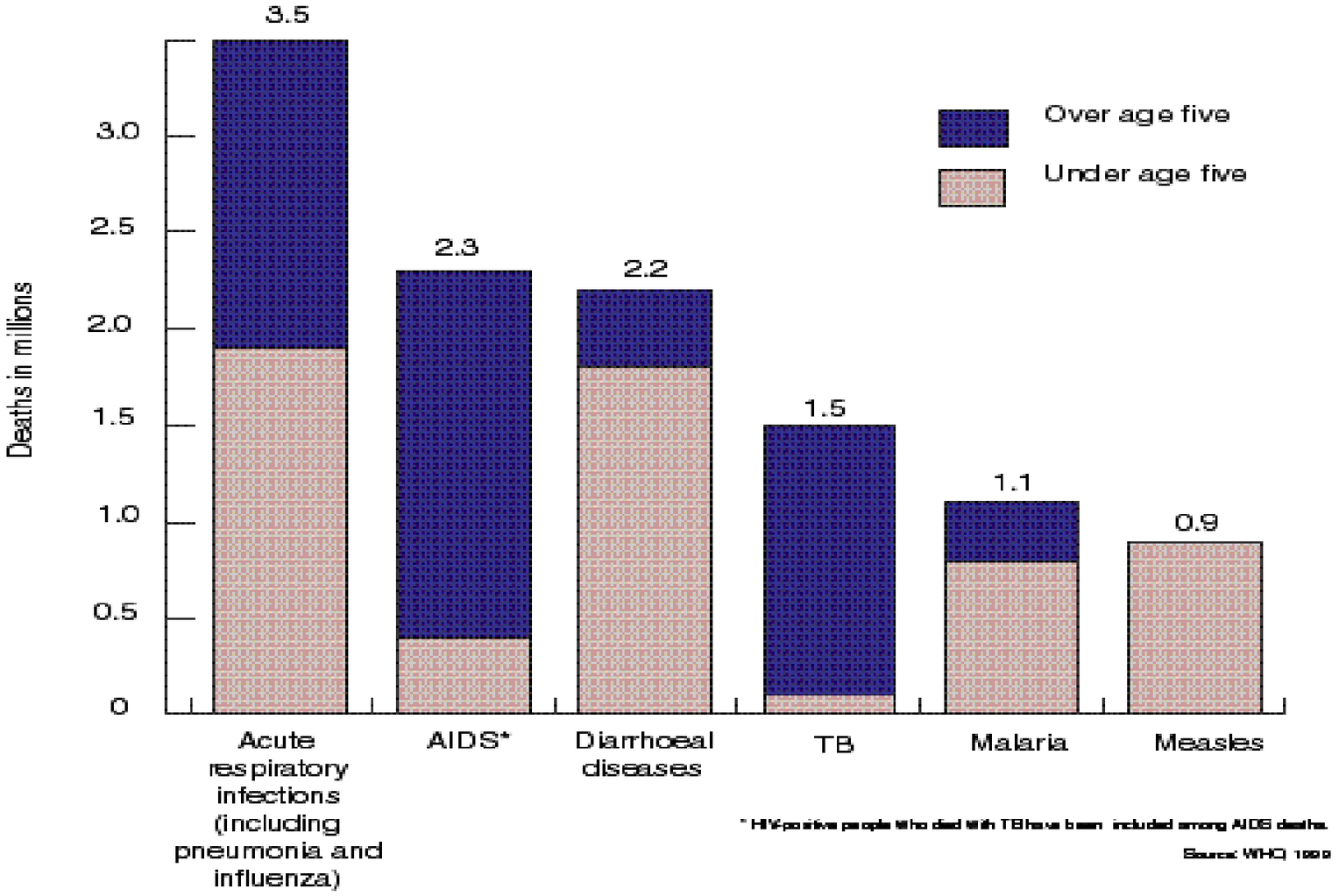


Source: WHO 1999

http://www.who.int/infectious-disease-report/pages/graph2.html

Leading infectious killers

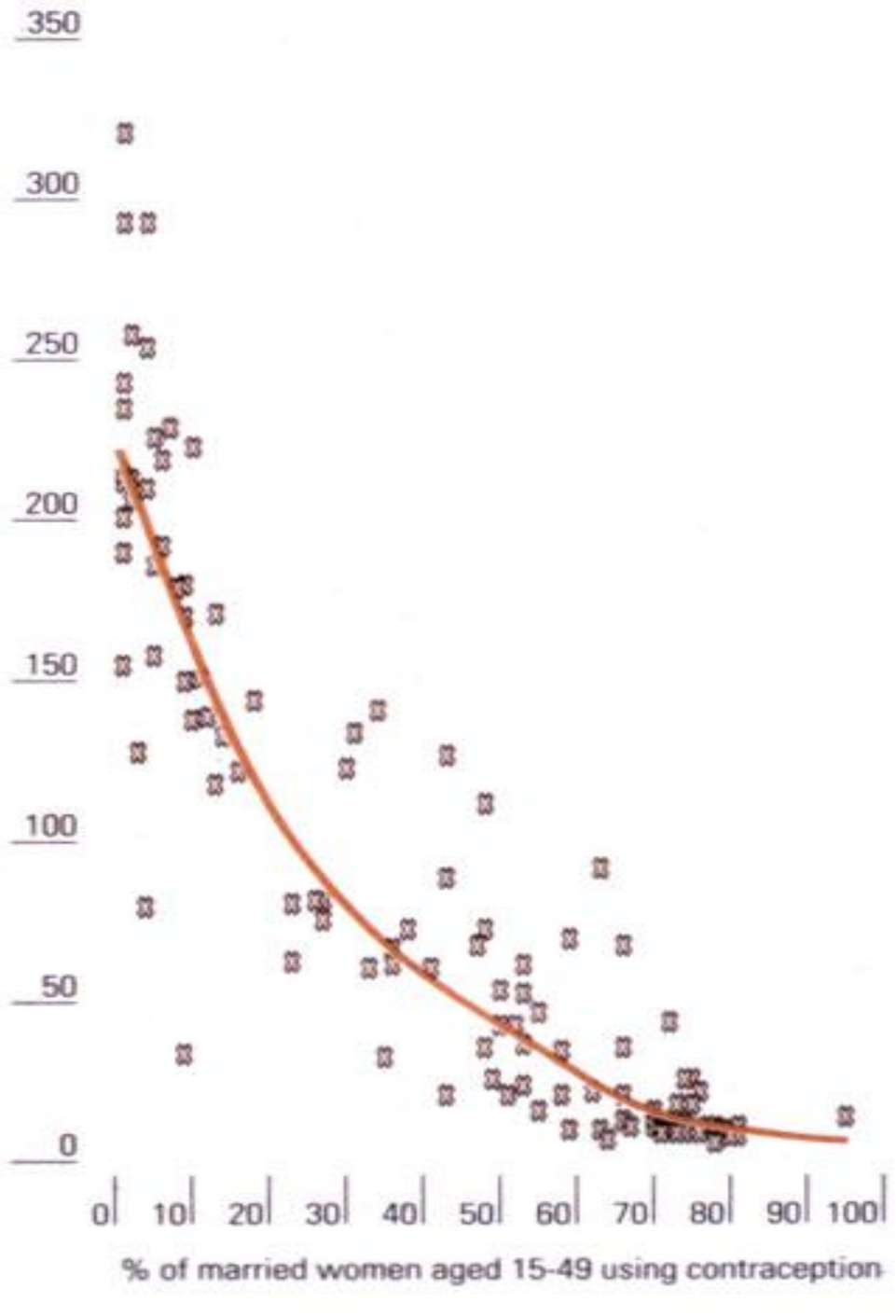
Millions of deaths, worldwide, all ages, 1998



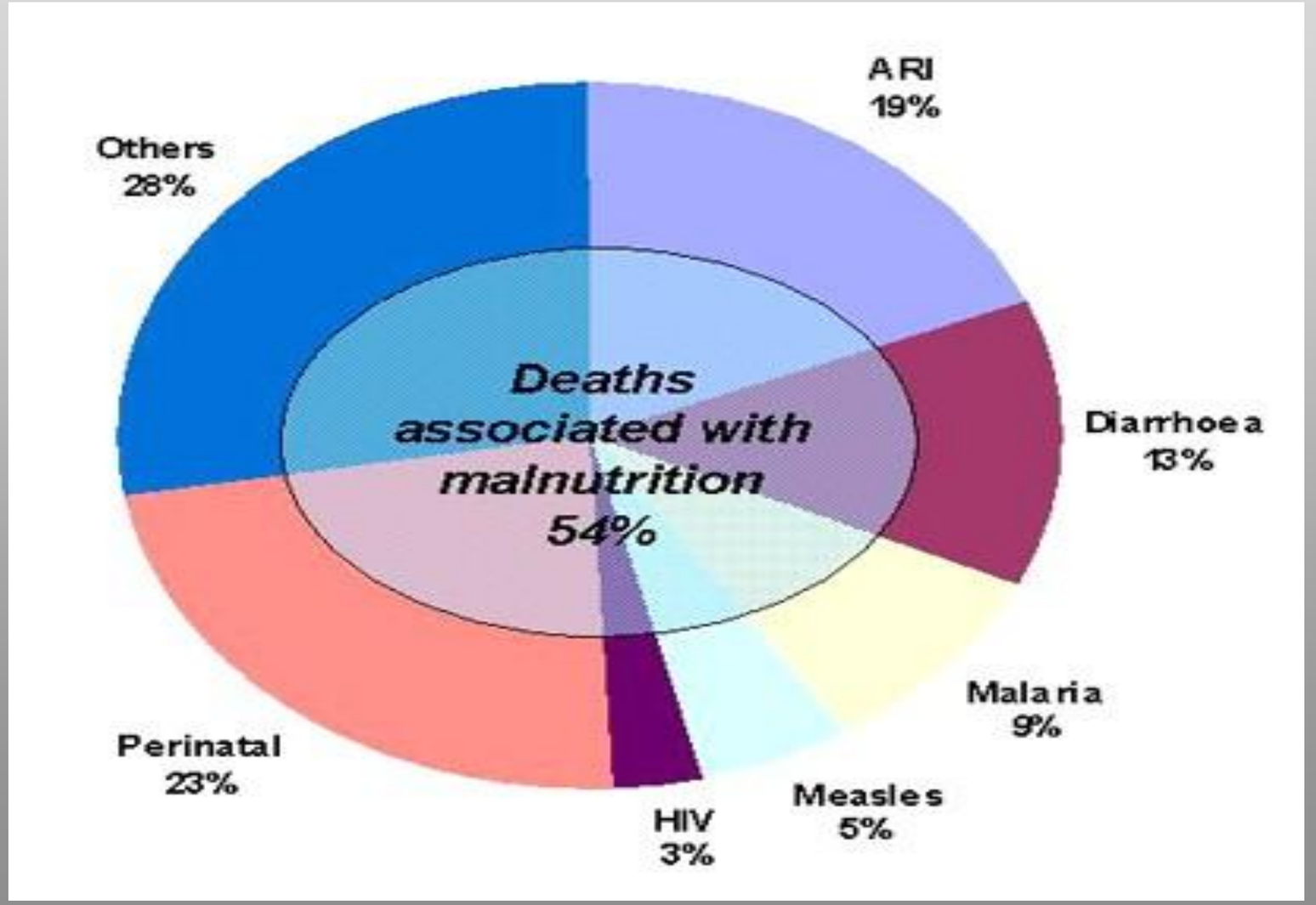
http://www.who.int/infectious-disease-report/pages/graph2.html

Confidence in survival

Under-five mortality rates (per 1000 live births) related to levels of contraception in 108 countries of the developing world.

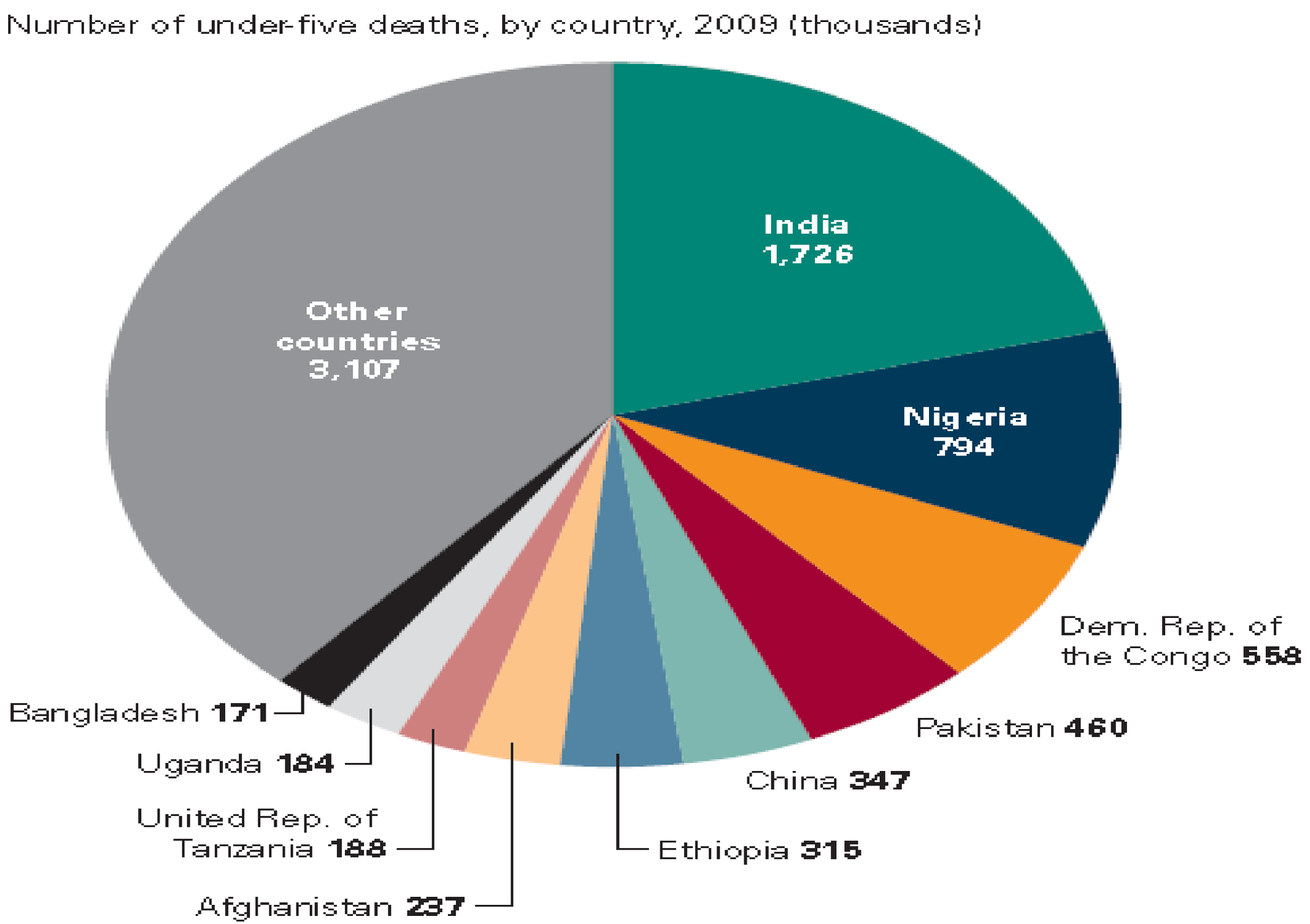


Major causes of death among children under five, worldwide, 2000

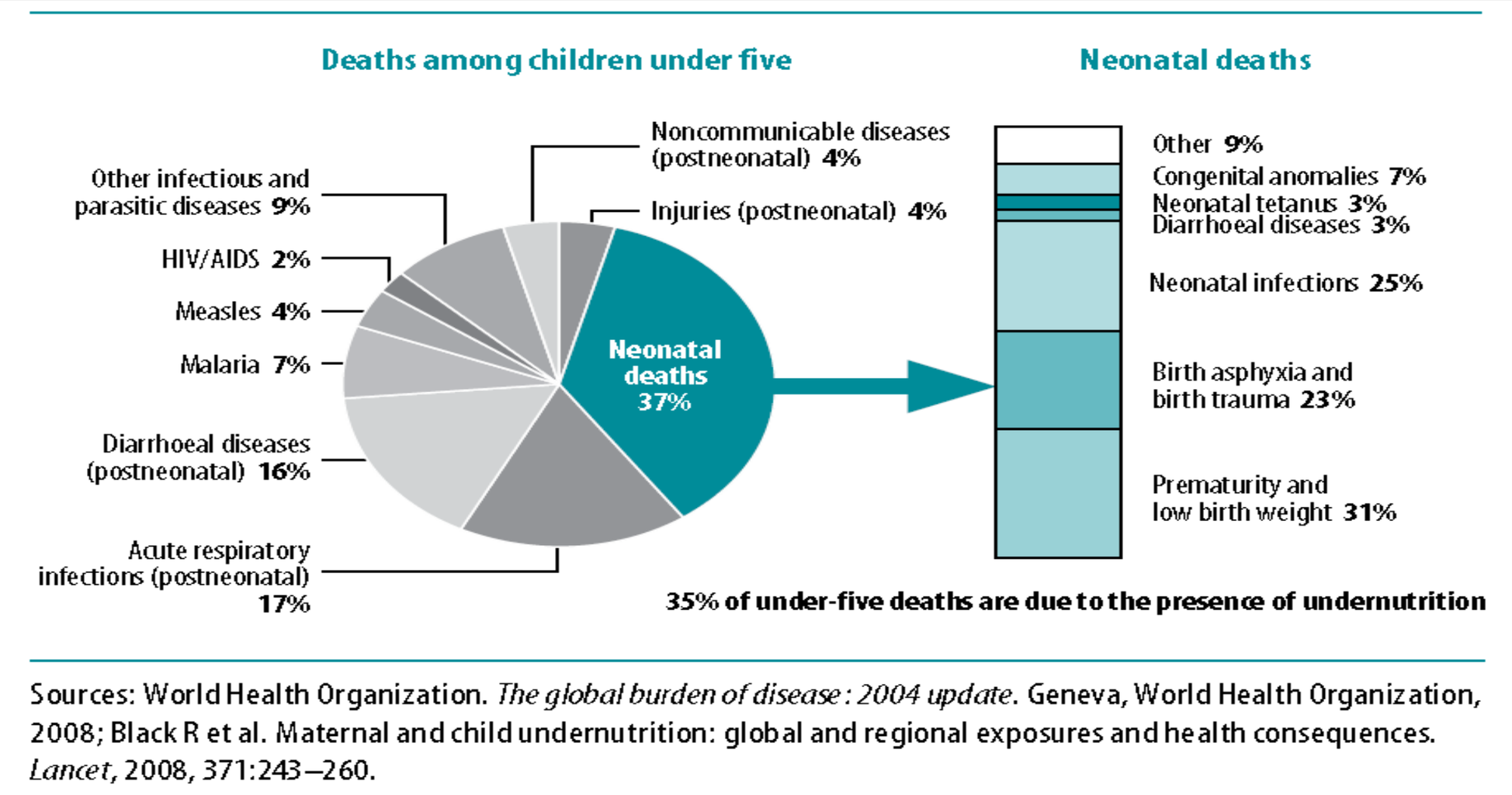


Source: http://www.who.int/child-adolescent-health/OVERVIEW/CHILD_HEALTH/piechart1.jpg

FIGURE 8 **The 10 countries with the most under-five deaths**



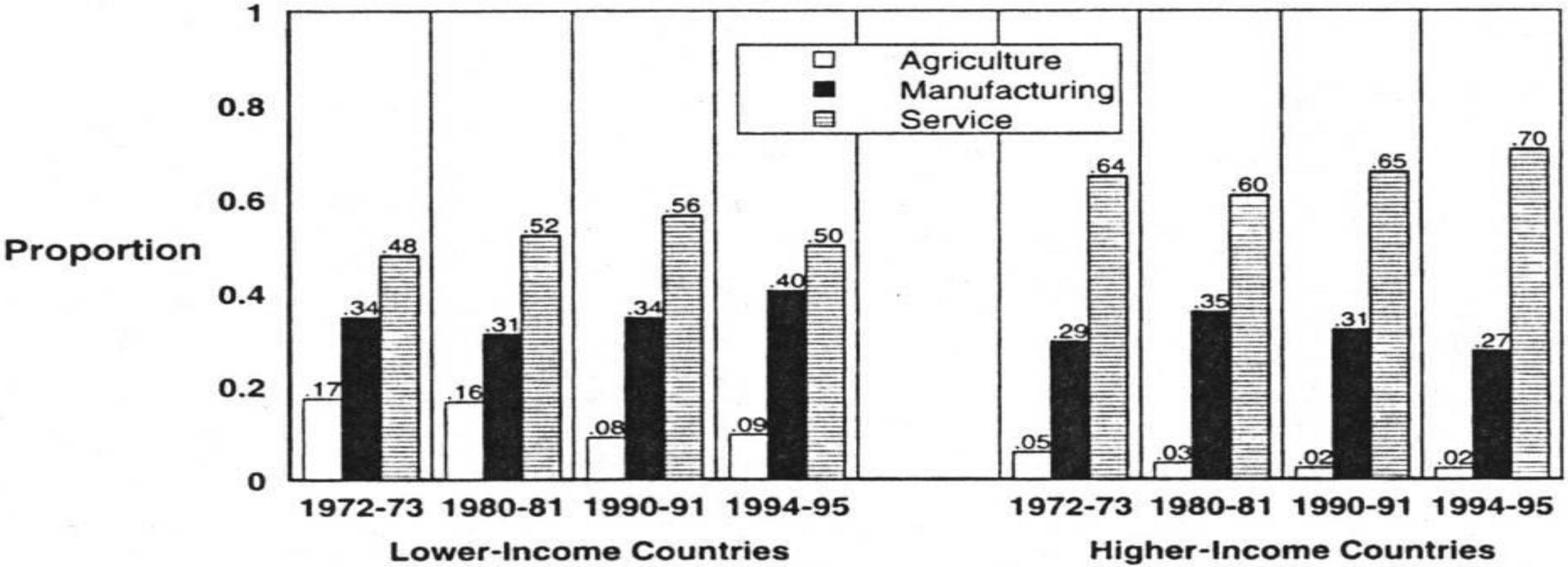
Major causes of death among children under five, worldwide, 2004



Sources: World Health Organization. *The global burden of disease : 2004 update*. Geneva, World Health Organization, 2008; Black R et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*, 2008, 371:243–260.

Source: http://www.who.int/child-adolescent-health/OVERVIEW/CHILD_HEALTH/piechart1.jpg

Shifts in the distribution of occupation, 1972-1995



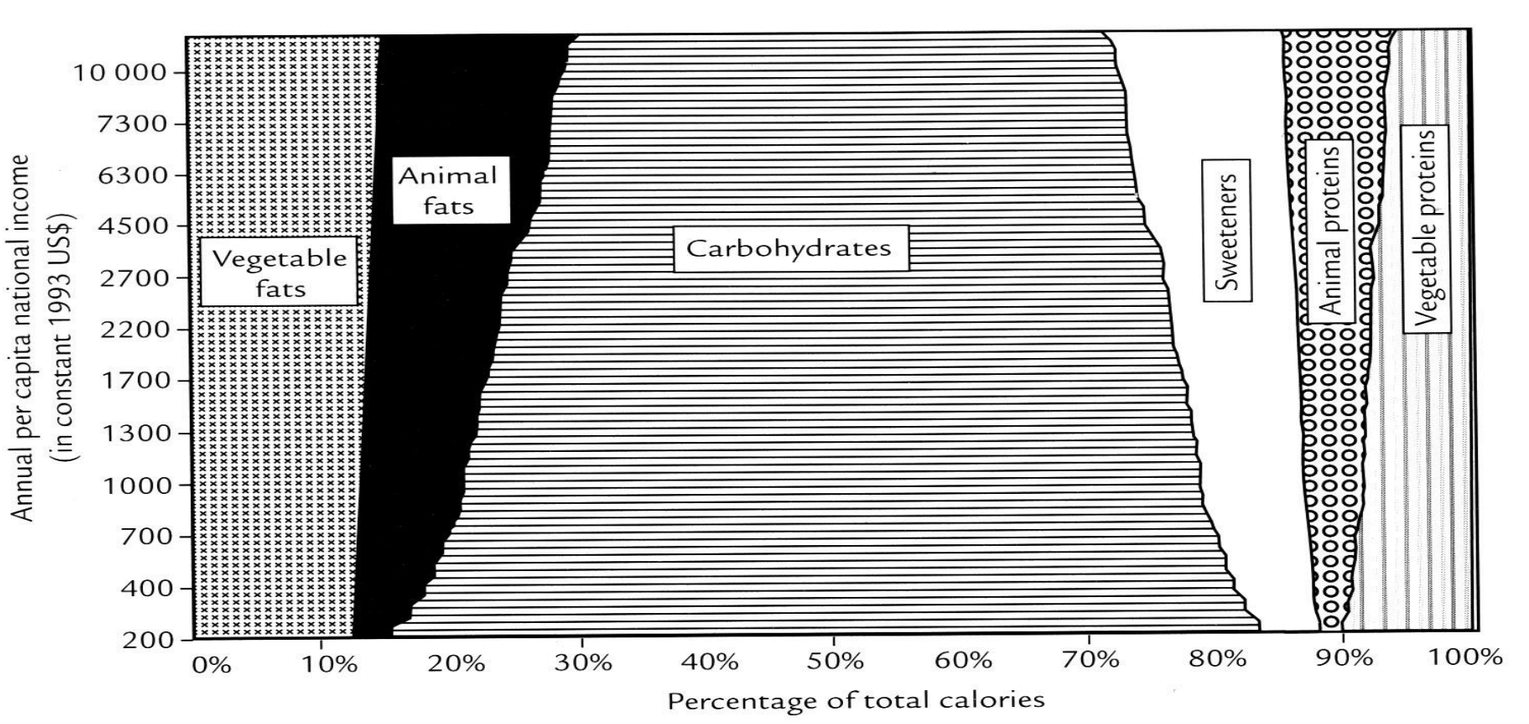
Popkin B. Public Health Nutrition 1:5-21, 1998

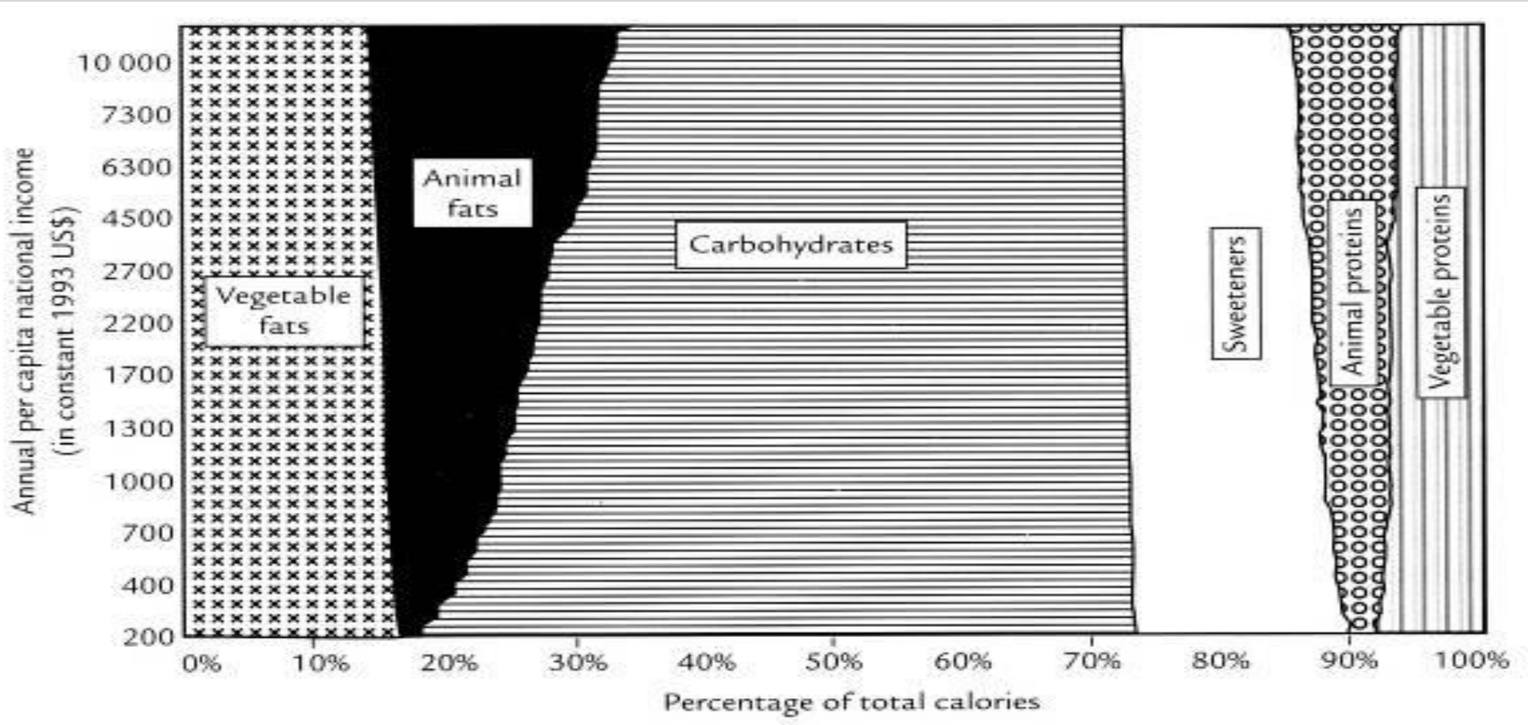
Relationship between the proportion of energy from each food source and GNP per capita in 1990

with the proportion of the population residing in urban areas placed at 25%

with the proportion of the population residing in urban areas placed at 75%

Source: Drewnowski and Popkin, Nutr Rev 55: 31-43, 1997.





The Millennium Development Goals Report

2006

UNITED NATIONS

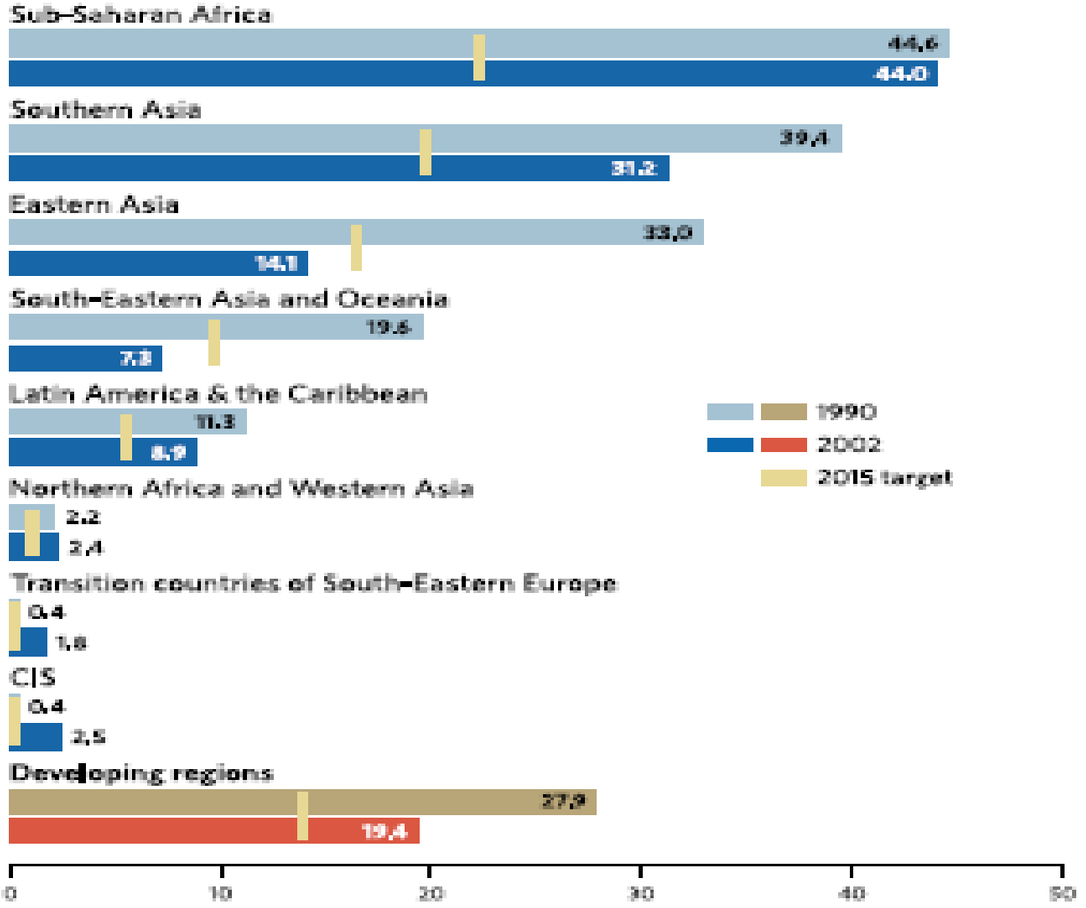
Goal 1
Eradicate extreme poverty & hunger

TARGET

Halve, between 1990 and 2015, the proportion of people whose income is less than $1 a day

Asia leads the decline in global poverty

Proportion of people living on less than $1 a day, 1990 and 2002
(Percentage)

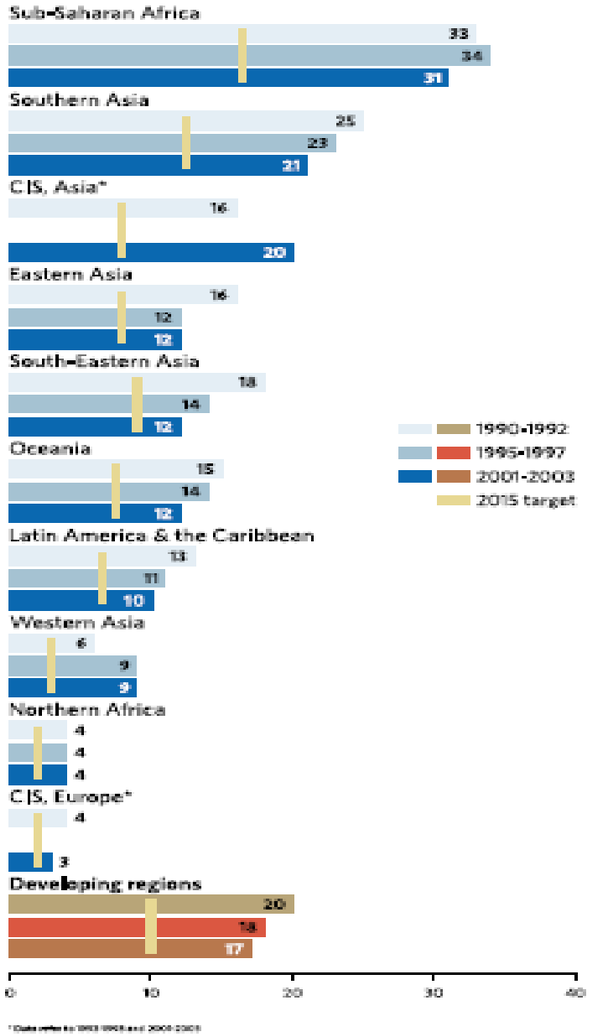


TARGET

Halve, between 1990 and 2015, the proportion of people who suffer from hunger

More people go hungry, even though worst-hit regions show improvement and rates of hunger decline

Proportion of people living with insufficient food
1990-1992, 1995-1997 and 2001-2003 (Percentage)



Chronic hunger – measured by the proportion of people lacking the food needed to meet their daily needs – has declined in the developing world. But progress overall is not fast enough to reduce the number of people going hungry, which increased between 1995-1997 and 2001-2003. An estimated 824 million people in the developing world were affected by chronic hunger in 2003.

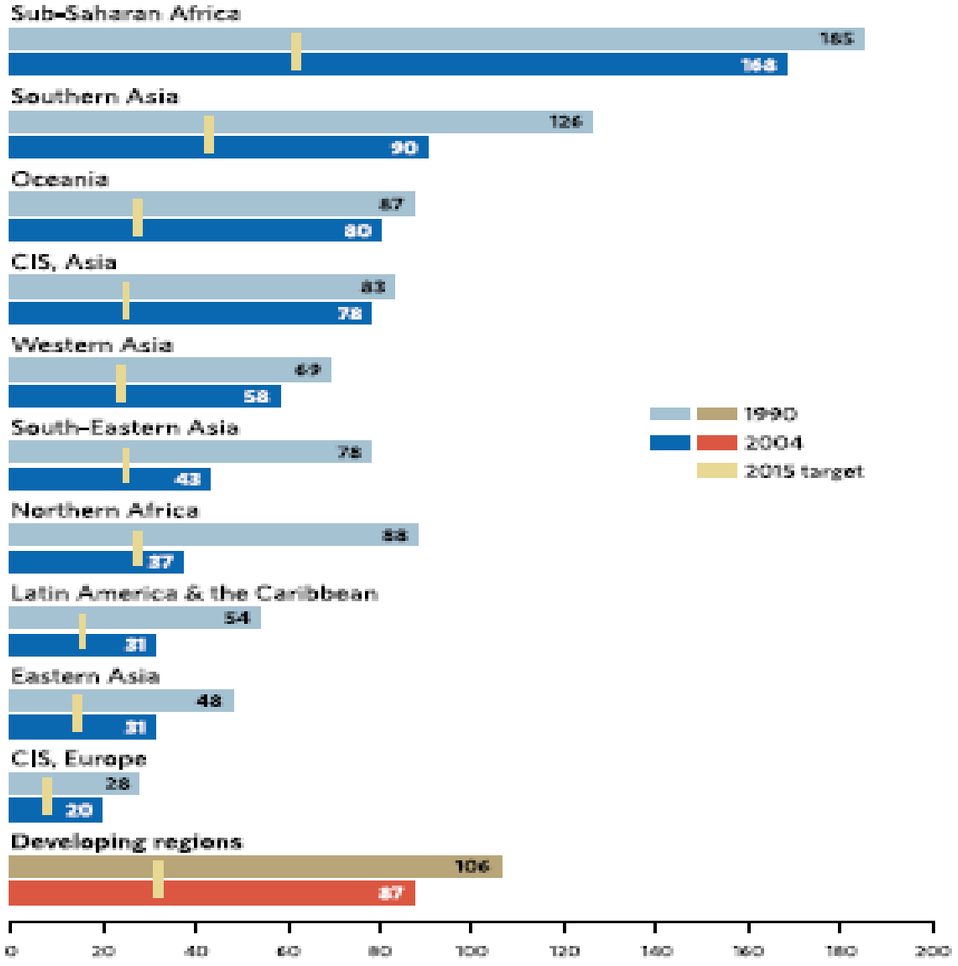
The worst-affected regions – sub-Saharan Africa and Southern Asia – have made progress in recent years. But their advances have not kept pace with those of the early 1990s, and the number of people going hungry is increasing. Of particular concern is Eastern Asia: in the early 1990s, the number of hungry people declined; but again it is on the rise.

Goal 4
Reduce child mortality

TARGET
Reduce by two thirds, between 1990 and 2015, the under-five mortality rate

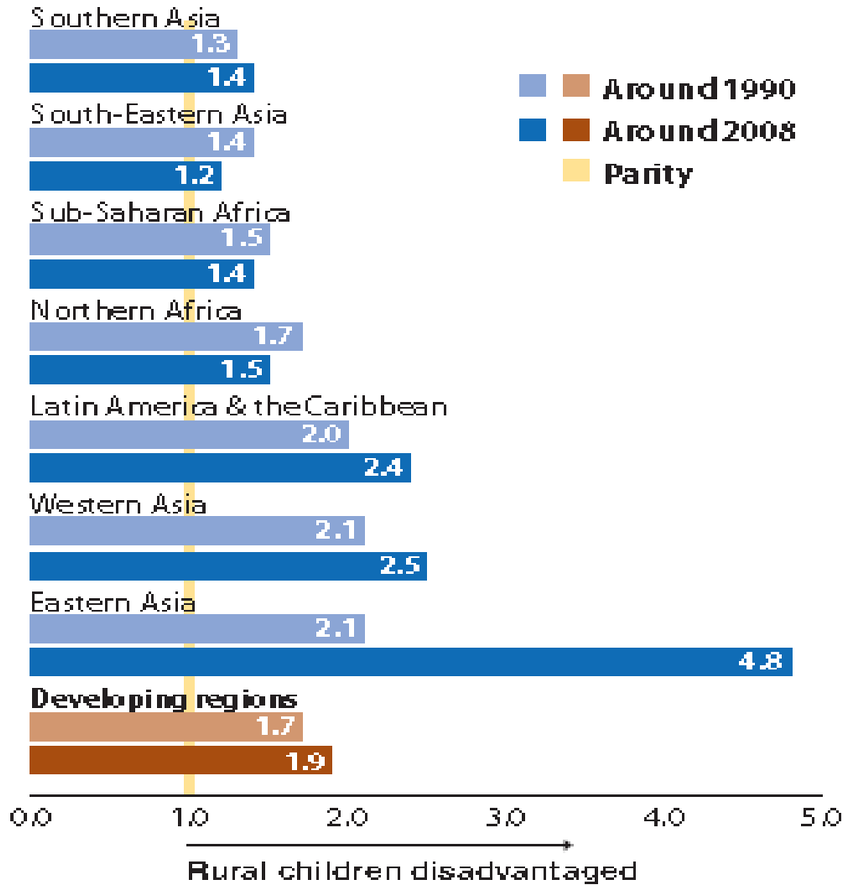
More children are surviving their first years of life, though sub-Saharan Africa trails far behind

Under-five mortality rate per 1,000 live births, 1990 and 2004



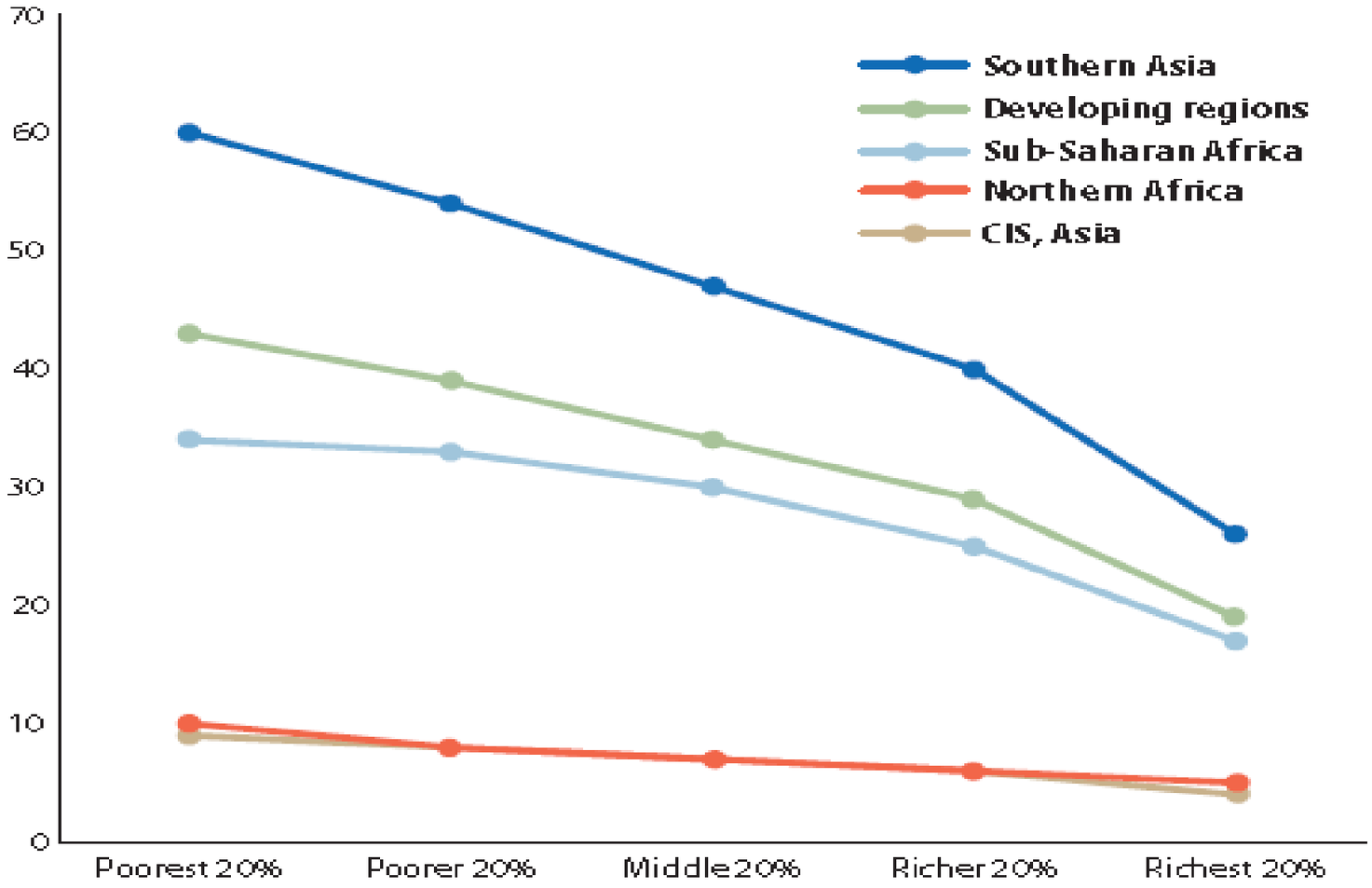
Children in rural areas are nearly twice as likely to be underweight as those in urban areas

Ratio between the proportion of under-five children who are underweight in rural areas and urban areas, 1990 and 2008



In some regions, the prevalence of underweight children is dramatically higher among the poor

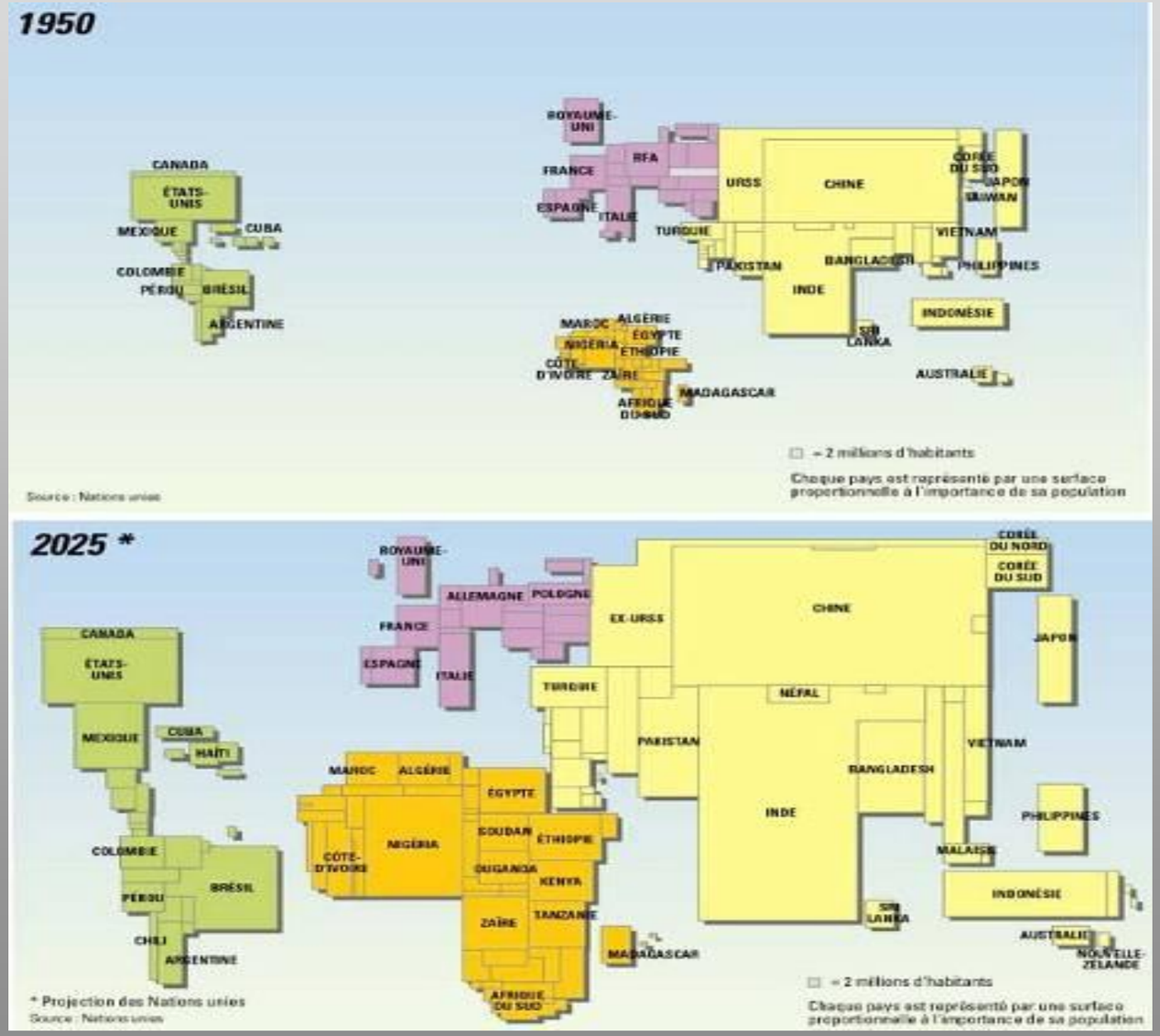
Proportion of under-five children who are underweight, by household wealth, around 2008 (Percentage)



Annual natural increase in population, more and less developed countries

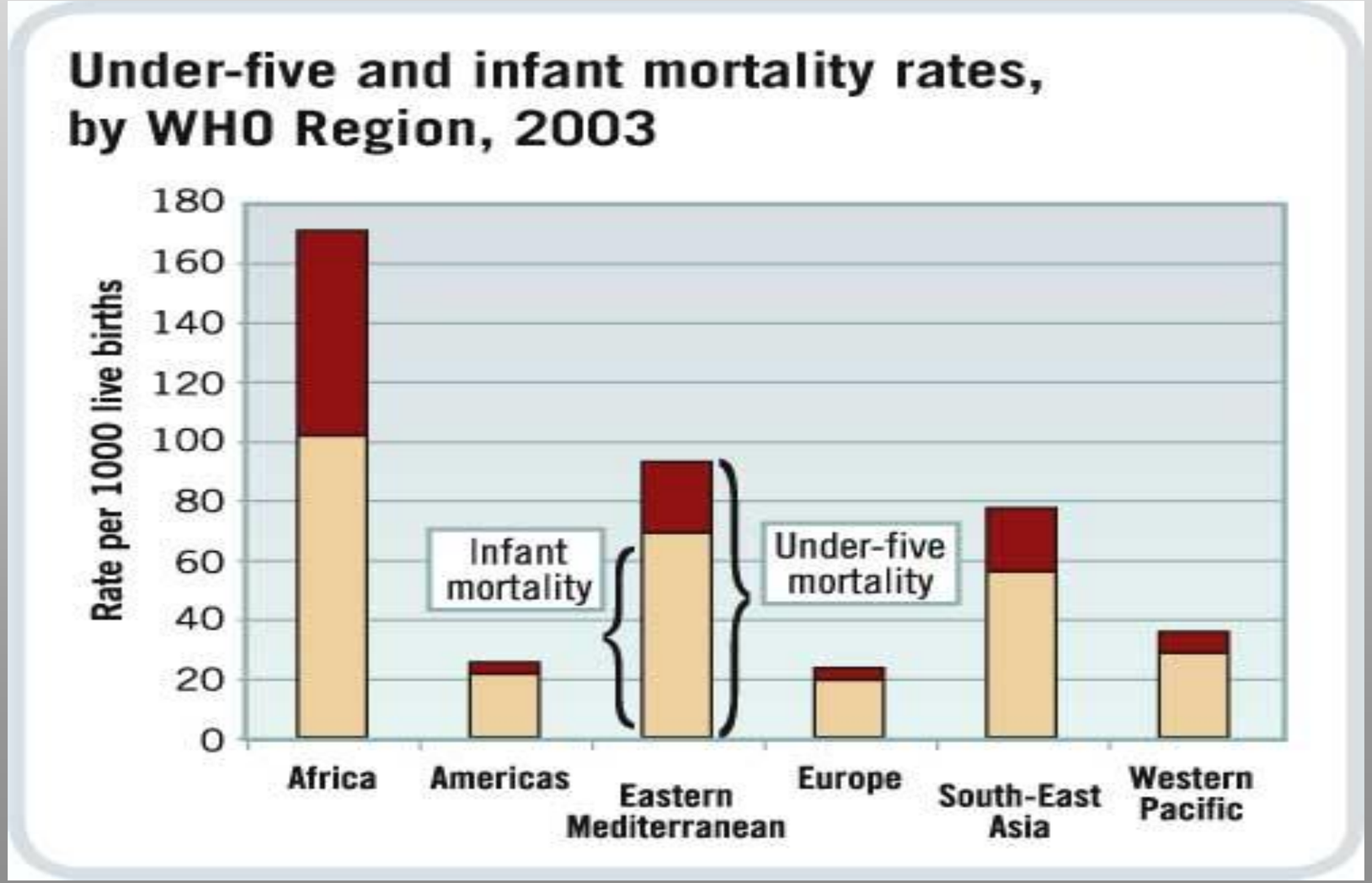
	World	More developed	Less developed
Population mid-1998 (millions)	5,926	1,178	4,748
Births per 1,000 population	23	11	26
Deaths per 1,000 population	9	10	9
Natural increase annual, %	1.4	0.1	1.7
Doubling time in years	49	548	40

Population of the world, 1950 and 2025



http://www.povertymap.net/pub/mipwa/sections/w-global/demo-pop/anamorphose-pop-world.htm

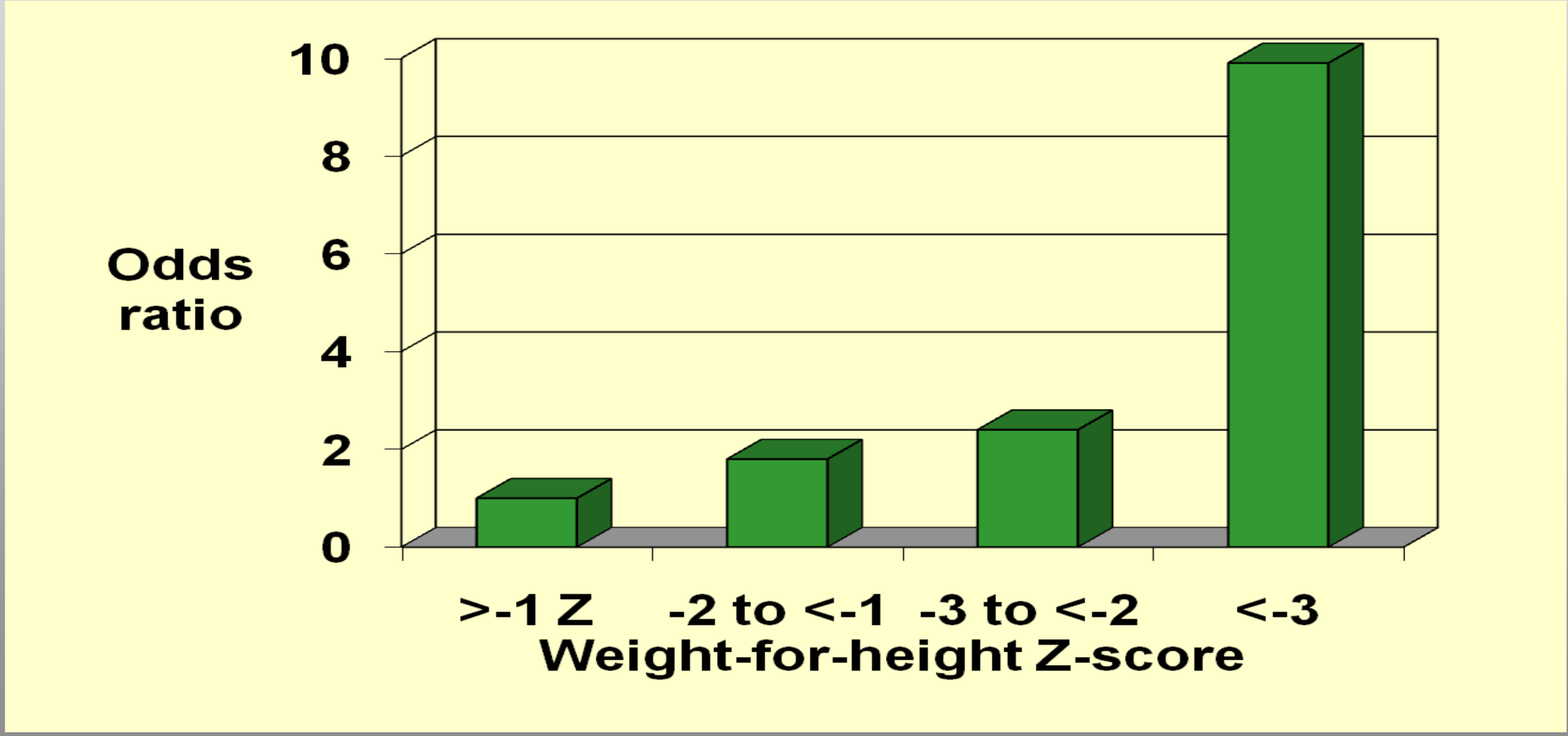
Child mortality rate per 1,000 births, 2003



http://www.who.int/healthinfo/statistics/02.whostat2005graph_under5infantmortality.jpg

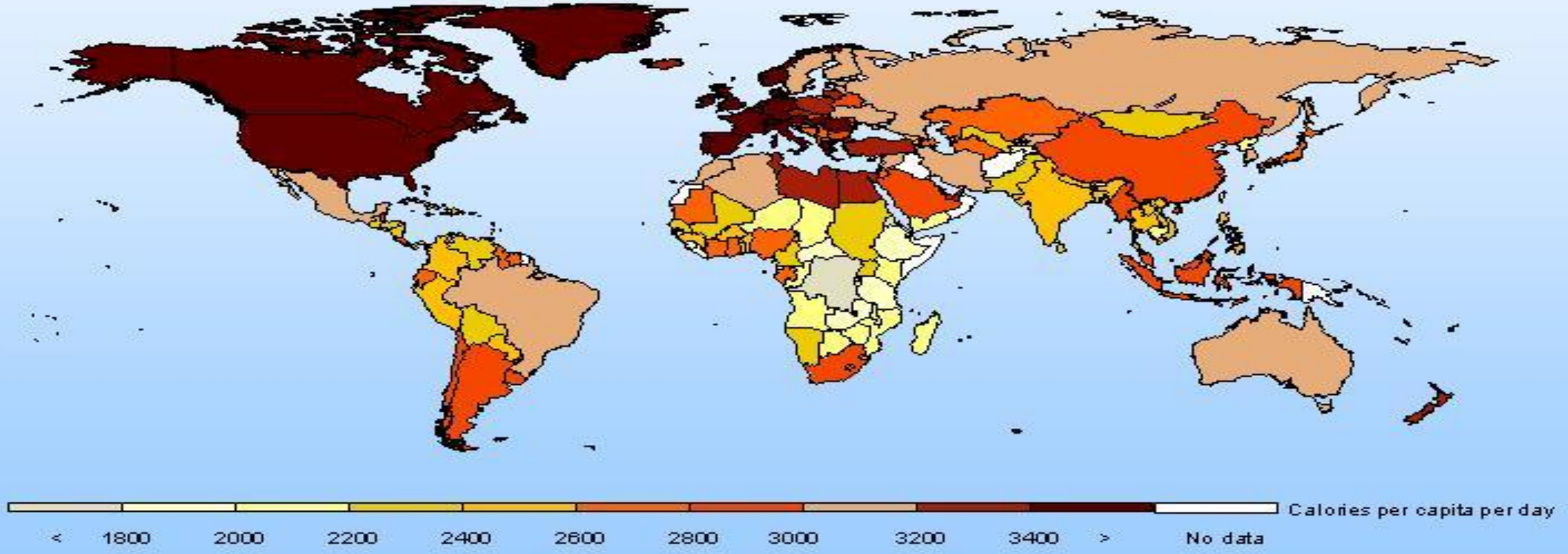

ALL
NATURAL
WHOLE
WHEAT
CEREAL
CHENEY

Mortality risk by weight-for-height Z-score*



**Black et al. Lancet; 2008.*

Dietary energy supply, 2001-2003



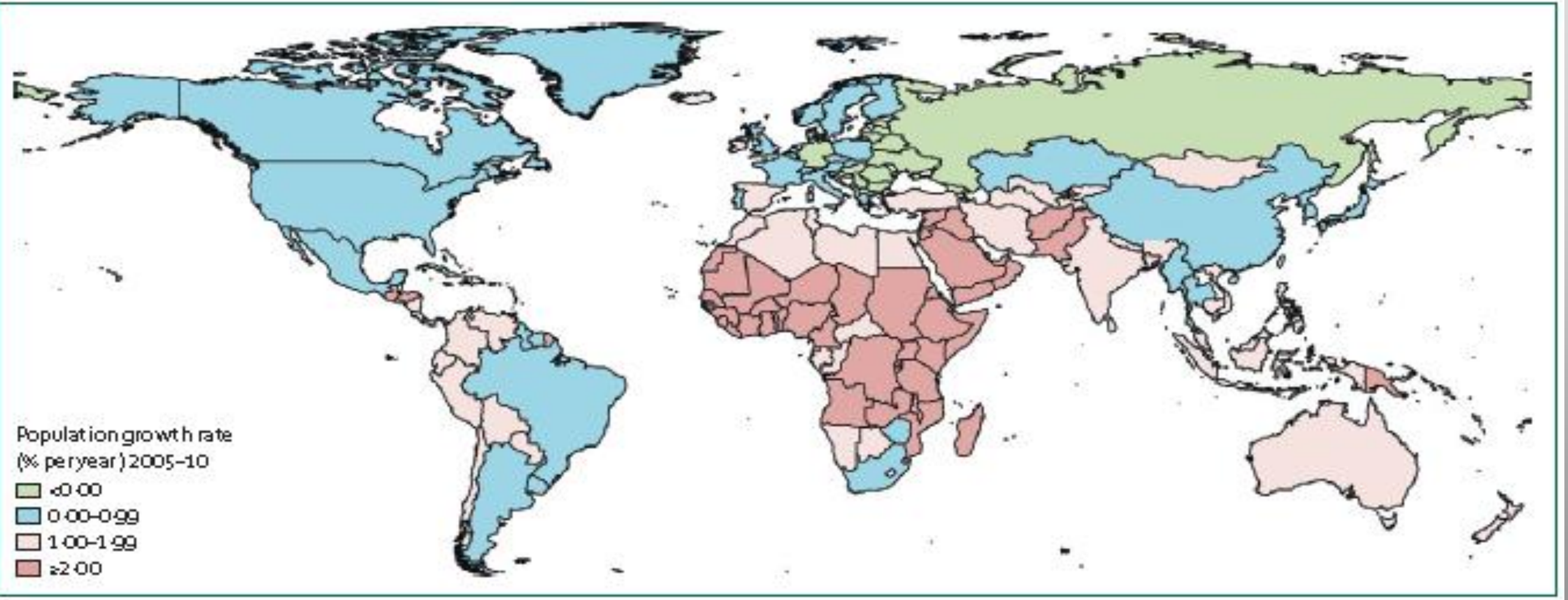


Figure 1: Population growth rate by country
Data from UN, 2011.[1]

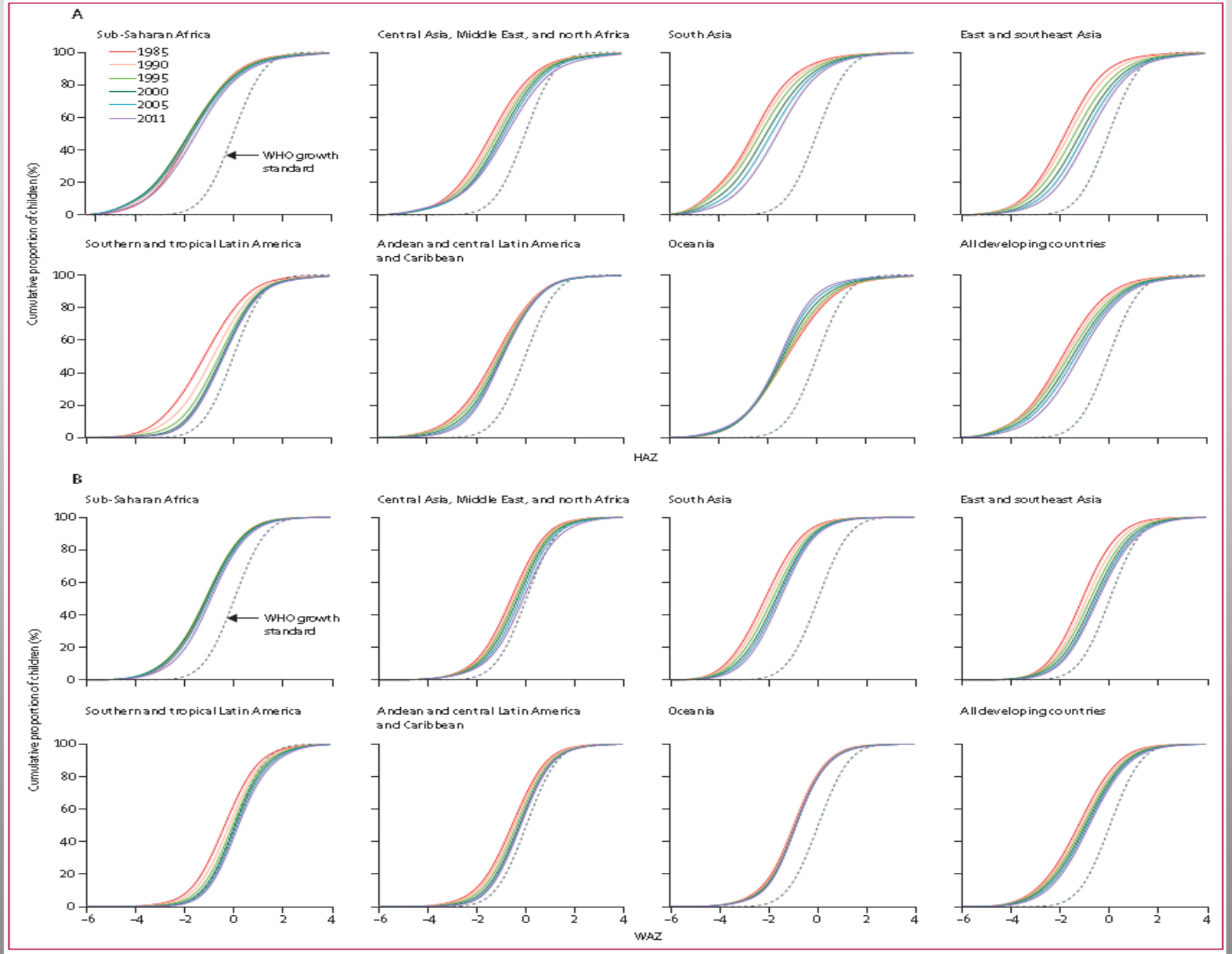
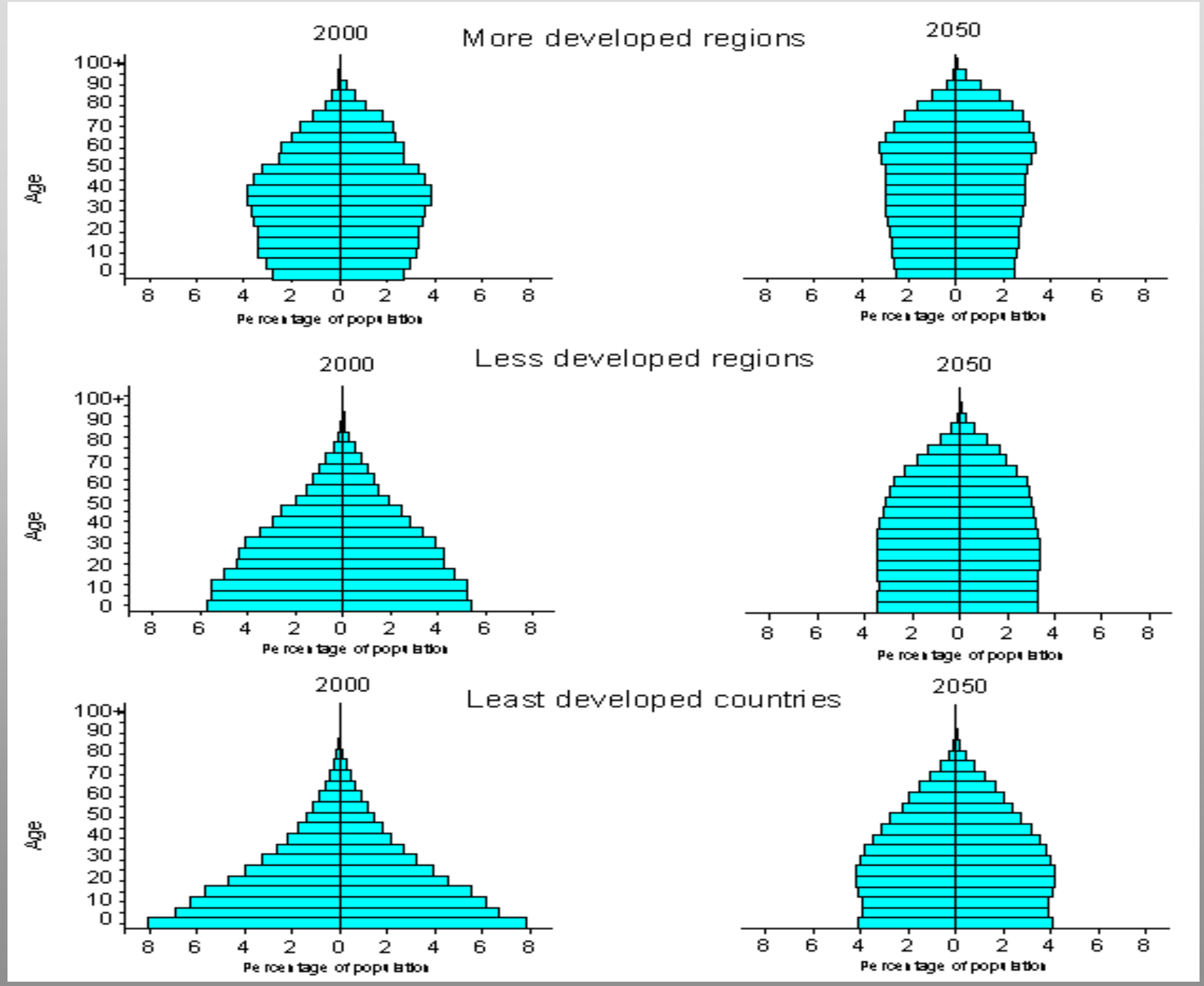


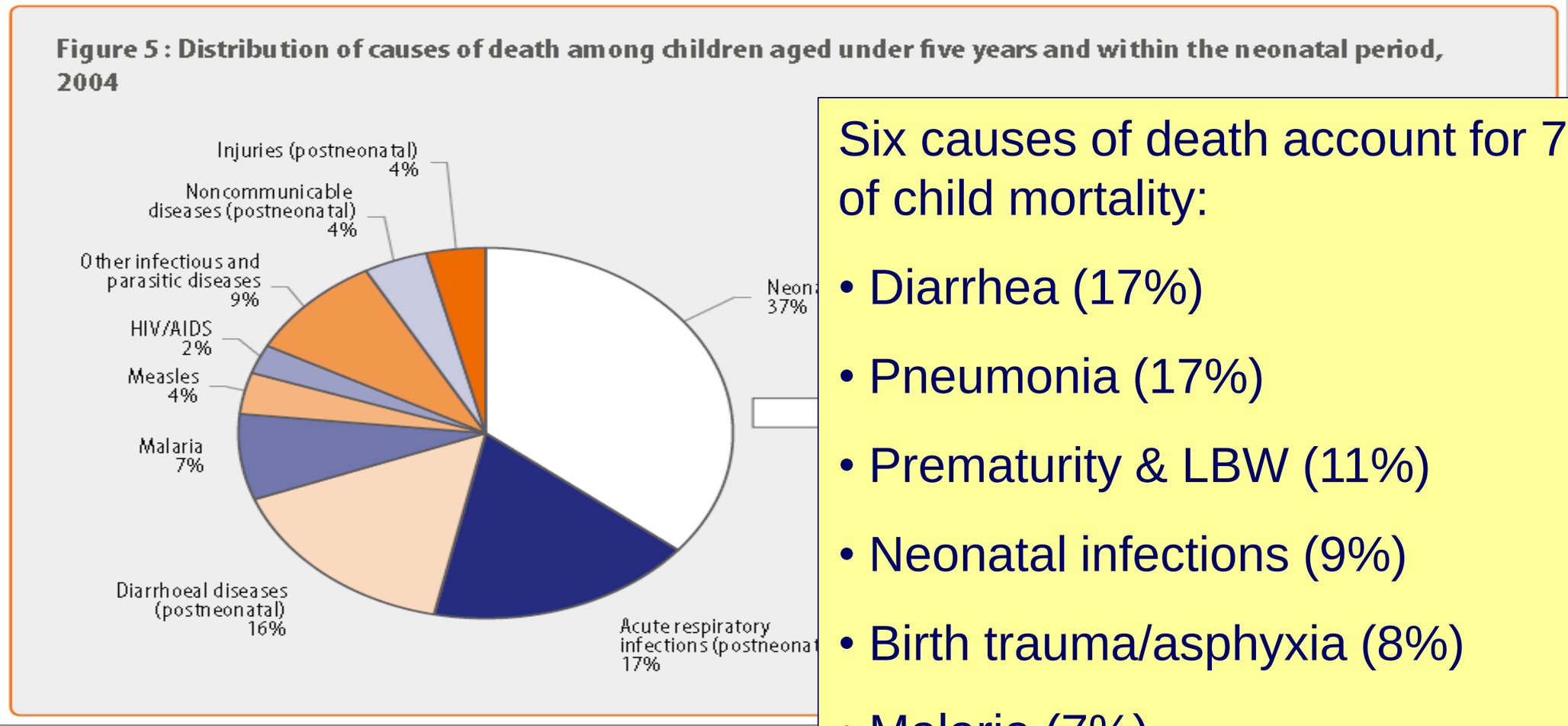
Figure 2: Trends in the cumulative distribution functions for HAZ (A) and WAZ (B) by region
Each curve shows the cumulative proportion of children (y-axis) that lies below a given HAZ or WAZ level (x-axis). Therefore, the lower the curve, the better the nutritional status of the region. All distributions are compared with the WHO standards. We present the trends by country in the appendix (pp 90–231). HAZ=height-for-age Z score. WAZ=weight-for-age Z score.

Population distributions by age, sex, and level of national development 2000 and 2050



Source: The Sex and Age Distribution of the World Populations: 1998 Revision, Volume II: Sex and Age (United Nations publication)

The global burden of disease



Six causes of death account for 73% of child mortality:

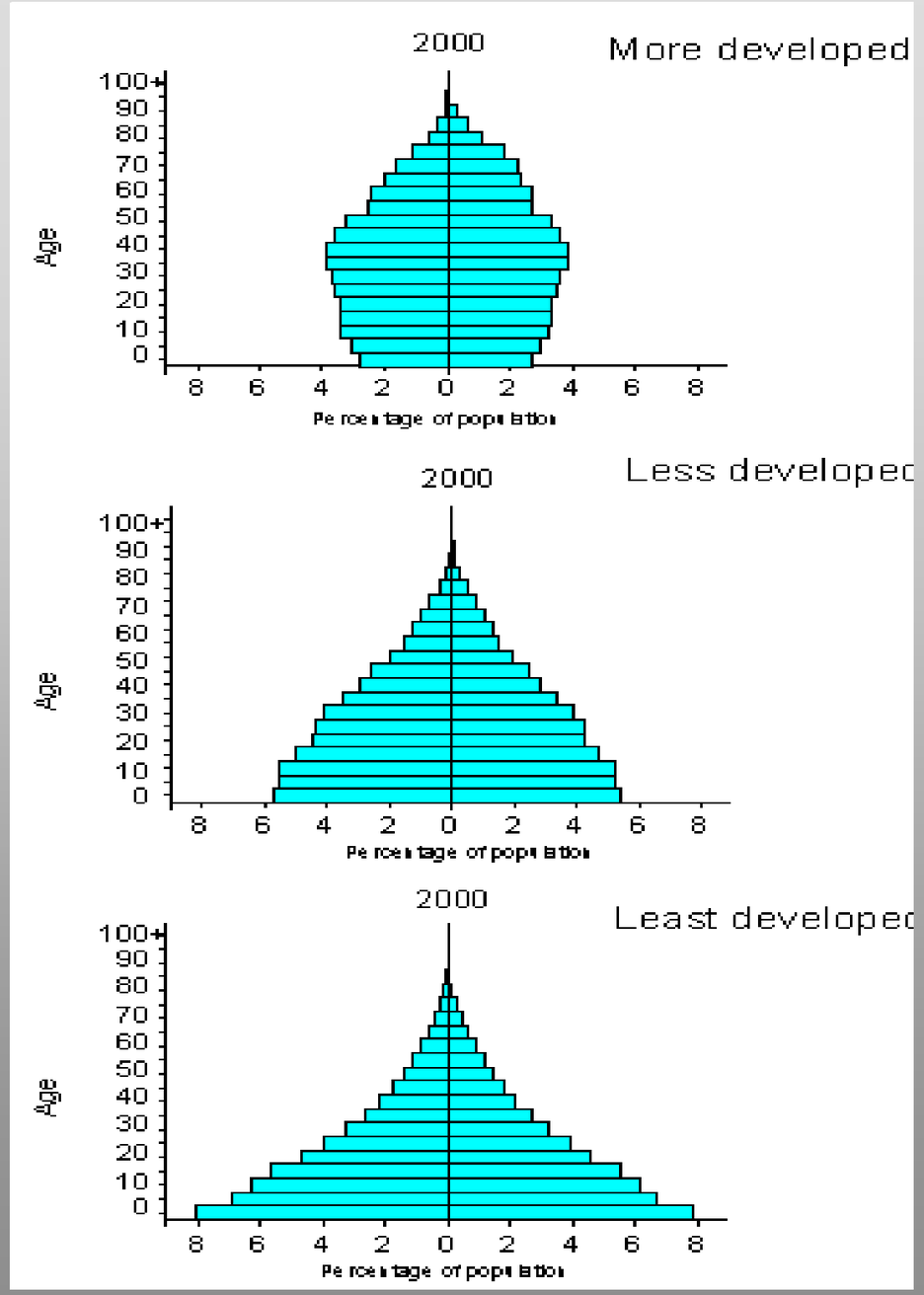
- Diarrhea (17%)
- Pneumonia (17%)
- Prematurity & LBW (11%)
- Neonatal infections (9%)
- Birth trauma/asphyxia (8%)
- Malaria (7%)

WHO Global Burden of Disease Project, 2008

Operational definition of “international nutrition”

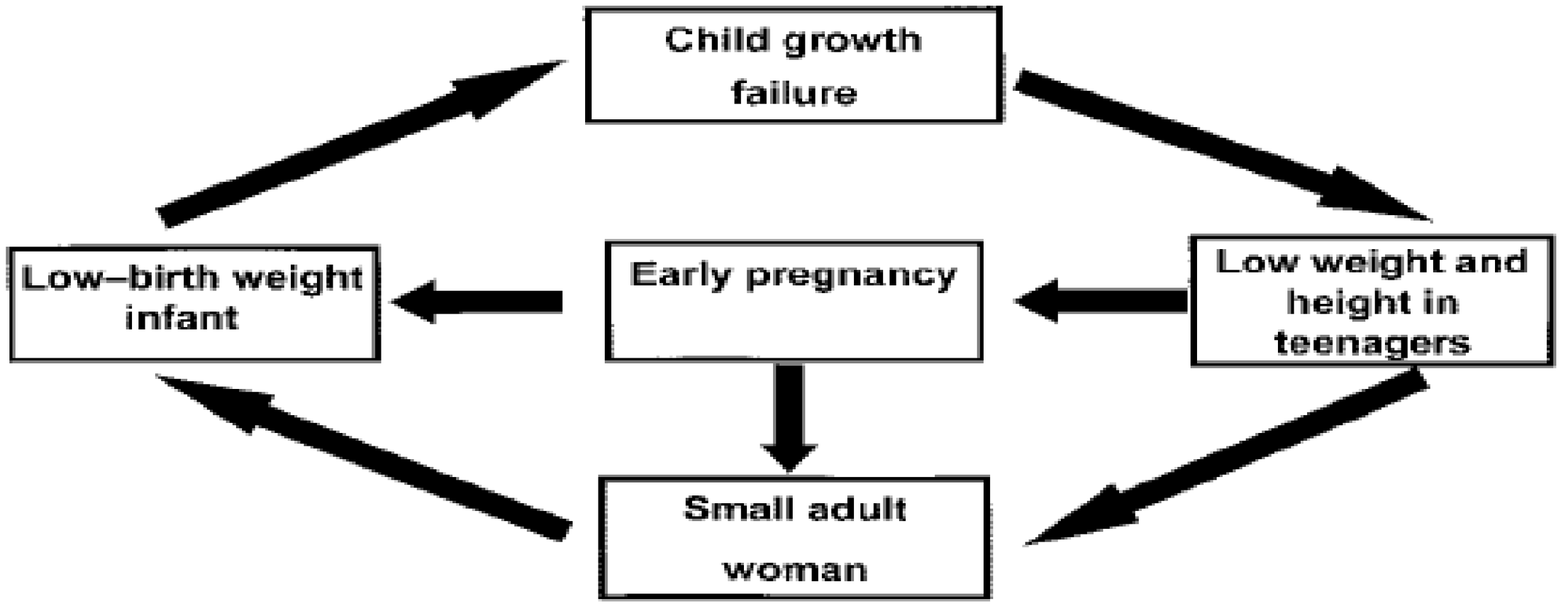
Those aspects of both nutrition science and related social and behavioral sciences that are of particular relevance to the nutritional well-being of human populations of economically less-developed countries

Population distributions by age, sex, and level of national development, 2000



Source: The Sex and Age Distribution of the World Populations: 1998 Revision, Volume II: Sex and Age (United Nations publication)

Intergenerational cycle of growth failure



Copenhagen Consensus -- conclusions

	Top ten investments to solve major global challenges
1	Micronutrient supplements for children (vitamin A and zinc)
2	The Doha development agenda
3	Micronutrient fortification (iron and salt iodization)
4	Expanded immunization coverage for children
5	Biofortification
6	Deworming and other nutrition programs at school
7	Lowering the price of schooling
8	Increase and improve girls' schooling
9	Community-based nutrition promotion
10	Provide support for women's reproductive role

www.copenhagenconsensus.com

Prevalence of overweight (BMI >25 kg/M^2) among women ≥30 yr, 2005

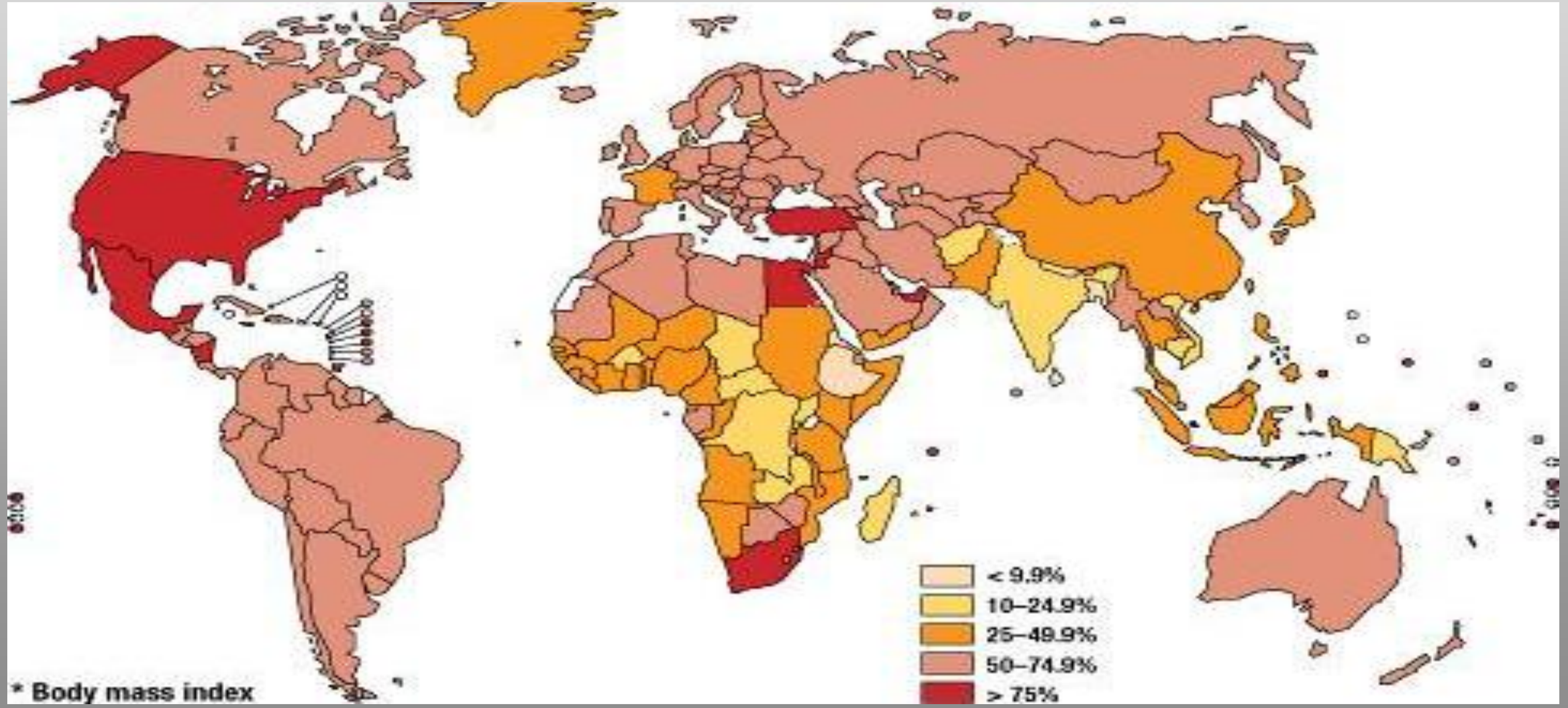


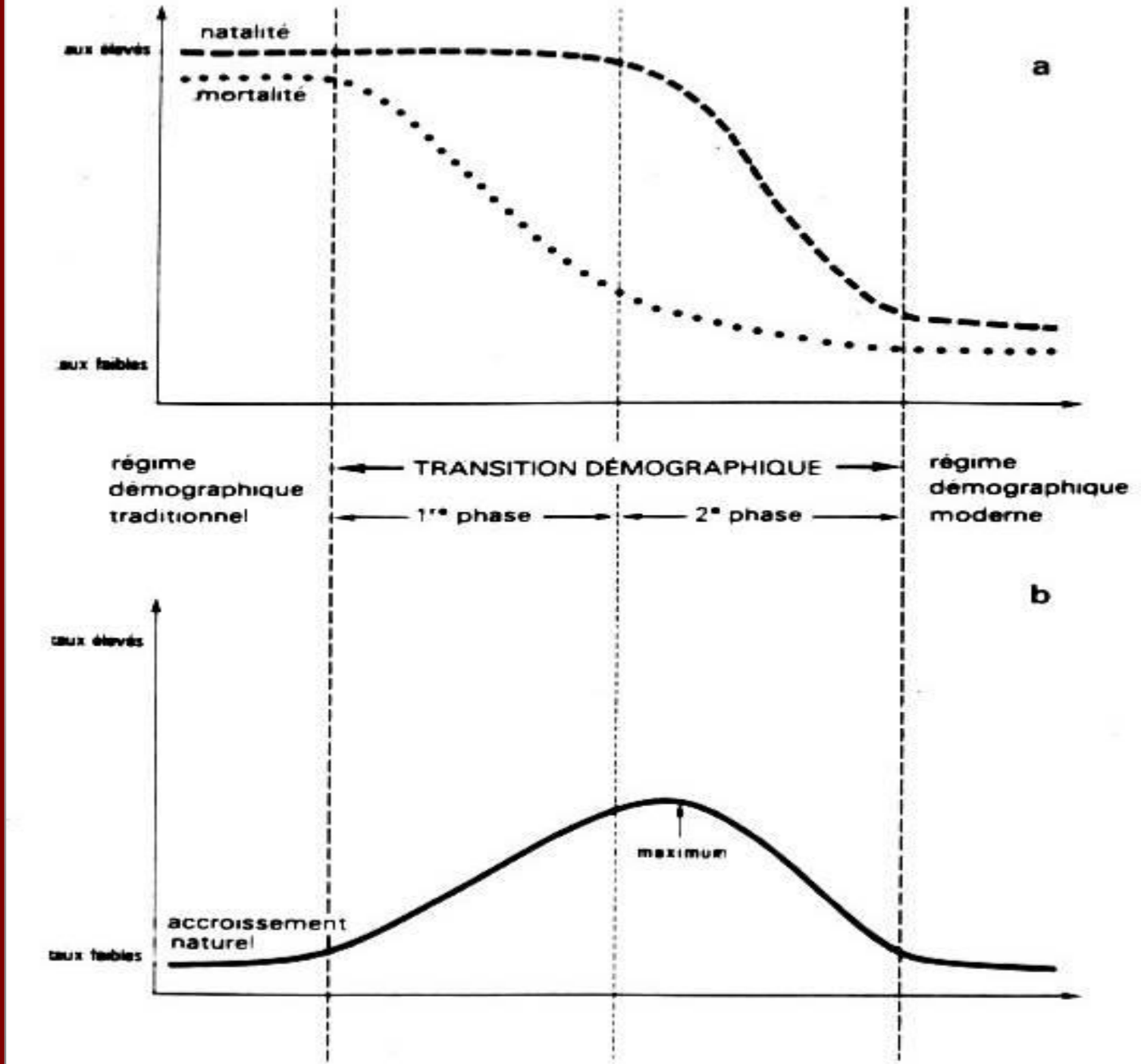
Figure from: WHO. Preventing chronic diseases: a vital investment, 2005

Indicators of socio-economic development*

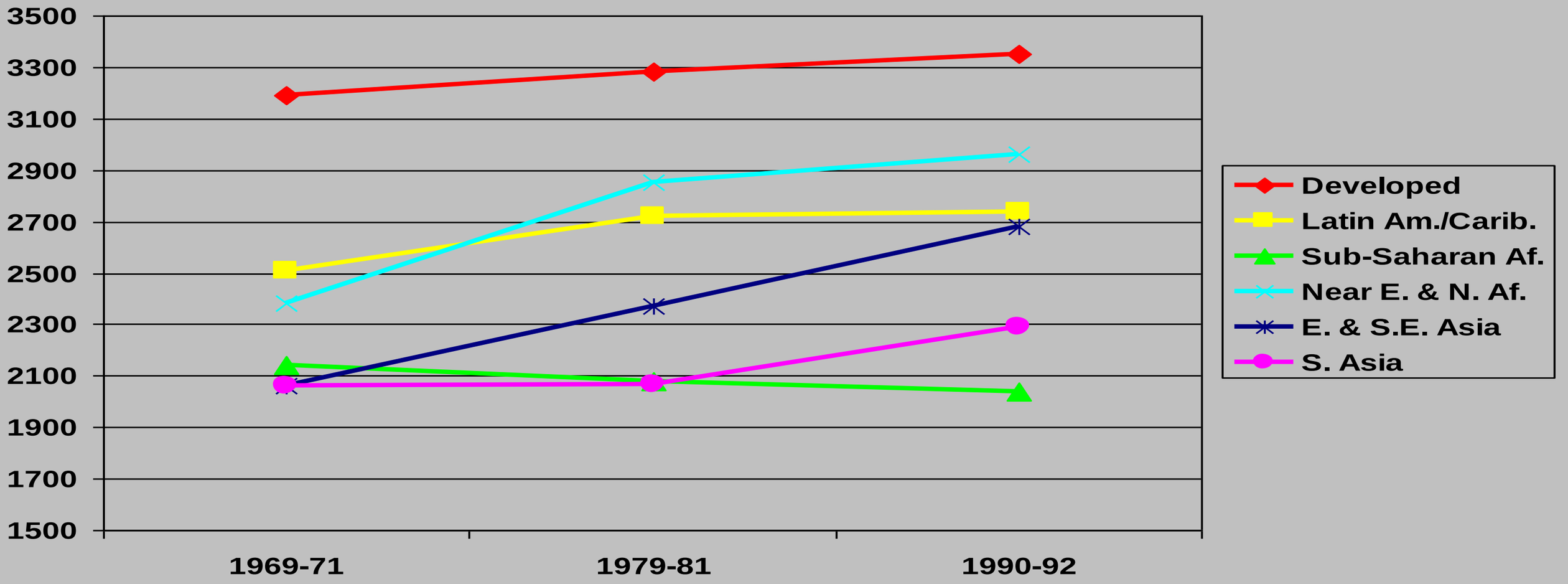
- **Economic**
  - GNI *per capita,* %GNP for education, %GNP for health
- **Demographic**
  - Population growth rate, % urban, fertility rate
  - IMR, U5MR, MMR
- **Food supply**
  - Per capita energy availability
- **Education**
  - % enrollment, % reaching grade 5, literacy (% >15)
- **Health**
  - Access to safe water
  - Physician/population, hospital bed/population
  - Reproductive health, women 15-49 (contraceptive prev, HIV prev)

*See UNDP world development reports.

Theoretical model of the demographic transition



Dietary energy supply by region and economic development over time



Sixth World Food Survey. FAO, p 11, 1996

Number of stunted and underweight children, by year and region

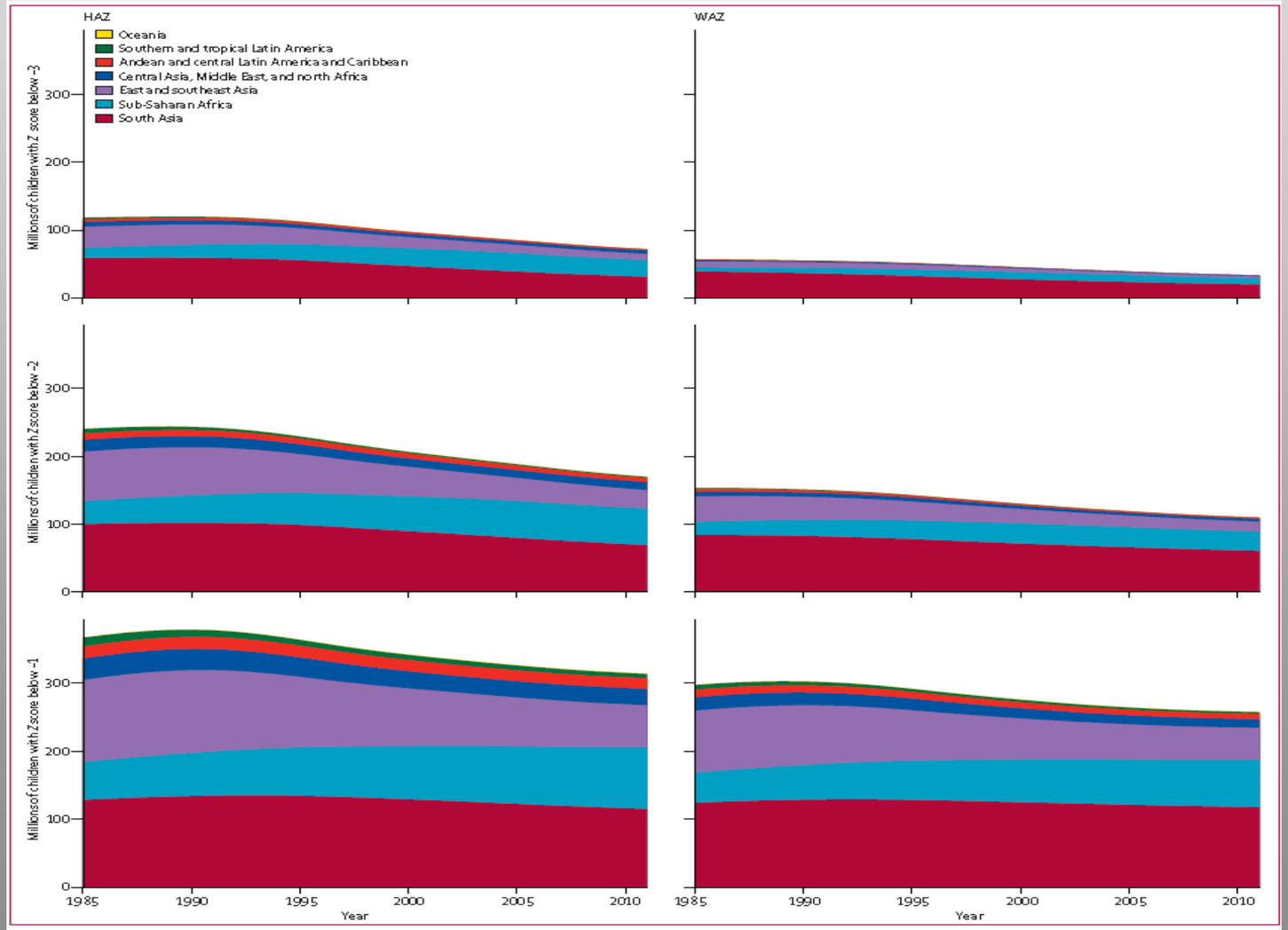


Figure 4: Number of children in the mild to severe parts of the HAZ and WAZ distributions, by region
The number of children with Z scores below –1 includes all children below this cutoff, including those with Z scores below –2 and –3. Similarly, the number of children with Z scores below –2 includes all children below this cutoff, including those with Z scores below –3. HAZ=height-for-age Z score. WAZ=weight-for-age Z score.

Stevens GA et al (NIMS). Lancet, 2012.