Nutrition of women, reproductive outcomes and stunting

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Women's nutrition and selected outcomes

Pre-conception
- Growth failure in early life
- Short adult stature
- Adolescent pregnancy
- Pre-conception BMI
- Micronutrient status

Pregnancy
- Weight gain
- Diet
- Micronutrient status

Interpregnancy
- Birth interval

Outcomes
- Marriage market
- Mortality (mother, fetus, child)
- Fetal growth and birth size
- Pre-term
- Stunting
- Human capital

Linear growth potential from conception to at least 5 years of age is similar around the world

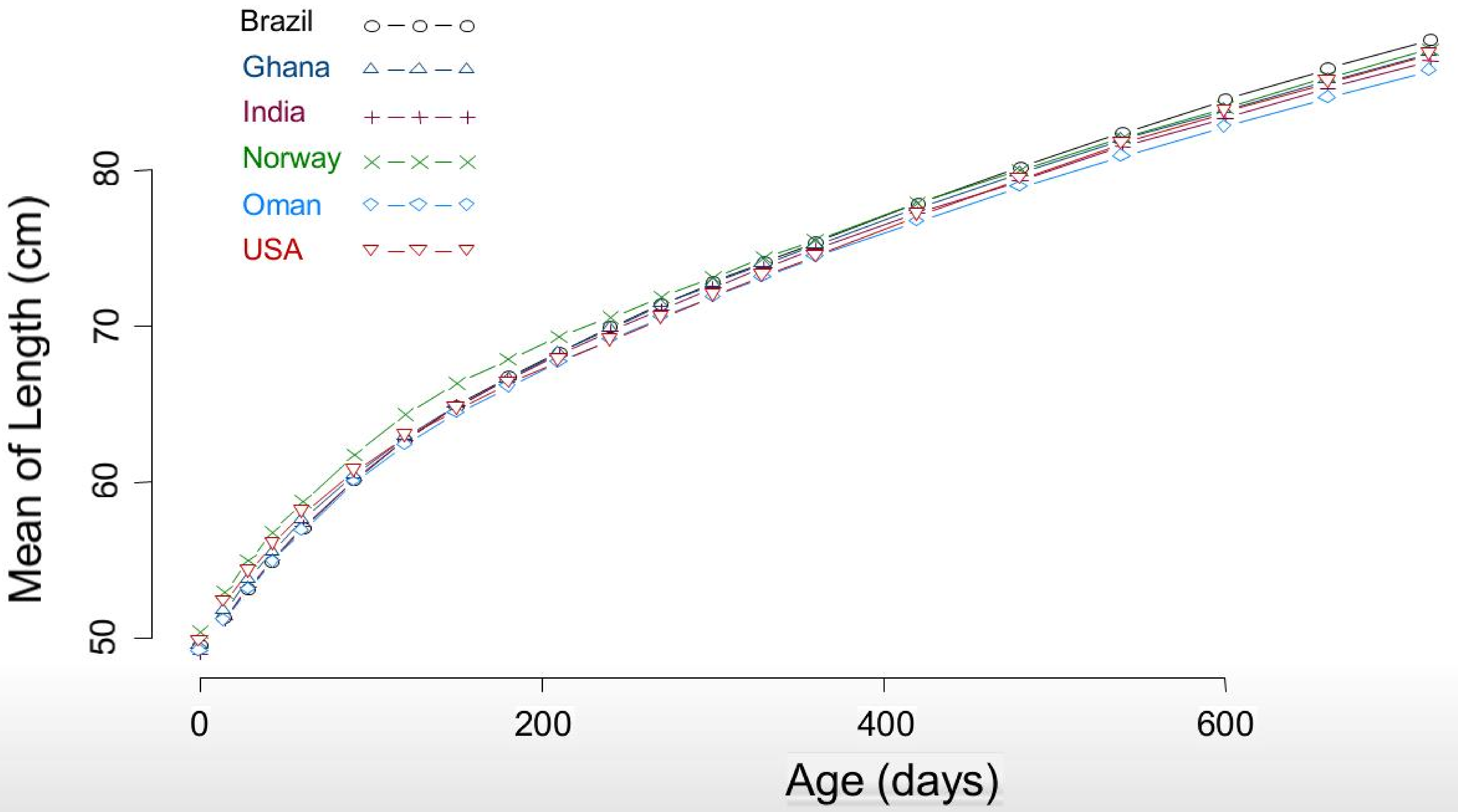
WHO Multicentre Growth Reference Study (MGRS)

MGRS uses **a** prescriptive approach and is therefore a Standard

- Optimal Nutrition
  - Breastfed infants
  - Timely complementary feeding
- Optimal Environment
  - Adequate environmental sanitation
  - No maternal smoking
- Optimal Health Care
  - Immunization
  - Routine Paediatric care

→ Optimal Growth

Mean length in the first 24 months in the children studies for the WHO child growth standards



M de Onis, C Garza, A W Onyango & R Martorell (Eds). WHO Multicentre Growth Reference Study Group. Assessment of linear growth differences among populations in the WHO Multicentre Growth Reference Study. Acta Paediatrica (2006).

The International Fetal and Newborn Consortium for the 21st Century (INTERGROWTH-21st)

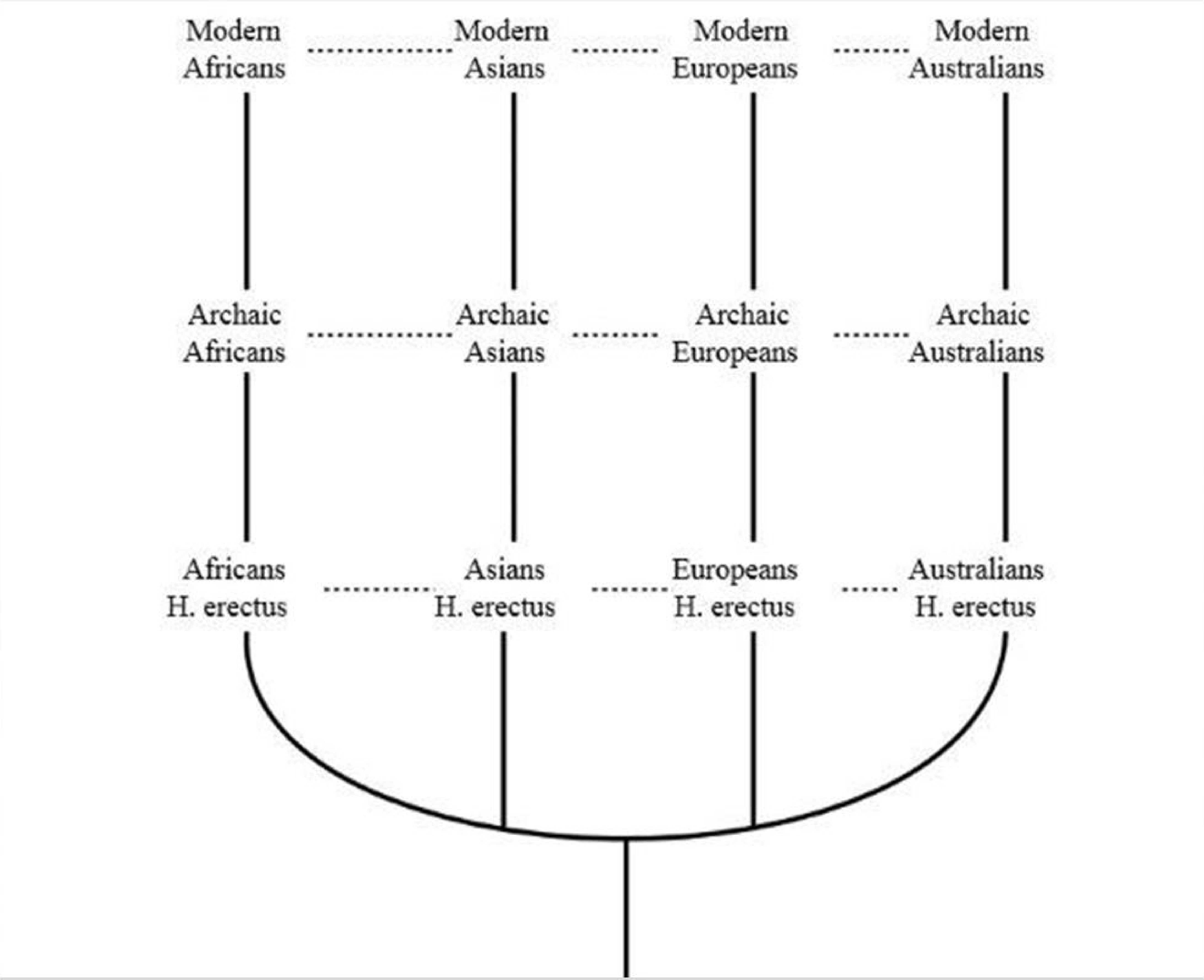
- Based on healthy populations from 8 countries: Brazil, China, India, Italy, Kenya, Oman, UK, USA.
- Fetal growth measurements: head circumference, biparietal diameter, occipitofrontal diameter, abdominal circumference and femur length.
- Fetal growth was similar in the 8 countries.
- Fetal growth curves just published in The Lancet.

Corollary

Marked differences in growth among populations, whether among or within countries, are a reflection of social inequalities and poor health and nutrition

What explains the similar growth of well-nourished children from around the world?

The Candelabra model of human evolution



Africa

Henn, B.M., Cavalli-Sforza, L.L. & Feldman, M.W. **The great human expansion**. *Proc. Natl. Acad. Sci. USA* 109, 17758–17764 (2012).

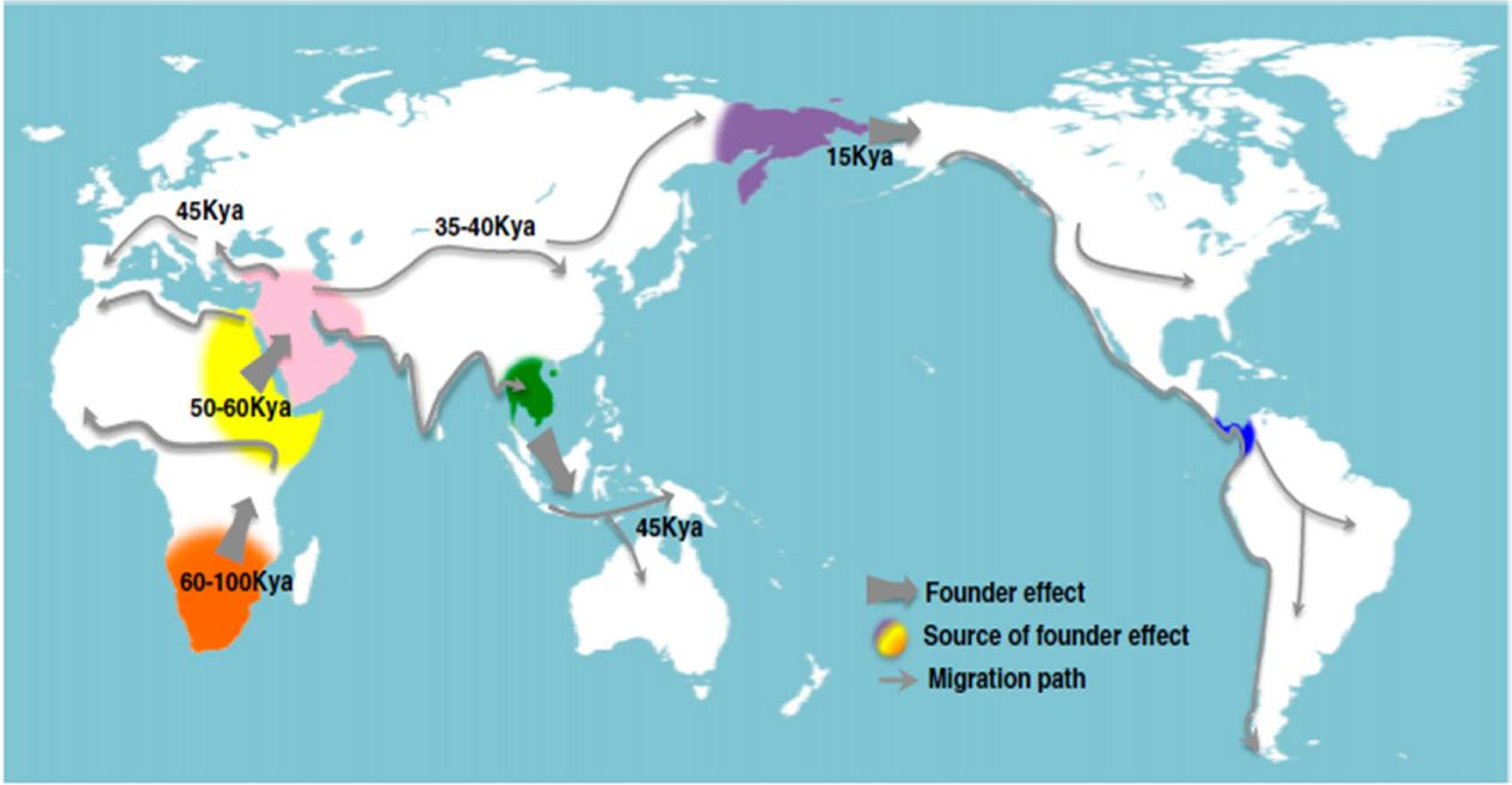
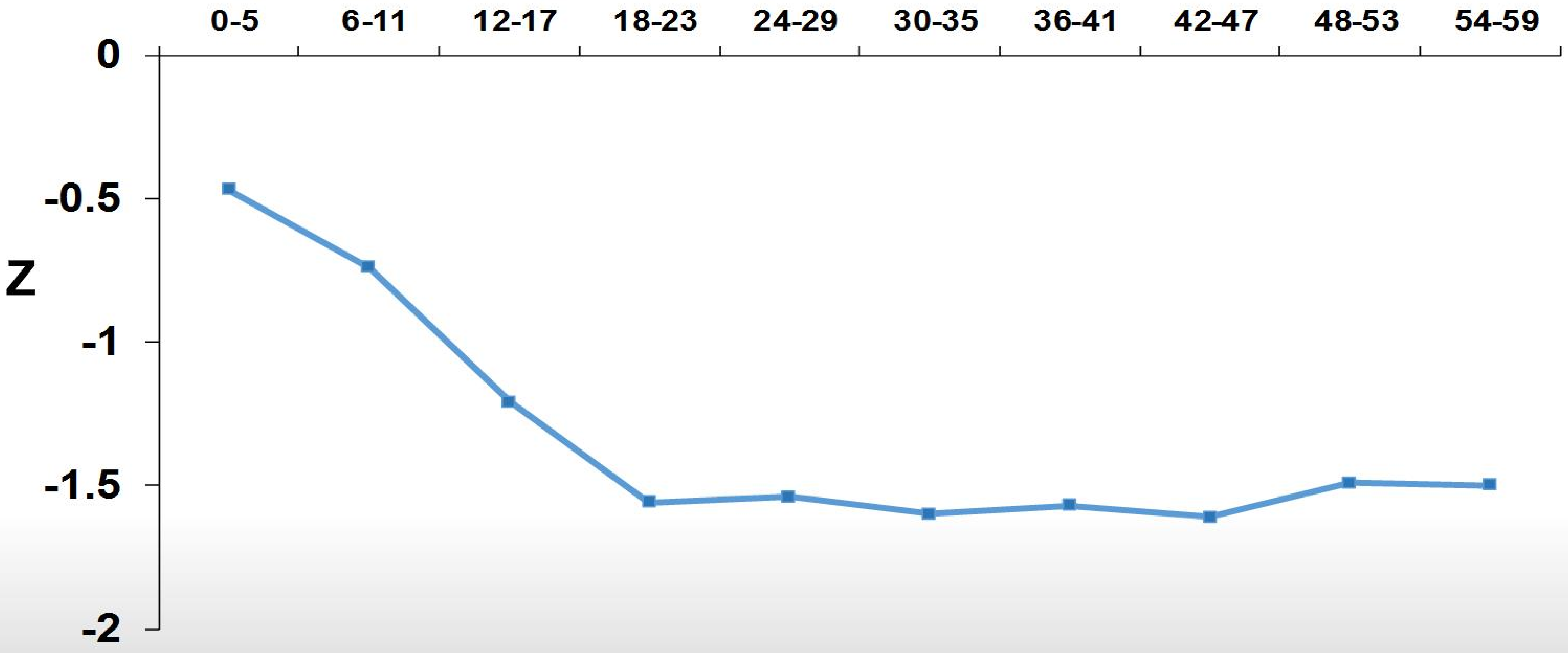


Fig. 1. Ancient dispersal patterns of modern humans during the past 100,000 y. This map highlights demic events that began with a source population in southern Africa 60 to 100 kya and conclude with the settlement of South America approximately 12 to 14 kya. Wide arrows indicate major founder events during the demographic expansion into different continental regions. Colored arcs indicate the putative source for each of these founder events. Thin arrows indicate potential migration paths. Many additional migrations occurred during the Holocene (11).

Linear growth failure in early life

- Begins in utero and continues until around 24 months (first 1000 days)
- About 20% of stunting at 2y is attributed to SGA (*Black et al, 2013*)

Mean Z-scores for height-for-age relative to the 2006 WHO standards for Peru, 2000



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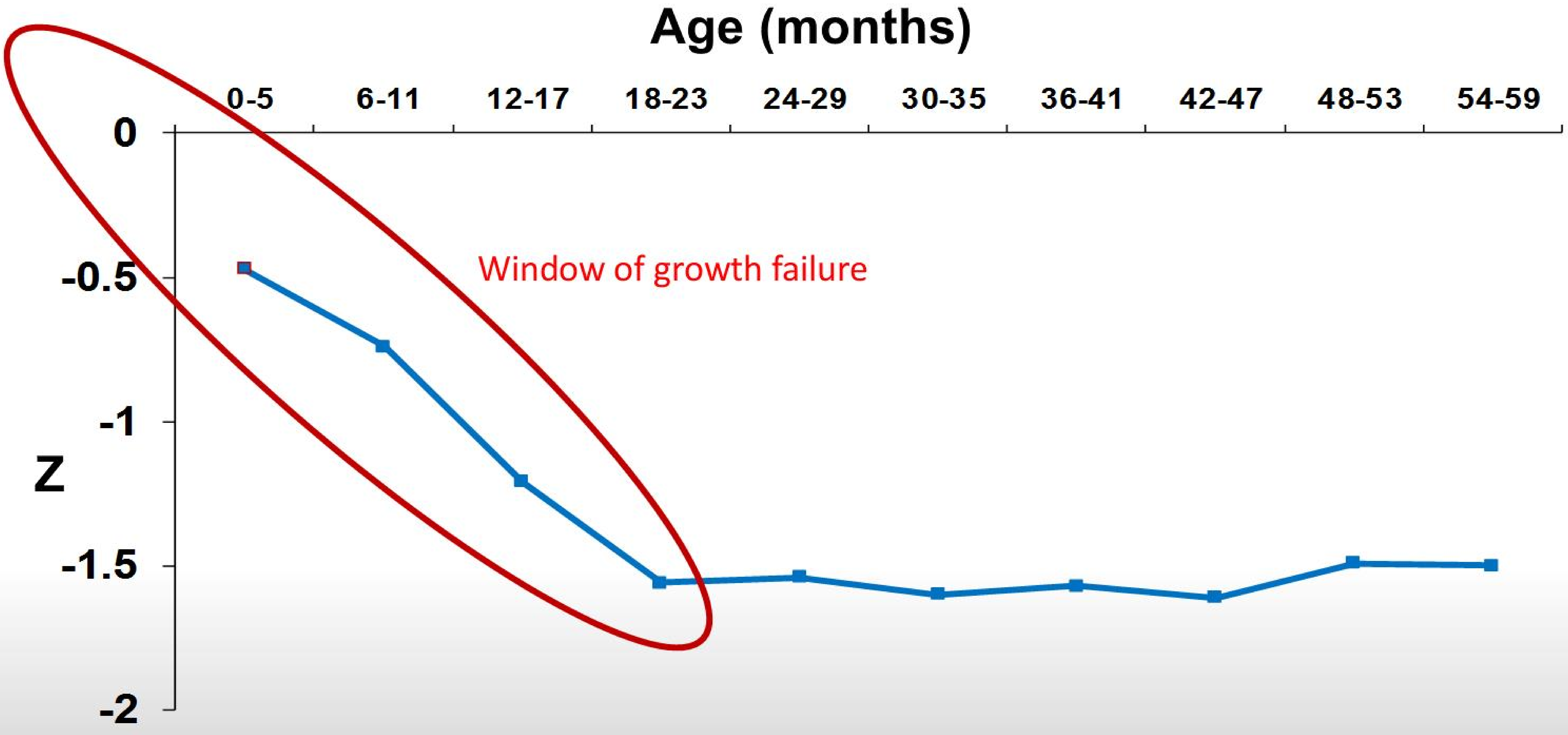
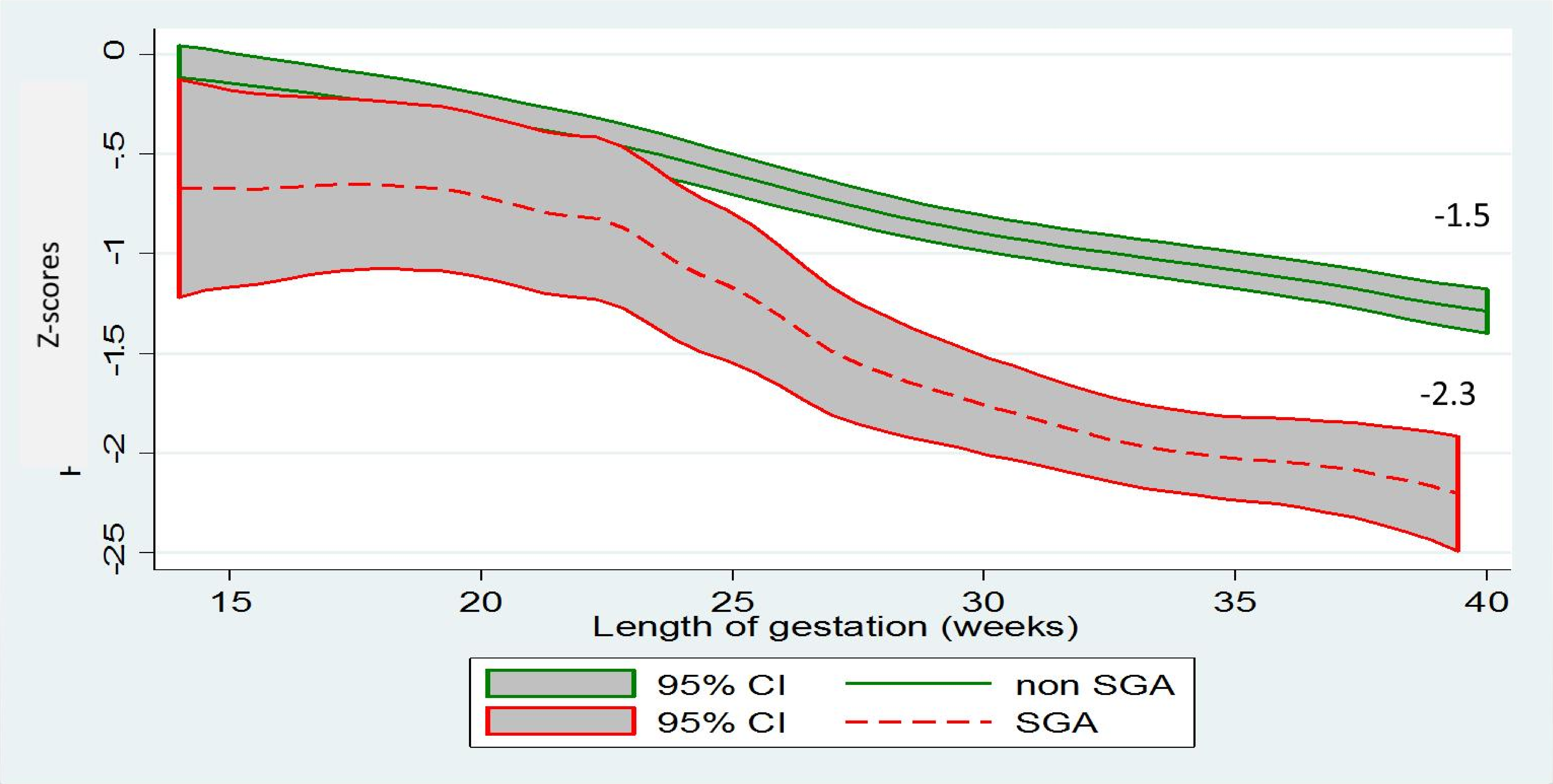
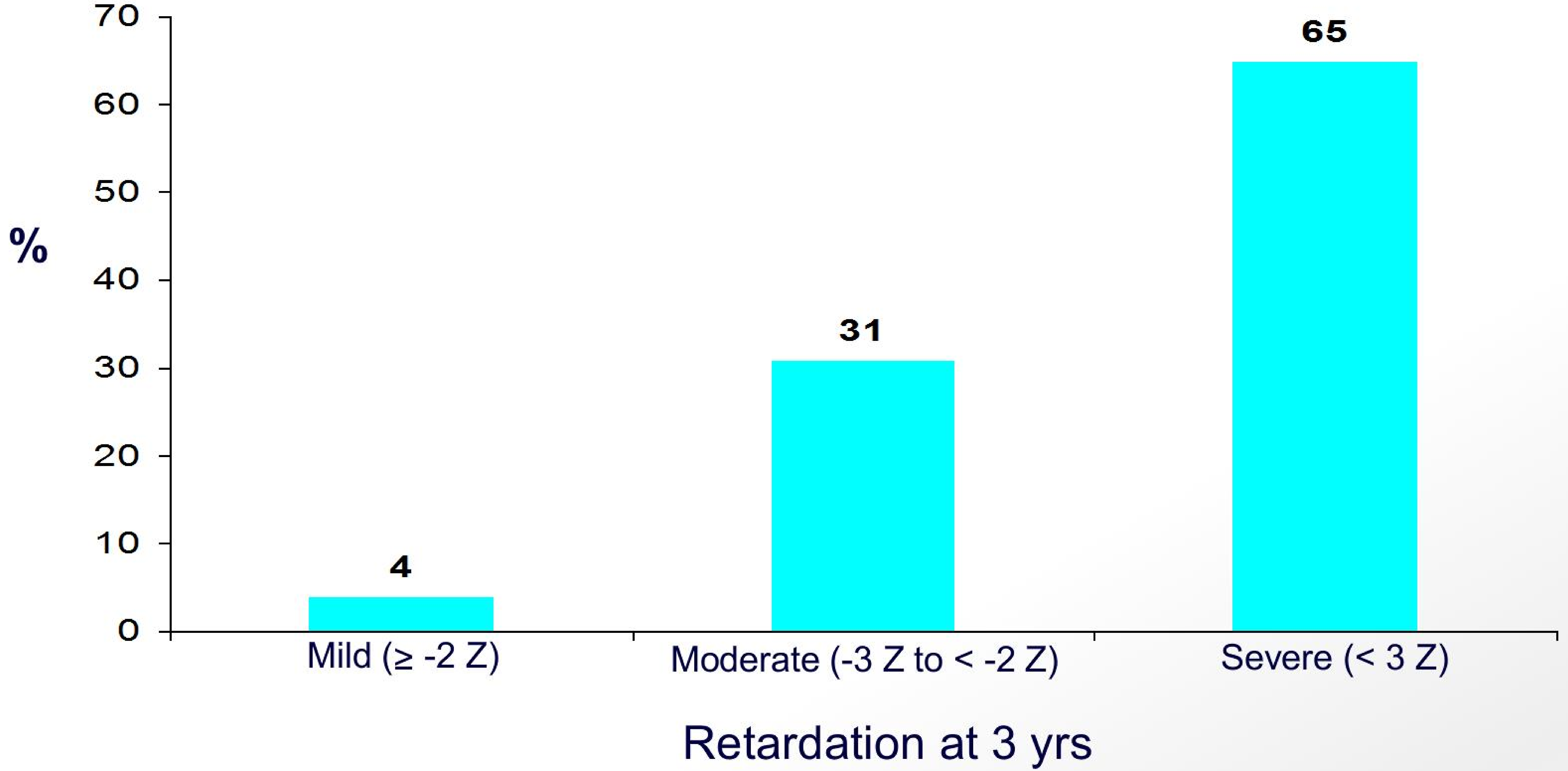


Mean Z scores based on INTERGROWTH-21st fetal growth standards for head circumference obtained by ultrasound (14-40 weeks of gestation) by SGA status at birth; Vietnam (Phuong et al, in preparation)



The short stature observed in adults in poor countries is an outcome of growth failure in early life

Percent low stature (< 148 cm) in Guatemalan women by degree of growth retardation at 3 yrs of age (unpublished)



Growth in early childhood influences birthweight of the next generation

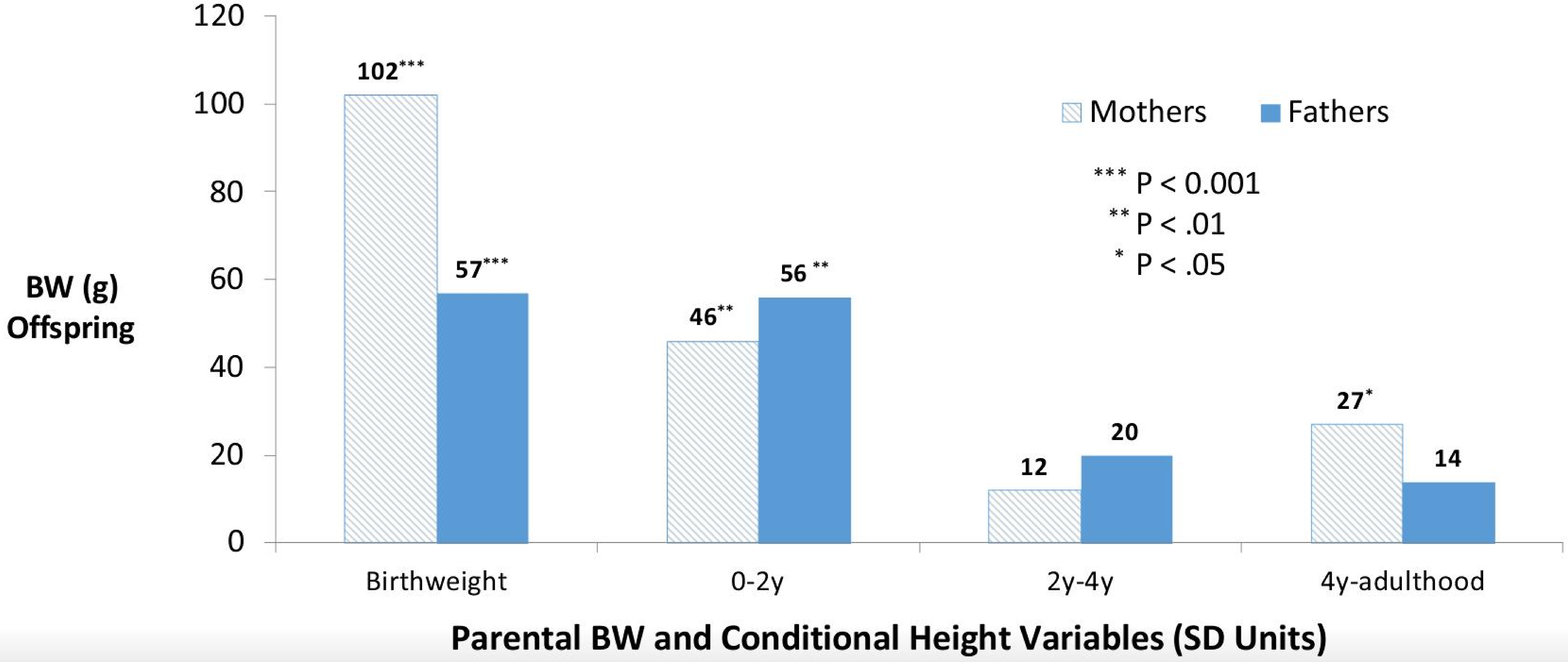
Parental childhood growth and offspring birthweight in cohorts from Brazil, Guatemala, India and the Philippines[+,++]

- 2,031 mothers and 3,455 offspring
- 1,361 fathers and 2,051 offspring

[+] Analyses and adjusted for sibling clustering, offspring sex, birth order, parental nutrition supplementation and study site.

[++] Addo et al. Parental childhood growth and offspring birthweight: pooled analyses from four birth cohorts in low and middle income countries. *Am. J. Hum. Biol* 27:99-105, 2015.

Change in offspring birthweight associated with a change in 1 standard deviation in parental birthweight and in linear growth



Associations between parental stunting at 2 years and offspring birthweight in 4 birth cohorts (3,392 parents; 5,506 offspring)+, ++

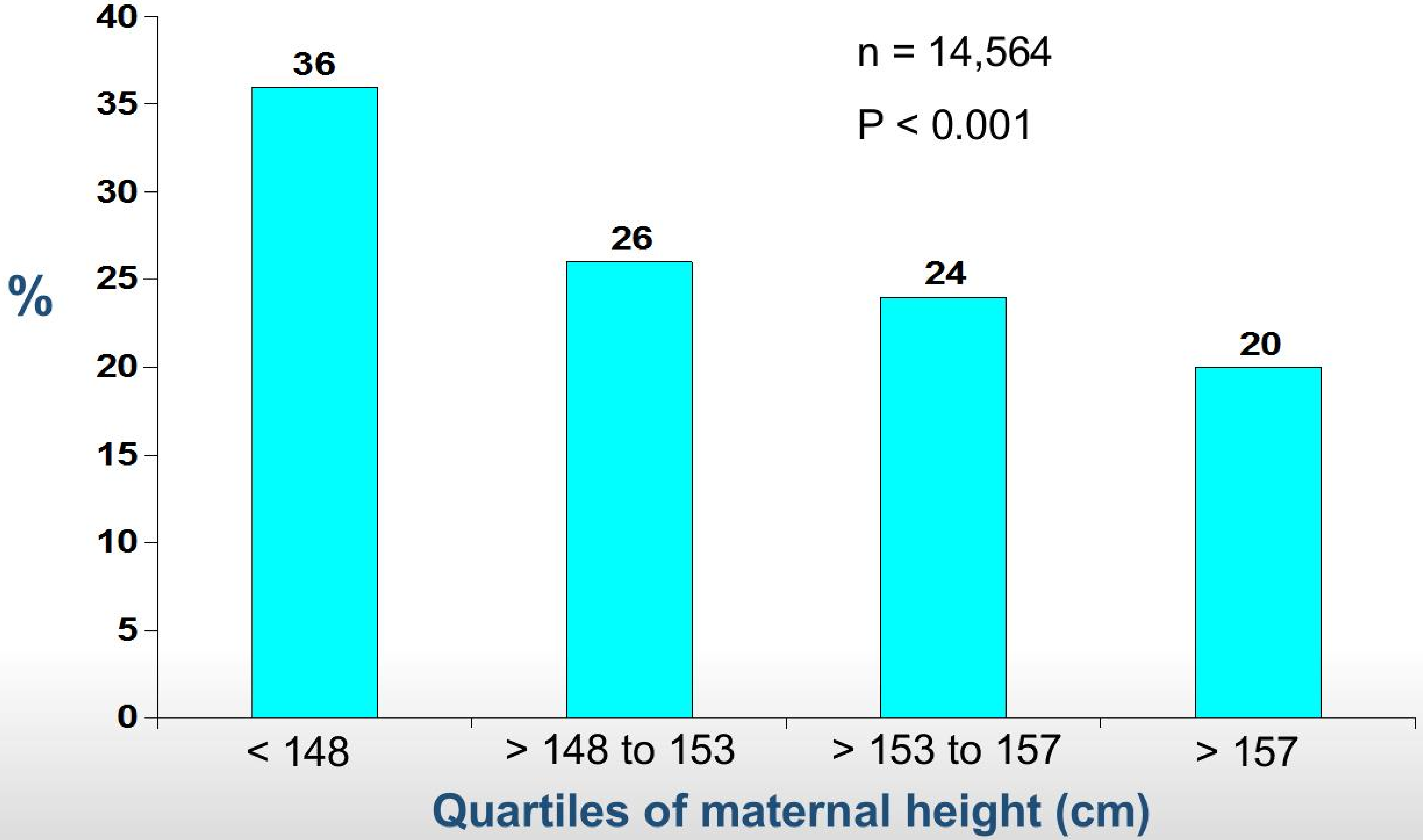
	Birthweight (g)	
Parental stunting status	Coefficient (95% CI)	*P*-value
Maternal stunting at 2 years	-108 (-160, -55)	< 0.01
Paternal stunting at 2 years	-29 (-95, 38)	0.40

+ Mixed linear and logistic models are adjusted for parental early childhood SES (quintiles), maternal/paternal firstborn status, offspring sex and firstborn status, nutrition supplementation status, site (4 categories), maternal age at delivery (< 18, ≥ 18 years), and sibling clustering (with random intercepts). Estimates obtained from multiple imputation analyses of 15 replicate datasets.

++ Addo et al. Parental childhood growth and offspring birthweight: pooled analyses from four birth cohorts in low and middle income countries. *Am. J. Hum. Biol* 27:99-105, 2015.

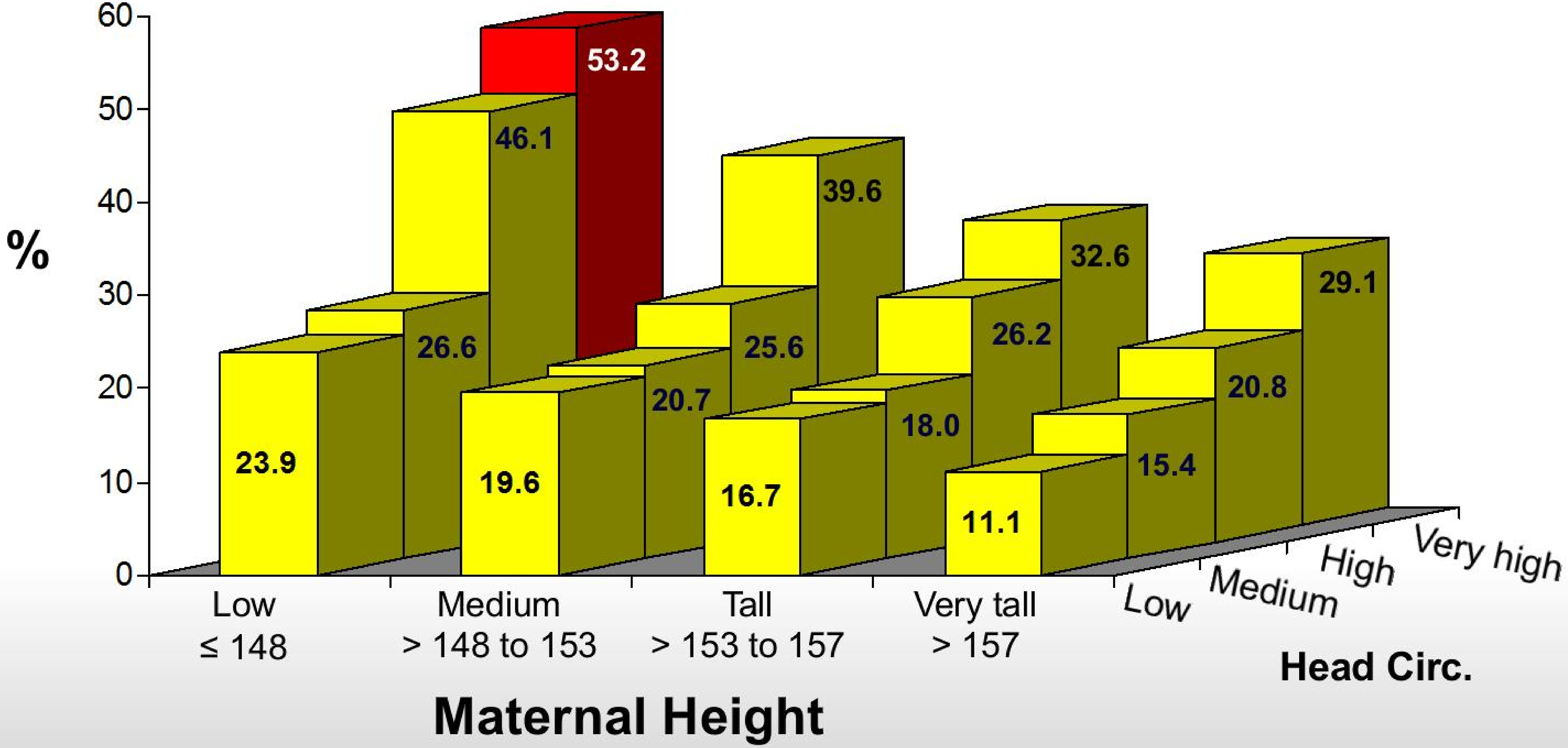
Short stature in adulthood increases delivery complications and risk of maternal and infant death

Incidence of intrapartum cesareans by quartile of height in the Social Security Hospital of Guatemala+



+ Merchant et al. *Br J Obstet Gynaecol* 108:689-696, 2001

Incidence of Intrapartum Cesareans in the Social Security Hospital of Guatemala by quartiles of maternal height and newborn head circumference+



+Merchant et al. *Br J Obstet Gynaecol 108:689-696, 2001*

Adult consequences of growth failure in early childhood

Hoddinott, Berhman, Maluccio, Melgar, Quisimbing, Ramirez-Zea, Stein, Yount, and Martorell. *Am J Clin Nutr* 2013; 98:1170-8.

Adult outcomes (25-42 yrs)+

Stunting at 2 yrs of age →

- Schooling
- Intellectual functioning
- Poverty
- Marriage market
- Fertility (women only)

+ *1328 adults; sample size varies by outcome*

Stunting, schooling and adult intellectual functioning

In comparison to those not stunted, stunted individuals:			
• leave school earlier	-3.1 years	(-5.9, -0.4)	P = 0.026
• have less schooling	-4.6 grades	(-7.8, -1.5)	P = 0.004
• perform poorly in reading⁺	-1.3 S.D.	(-2.3, -0.3)	P = 0.003
• are less intelligent⁺⁺	-1.1 S.D.	(-2.0, -0.3)	P = 0.006

⁺ Interamerican Reading Series; S.D., standard deviation

⁺⁺Raven's standard Progressive Matrices, S.D., Standard Deviation

Stunting, and household poverty

In comparison to those not stunted, stunted individuals live in households that:			
• have lower per capita household expenditures	-53%	(-73.0, -18.0)	P = 0.006
• have greater probability of living in poverty⁺	42 pp	(2.0, 82.0)	P = 0.040

⁺ With expenditures below the poverty line
pp = percentage points

Stunting at 2y and the marriage market

In comparison to spouses of those not stunted, stunted individuals have spouses that:			
• marry at a younger age	-6.8 years	(-11.7, -1.9)	P = 0.007
• have less schooling	-4.4 grades	(-7.7, -1.1)	P = 0.009
• are shorter	-3.3 cm	(-7.5, 0.9)	P = 0.124^{+}

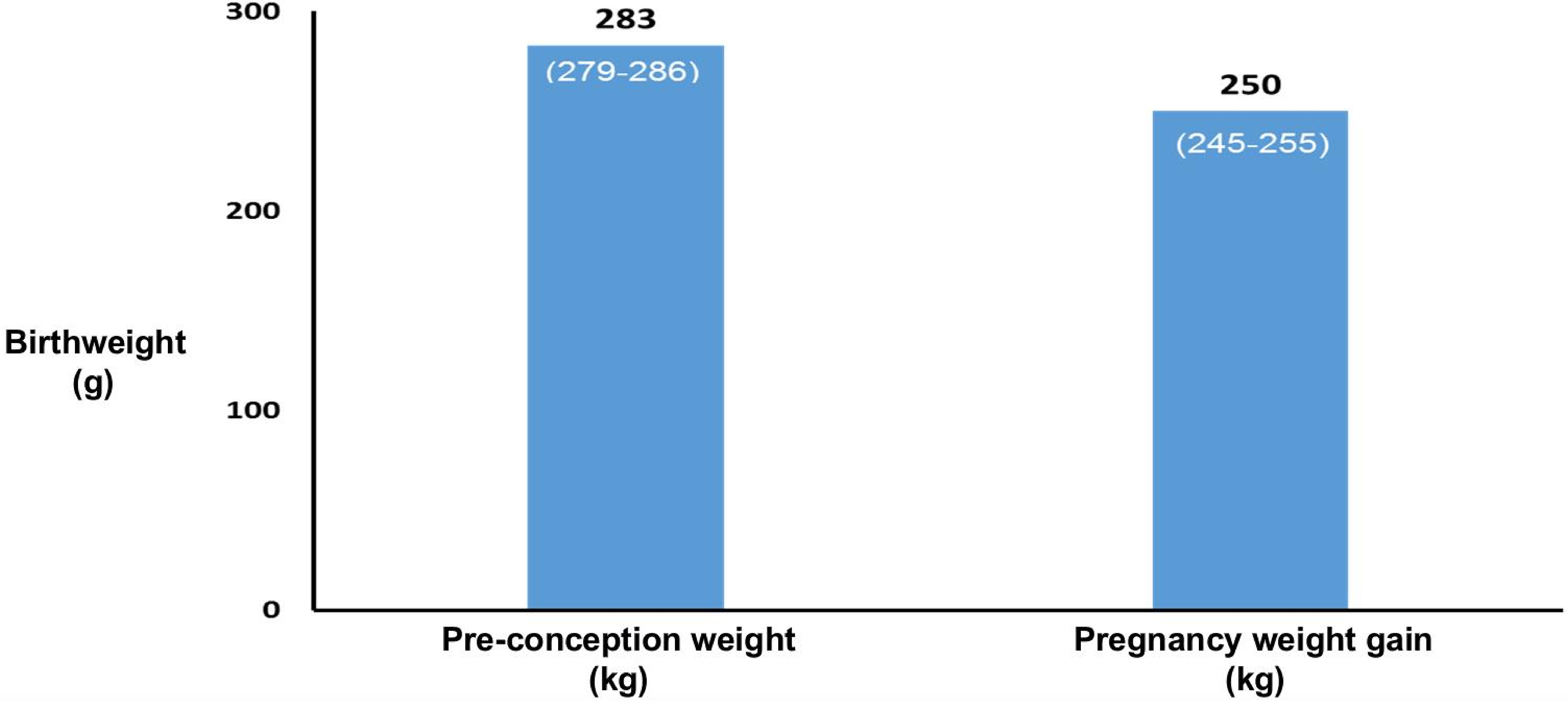
$^{+}$This relationship is significant in continuous analyses that use z-scores at 2 years.

Stunting at 2y and fertility

In comparison to those not stunted, stunted women:			
• marry at a younger age	-4.3 years	(-7.4, -0.9)	P = 0.008
• have more pregnancies	2.4 pregnancies	(0.7, 4.1)	P = 0.006
• have more children	1.7 children	(0.3, 3.2)	P = 0.22

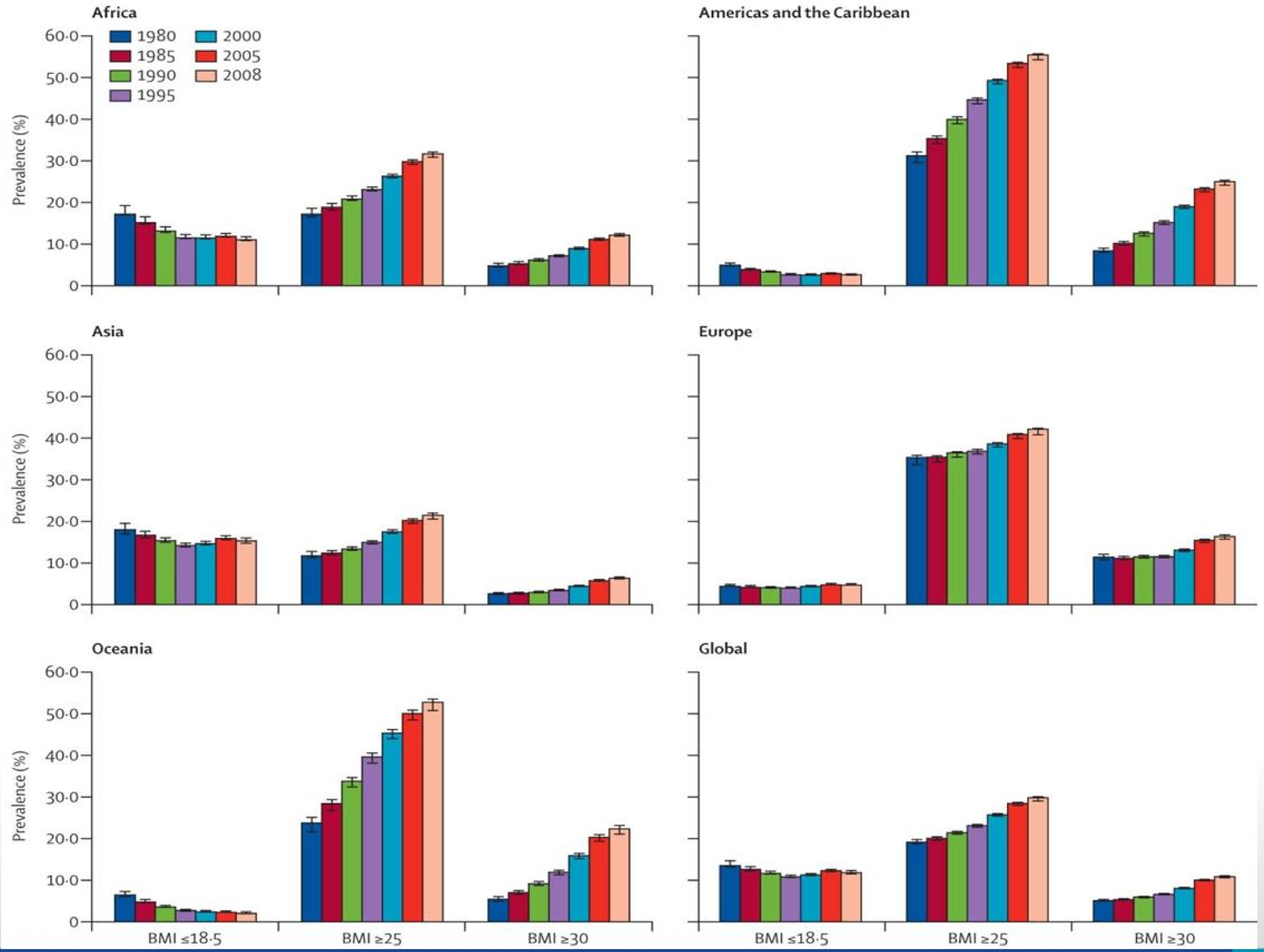
The importance of pre-conception weight

Increase in birthweight (g) associated with a change in one standard deviation in weight prior to conception and in pregnancy weight gain in a prospective study in Vietnam where 30% of WRA have low BMI (n = 1436)+



+ Adjusted for potentially confounding variables; Young et al, under review

Tendency in thinness and obesity by WHO region (1980-2008)



According to the Lancet series on maternal and child nutrition (Black et al, 2013)

Maternal obesity increases the risk of gestational diabetes, preeclampsia, hemorrhage, and neonatal and infant mortality.

The importance of micronutrient status

Effect of preconceptional micronutrient interventions on Birth Defects

Periconceptional folic acid supplementation reduces neural tube defects by 72%[1]

	Neural Tube Defects[2,3]	Congenital Defects[2,4]
Folic Acid	0.43 [0.13, 1.24]	0.58 [0.42,0.79][2]
Multivitamins	0.51 [0.31, 0.82]	0.53 [0.34, 0.97]

[1]DeRegil et al (2010); [2]Dean et al (2014);
[3]Pooled RR or aOR (95% CI); [4]Congenital heart defects

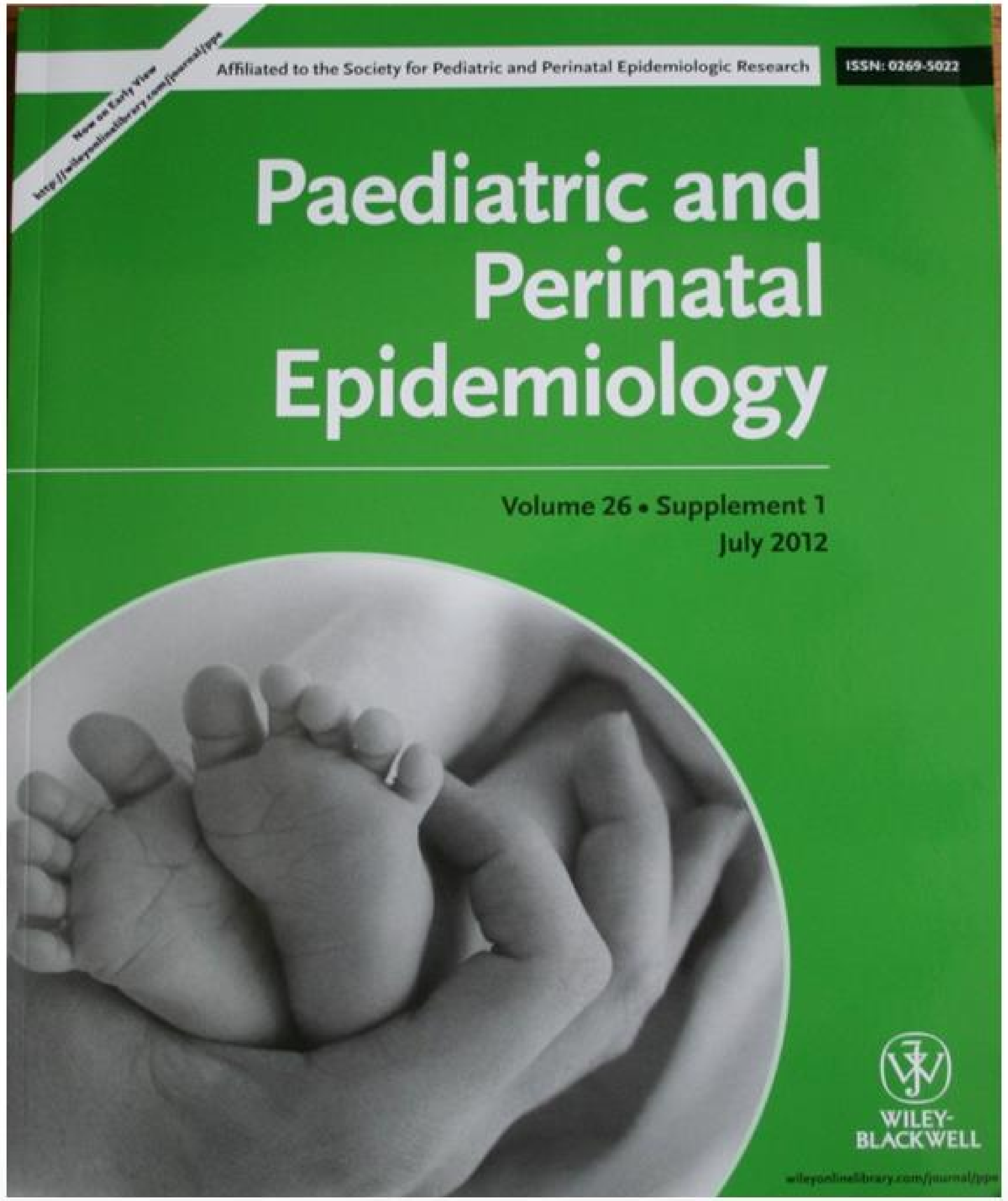
Anemia and calcium deficiency (Black et al, 2013)

Series confirms anemia is a risk factor for maternal deaths, most likely due to hemorrhage, the leading cause of maternal deaths (23% of total deaths)

Calcium deficiency increases the risk of pre-eclampsia, currently the second leading cause of maternal death (19% of total deaths)

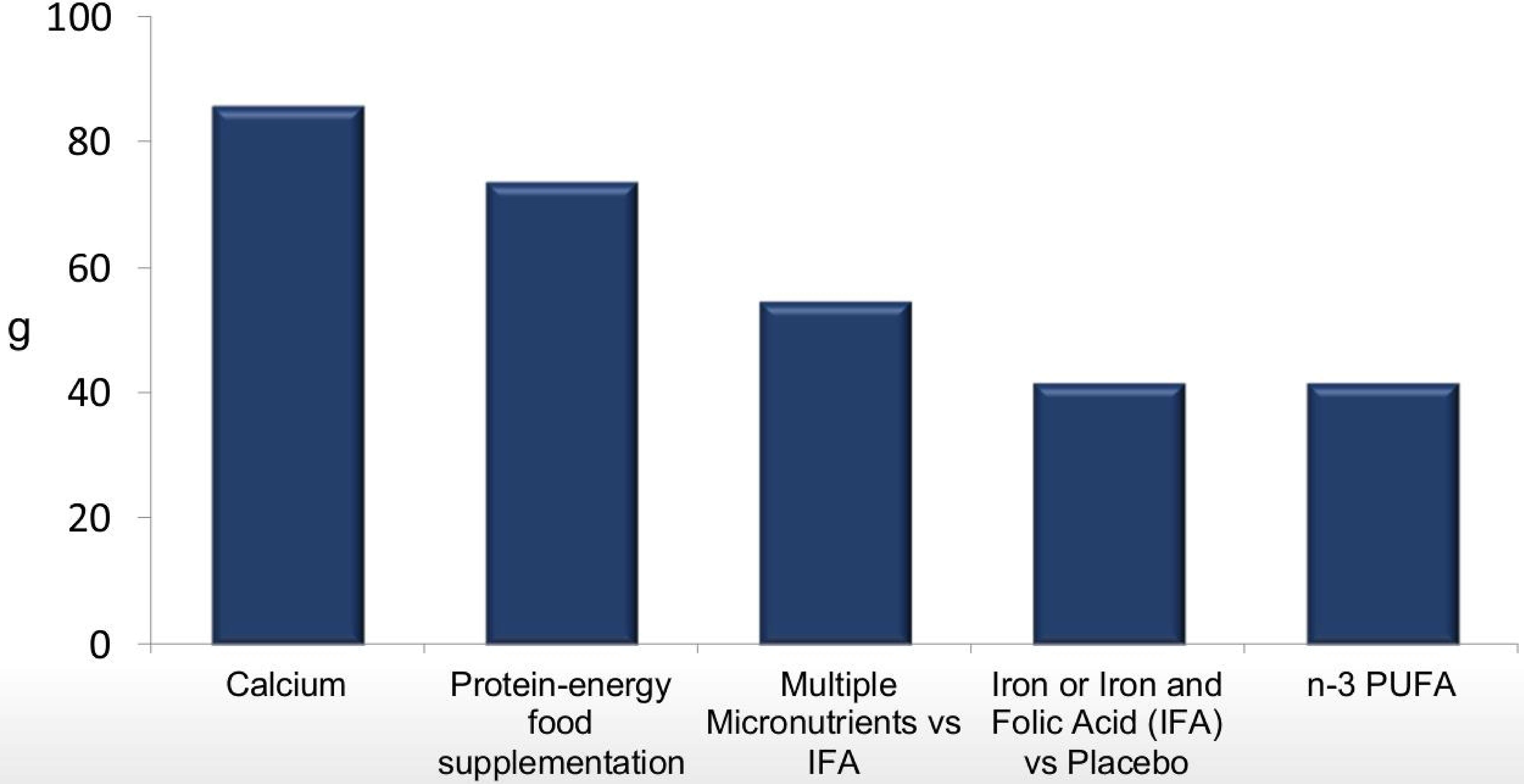
Addressing these deficiencies could result in substantial reduction of maternal deaths

The scientific evidence for maternal nutrition interventions



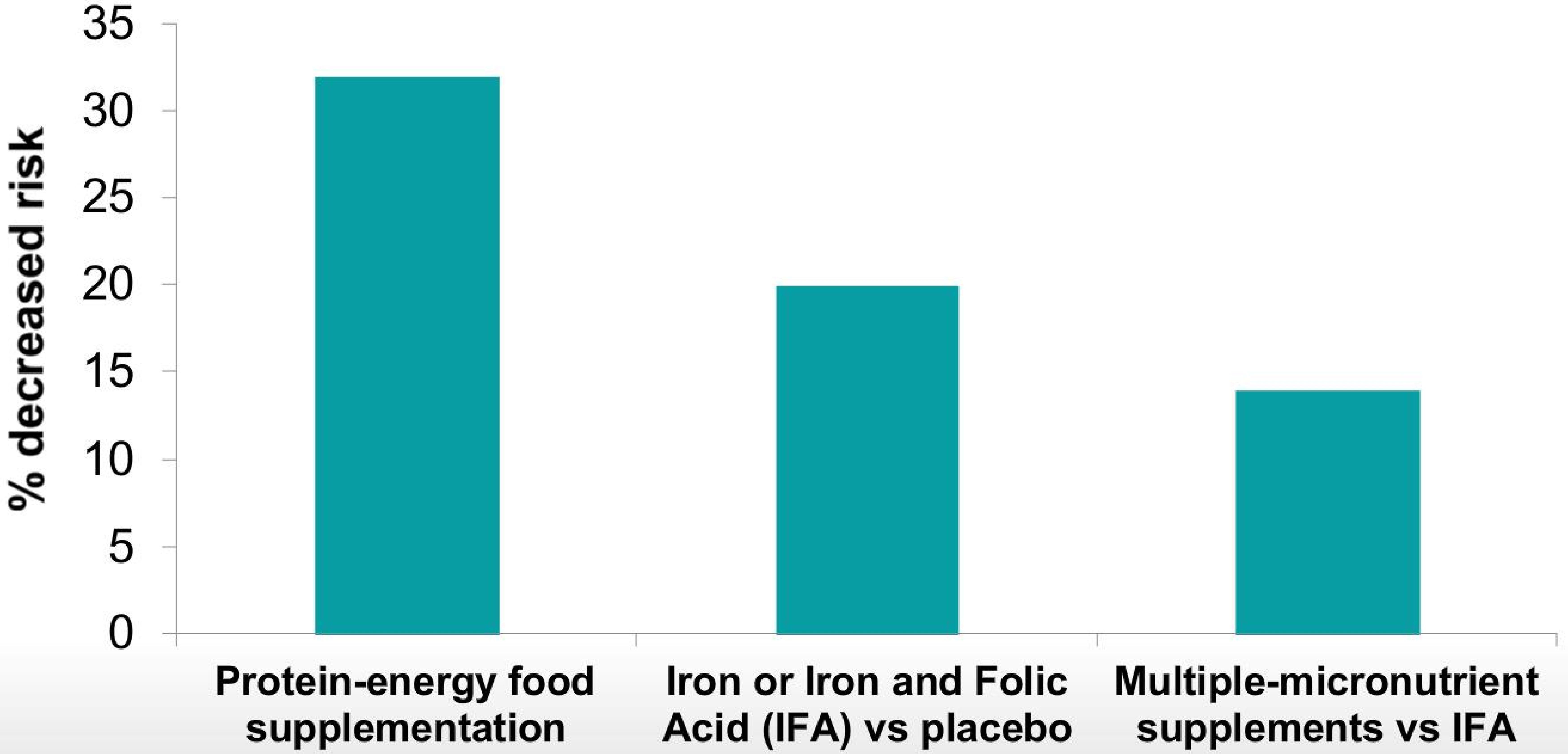
Funded by the Gates Foundation
http://onlinelibrary.wiley.com/doi/10.1111/ppe.2012.26.issue-s1/issuetoc

Nutrition interventions during pregnancy and birth weight



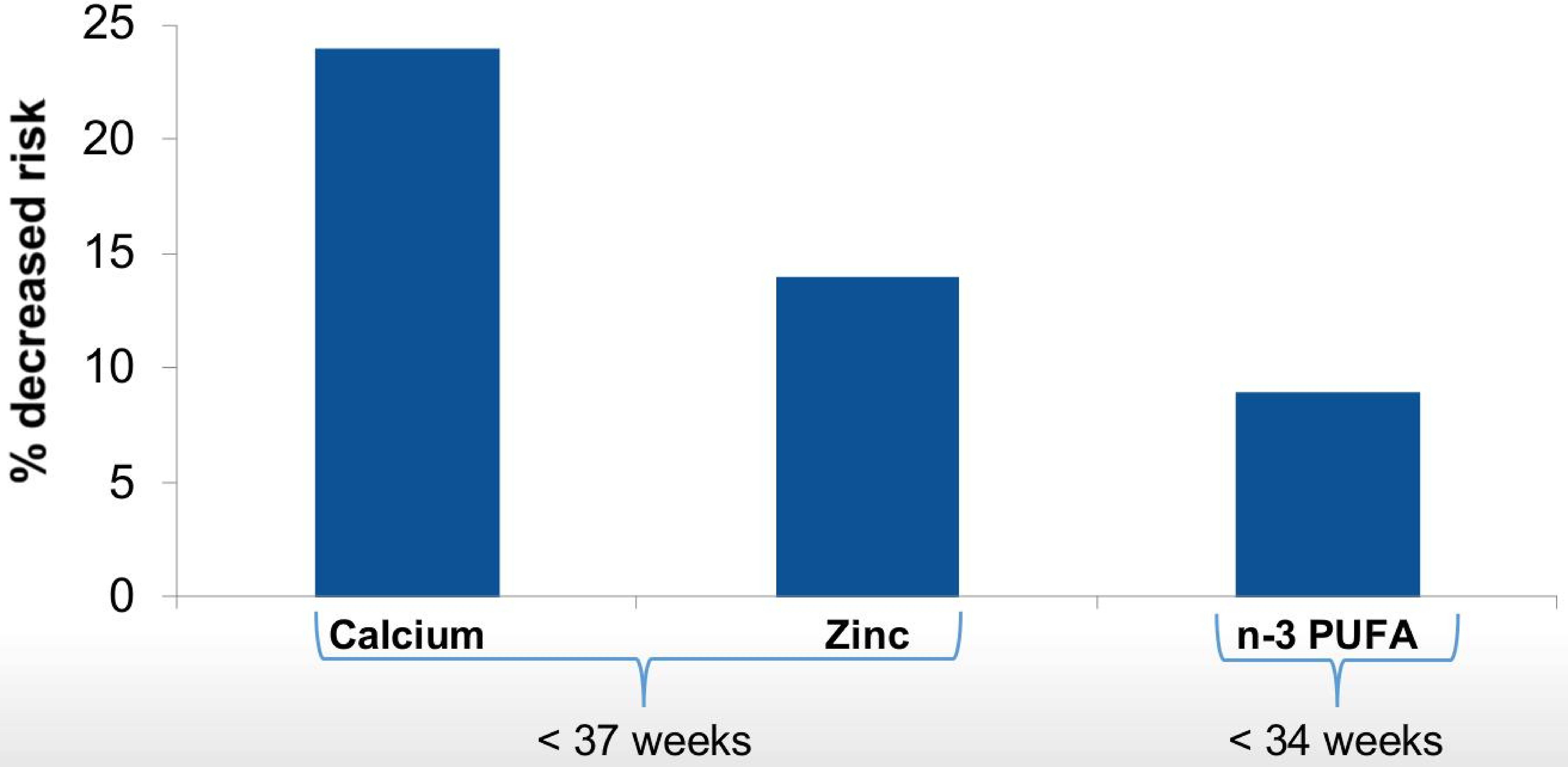
Meta-analyses of moderate to high quality studies; all estimates are significant.

Nutrition interventions during pregnancy and low birthweight (LBW)



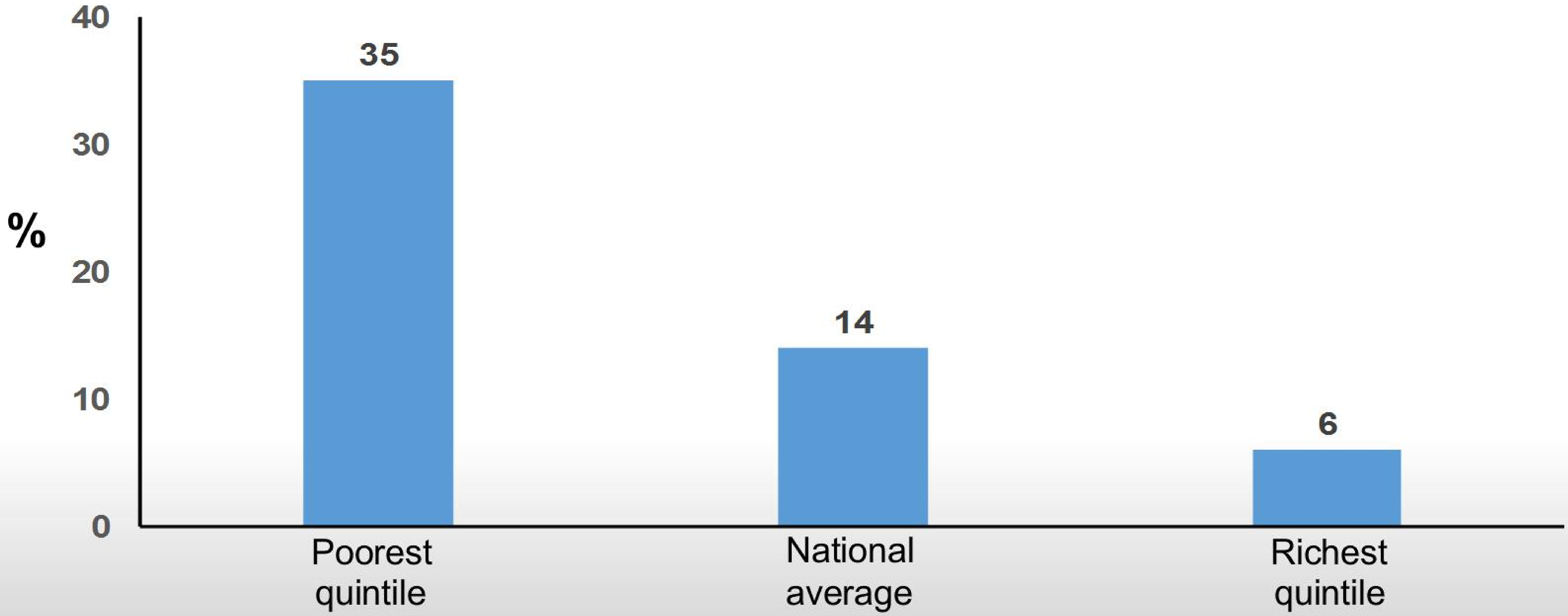
Meta-analyses of moderate to high quality studies; all estimates are significant.

Nutrition interventions during pregnancy and preterm birth (PTB)



Meta-analyses of moderate to high quality studies; all estimates are significant.

Proportion of women ages 15 to 49 by who have begun childbearing by age 18 y by wealth quintile in Perú (PRB, 2013 Data Sheet)



Pregnancies in adolescents

There is a large body of literature documenting that teen pregnancies have profound social consequences such as increased risk of school dropout, higher risk of living in poverty, low empowerement,etc.

Importance of reproductive timing+

- **Early age at first pregnancy**
  ↑Risk of anemia, LBW, VLBW, preterm birth, early preterm birth, neonatal mortality

- **Short interpregnancy interval**
  ↑Risk of preterm birth, early preterm birth, LBW, stillbirth and neonatal mortality

+ *Both factors increase risk of LBW and PTB by 39 to 68%*

Intergenerational influences

Intergenerational Effects (Behrman, Calderón, Preston, Hoddinott, Martorell & Stein; AJCN, 2009)

- Offspring of women exposed to a nutritious supplement were heavier at birth (116 g) and were taller (1.3 cm) and had greater head circumferences (0.6 cm) in childhood compared to those who were not.
- Father's exposure to improved nutrition in early life, did not influence their offspring's characteristics.

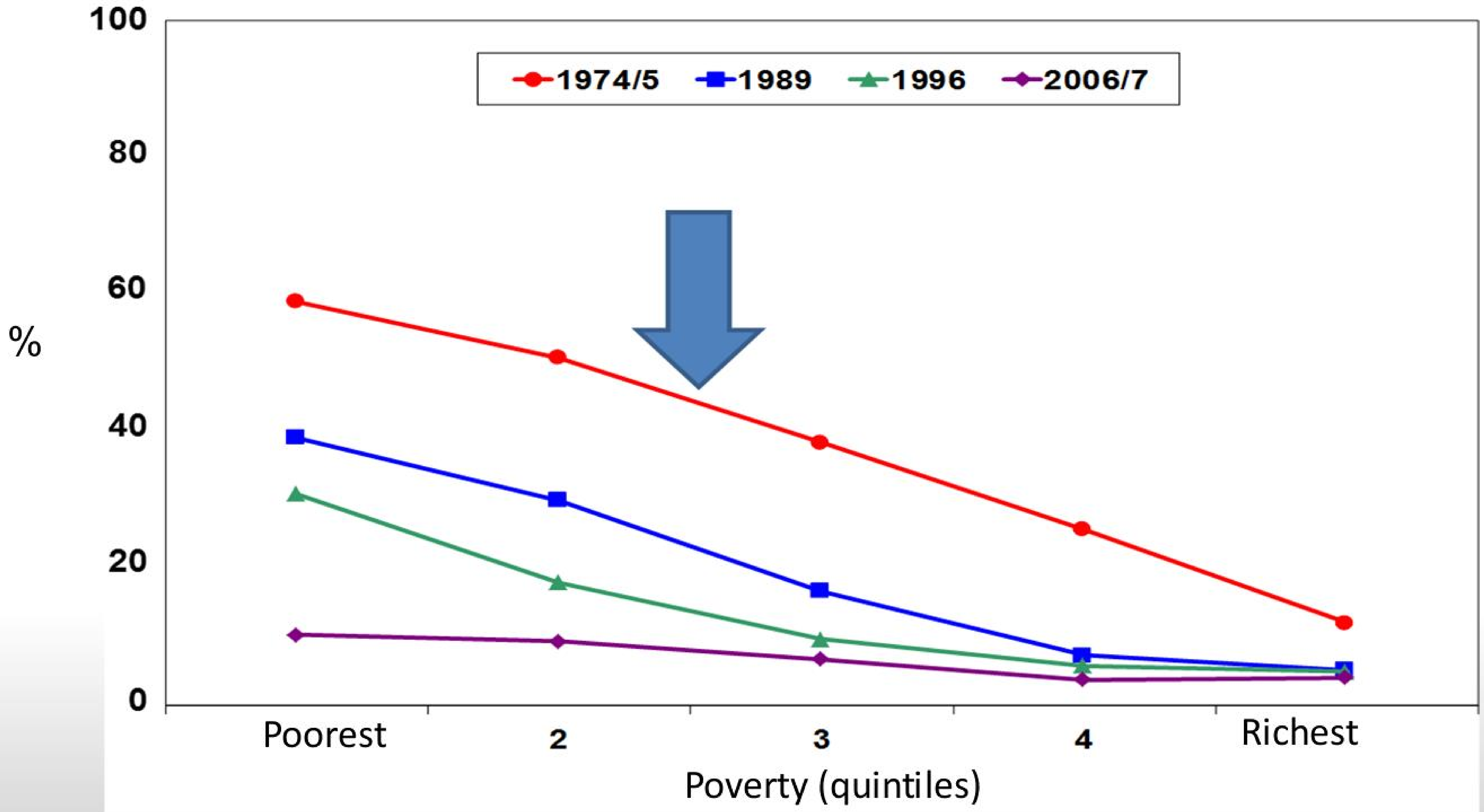
Improving reproductive outcomes

- Efforts should begin by improving the nutrition of young girls and preventing stunting.
- The prevention of teenage pregnancies is a priority for biological and social reasons.
- Raising women’s status and empowerment is key to improving their nutrition.
- Approaches are needed to improve the nutritional status of women prior to conception and thereafter (e.g., newly wed package of interventions), with specific attention to achieving a healthy BMI, the timely introduction of folic acid supplementation and addressing iron and calcium deficiencies.

Reducing stunting: the case of Brazil

Effective policies and programs can reduce stunting dramatically in a relatively short time

The social inequalities in stunting in chidren < 5 y decreased over time in Brazil (Monteiro et al, 2009)



Potential explanations for declines in stunting and for the reduction in inequalities in Brazil

- Continuity of policies and programs despite changes in government and parties.
- Pro-poor agenda: Improvements in the social determinants of health (e.g., poverty, female education, fertility reductions).
- Creation of a unified national health system, with emphasis on primary health care for underserved areas.
- Many interventions outside the health system: conditional cash transfers, water and sanitation, etc.
- Vertical programs against specific diseases.