# Early Growth and Adult Health and Human Capital: Pooled Analyses from Five Cohorts from Developing Countries

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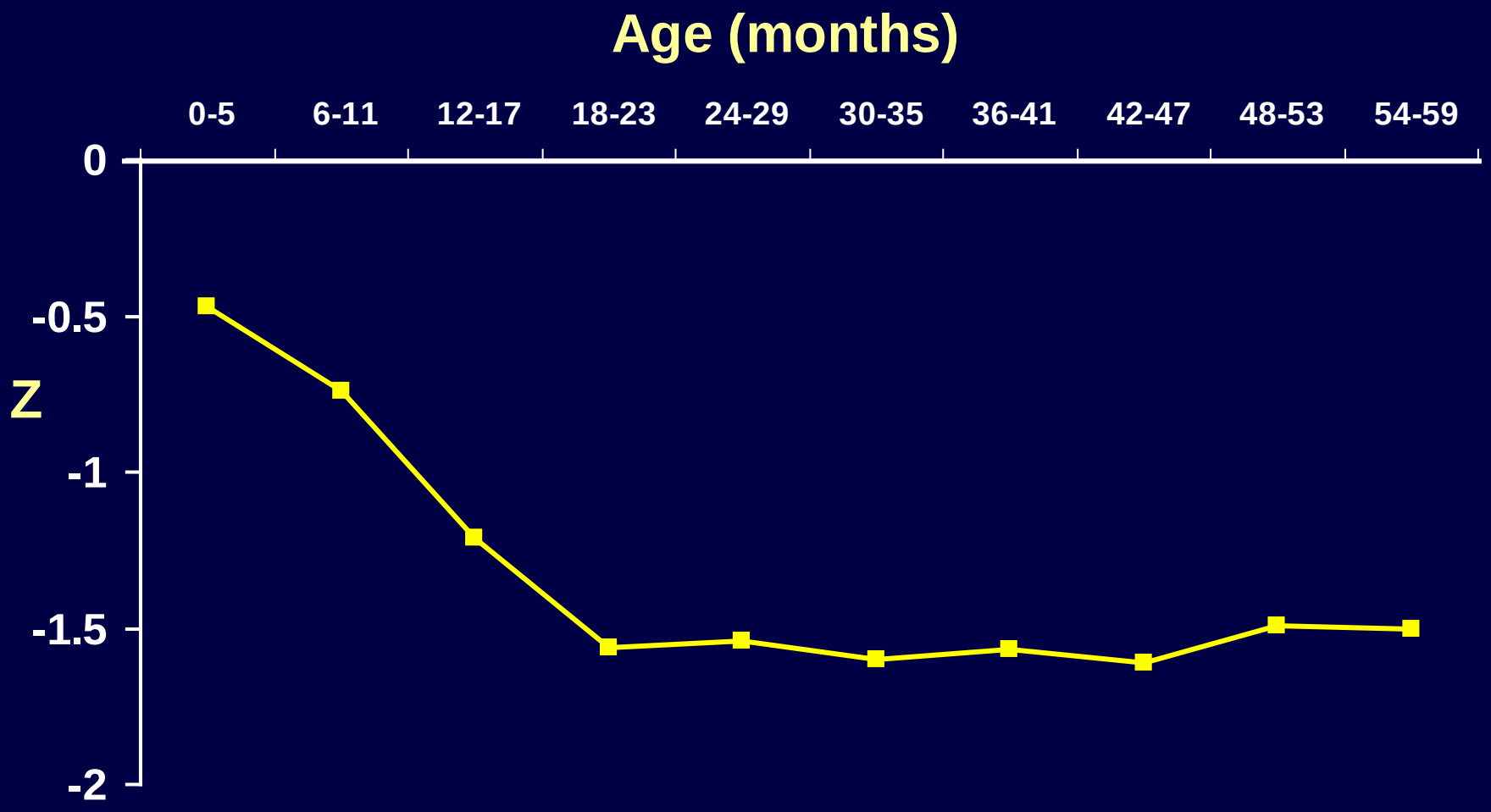
On behalf of the
INCAP and
COHORTS Groups

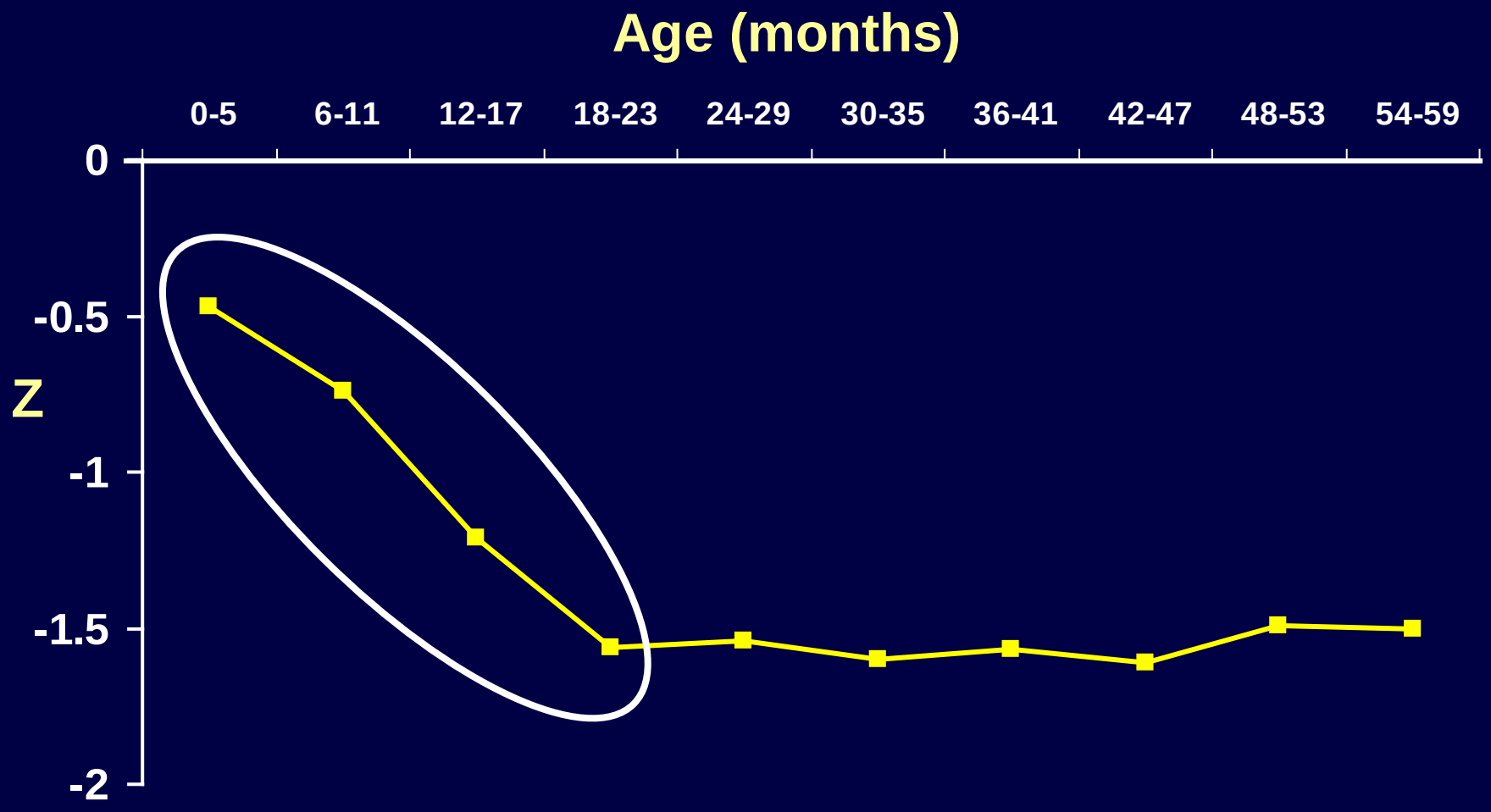
# The first 1000 days of life represent a window of vulnerability for human development

- High nutritional requirements
- Rapid growth and development, including brain growth
- Greater susceptibility to infections
- Fully dependent on others for care

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



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



THE LANCET


# COHORTS

Consortium of Health Orientated Research in Transitioning Societies

Brazil Guatemala India Philippines South Africa

# INCAP longitudinal study, 1969-77

- Community-randomized supplementation trial
(2 large and 2 small villages).

- Two villages (1 large, 1 small) received Atole, a nutritious supplement made from Incaparina, milk and sugar, and two (1 large, 1 small) received Fresco, a less nutritive drink

- Included all children 7 y or younger in 69 and all births 69-77

*Martorell R, Habicht J-P, Rivera JA. History and design of the INCAP longitudinal study (1969-77) and its follow-up (1988-89). Journal of Nutrition 125(Suppl. 4S):1027S-1041S, 1995.*

# Impact on total nutrient intakes and on growth

- Supplement and home dietary intakes measured
- Total diets of young children < 3y from Atole villages were greater by 9 g of protein, 100 kcal/day and in micronutrients when compared to diets of children from Fresco villages.
- Length was increased by 3 cm in Atole vs. Fresco but only in the first three years of life.

# Nutrition, human capital, and economic productivity (2002-04)


Emory

INCAP

IFPRI

Univ. of Penn.

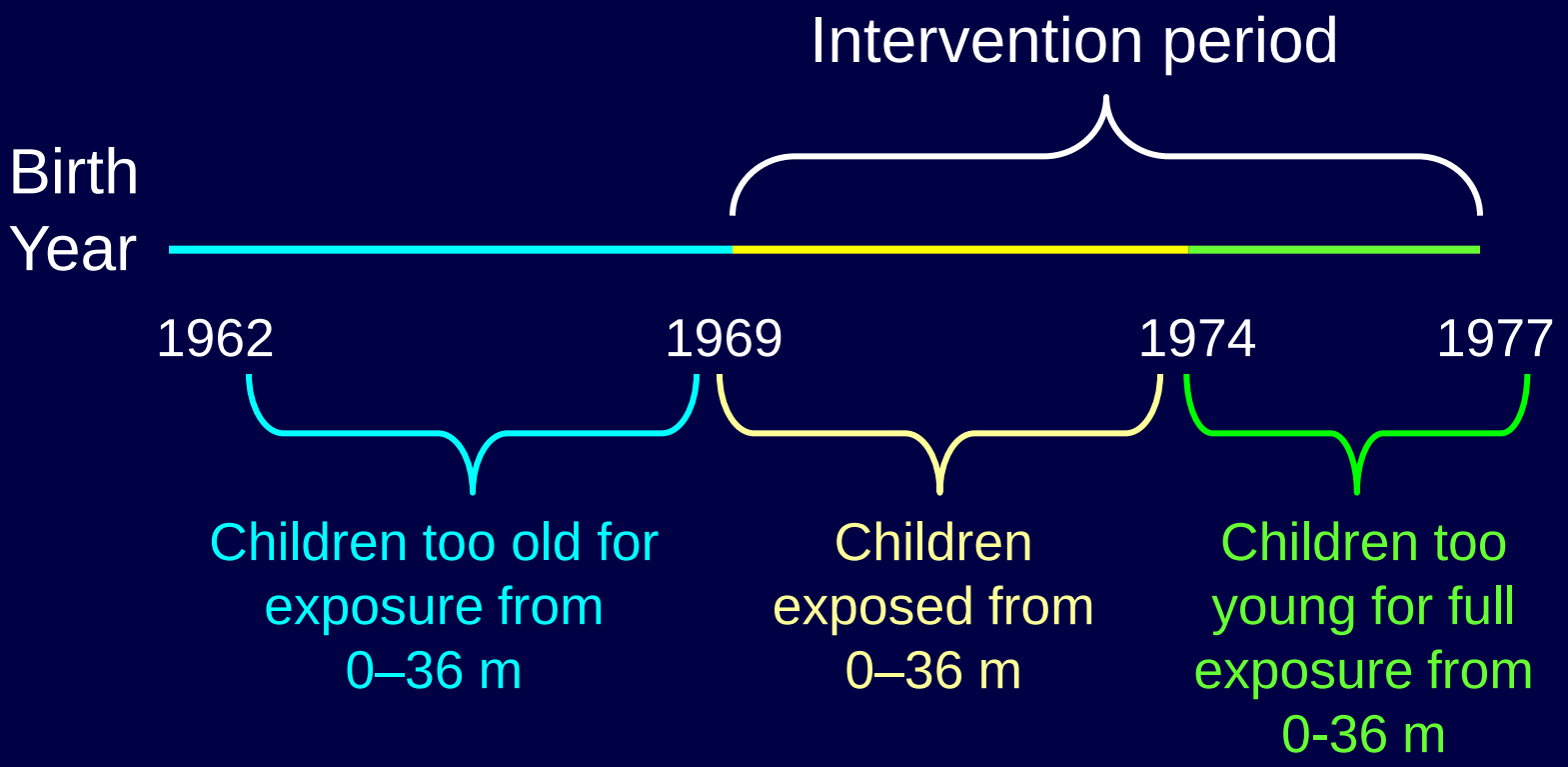
Average age of cohort was 32 y

Funded by Fogarty International Center, NIH, and NSF

# Analytic approach of the Human Capital Study (2002-04)

- Exploits the fact that children were exposed to the supplements at various ages depending on birthdates
- Focus on testing effects for “windows of exposure” using all subjects to estimate double-differences

# Example: assessing exposure to either Atole or Fresco from 0-36 months



# Double-difference estimate for exposure from 0-36 months of age

(Average outcome for those exposed to *atole* 0–36 m completely – Average outcome for those exposed to *fresco* 0–36 m completely) –

(Average outcome for those NOT exposed to *atole* 0–36 m completely – Average outcome for those NOT exposed to *fresco* 0–36 m completely)

# Control variables

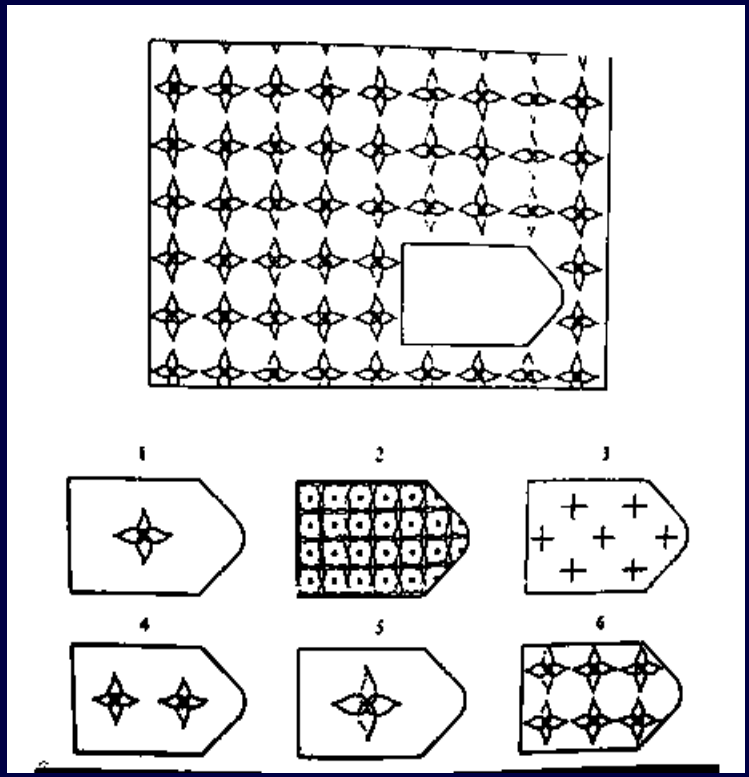
- Individual level: age ( cohort effects) ; stratified by sex

- Family : SES, parental schooling, mother's age and height

- Community : village fixed effects; historical demographic , social and economic changes in relationship to when the individuals were 7 or 18 y old (e.g. student /teacher ratios when 7y old; producer prize of maize when 18 y old).

# Human Capital measures

- Schooling
- Intelligence (Raven test)
- Reading ability (Inter- American Reading test)



# Exposure to improved nutrition from 0–3 years of age and education (n=1471)[+]

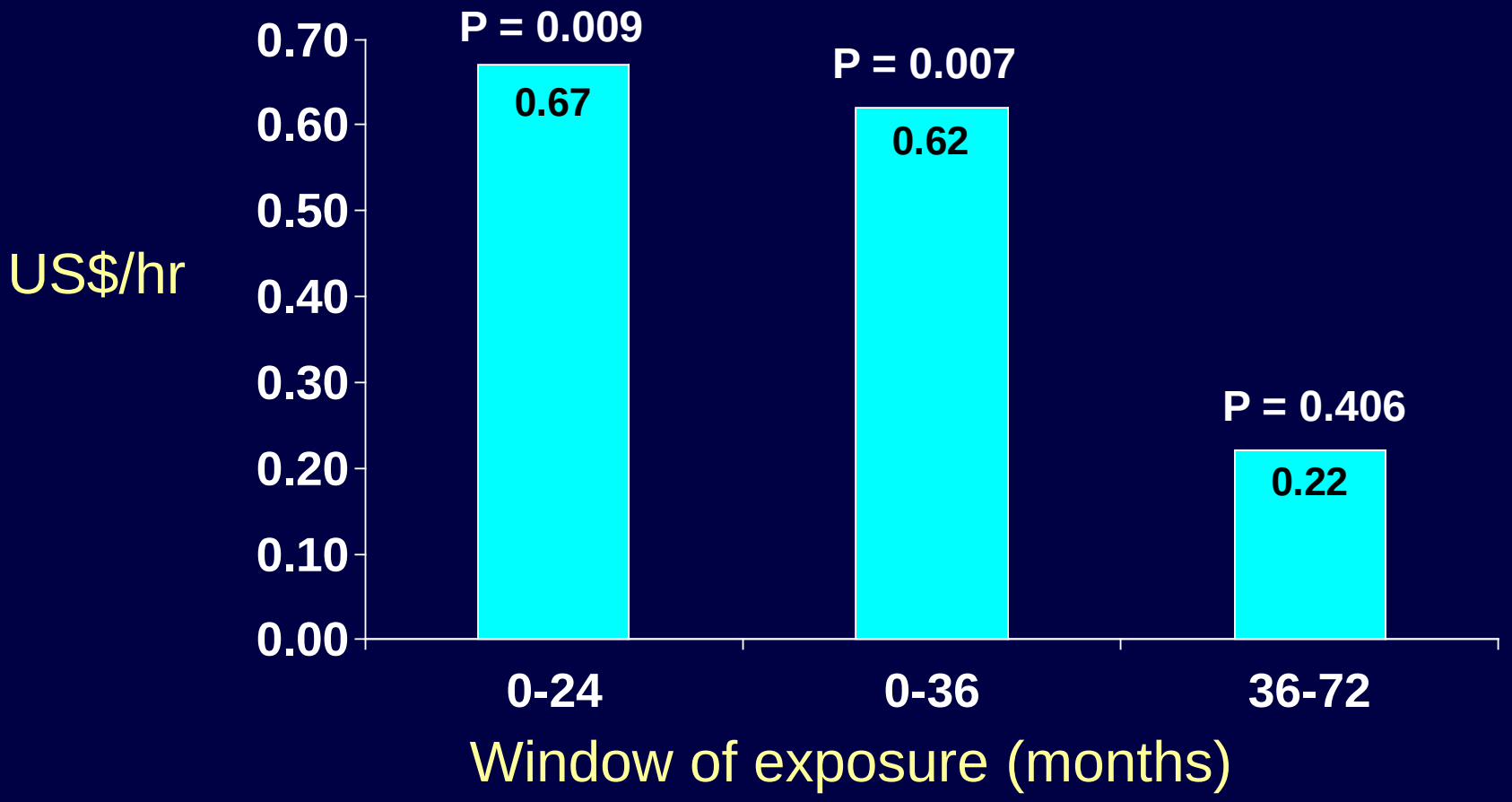
- Schooling: Effects found in women only
  - Improved by 1.2 years (36% of SD)
- Reading: Effects found in men and women
  - Improved scores by 28% of SD[++]
- Cognition: Effects found in men and women
  - Improved Raven scores by 24% of SD[+++]

[+] *Maluccio J, Hoddinott J, Behrman JR, Martorell R, Quisumbing A, and Stein A. The impact of improving nutrition during early childhood on education among Guatemalan adults . The Economic Journal, 119:734-763. 2009.*

[++] *Raven Progressive Matrices*

[+++] *Inter-American Reading Series*

# Impact of exposure to atole during early life on income (in US$) earned per hour; n = 602 men; age ~32 years[+]

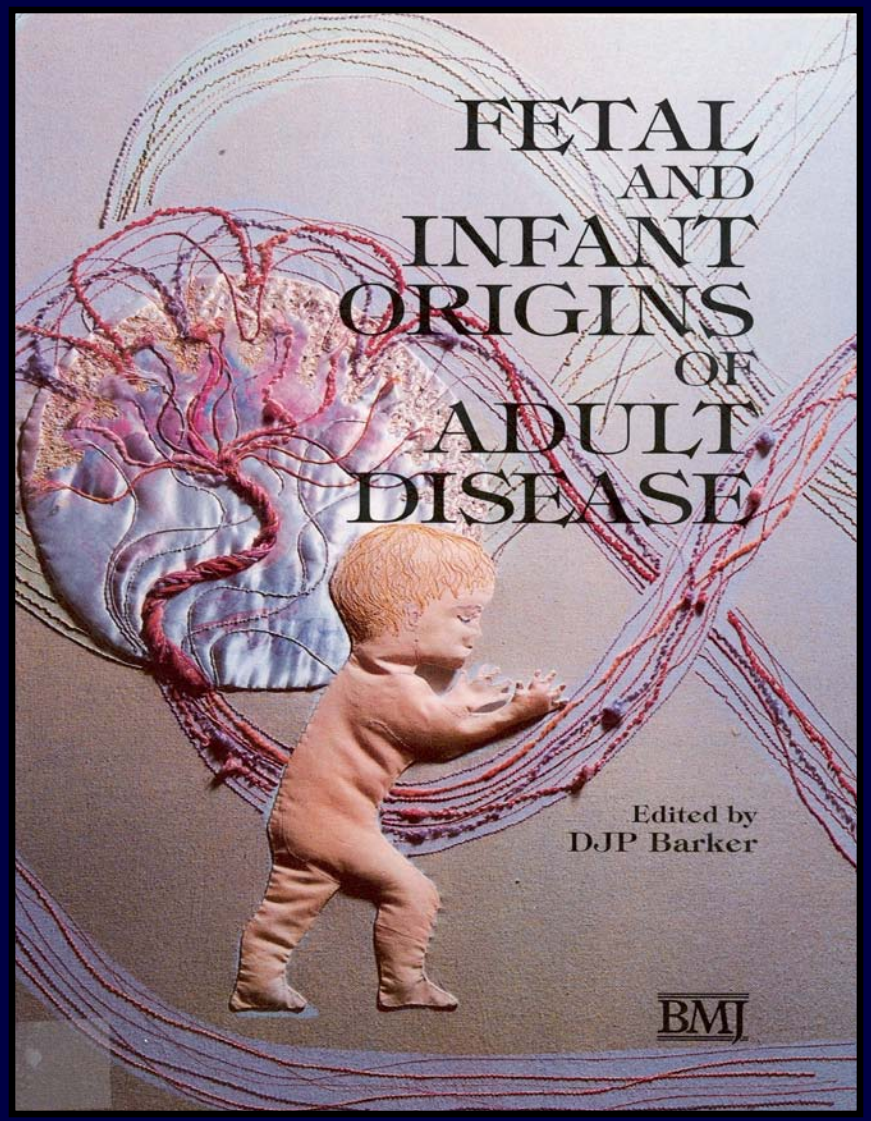



[+] *Hoddinott, Maluccio, Behrman, Flores and Martorell. Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults (The Lancet, 2008).*

Is there a tradeoff from improving nutrition in malnourished infants between

- improved human capital ( IQ, schooling , income, etc.)
- but poor adult health ( increased cardiovascular disease risk, abdominal obesity, etc ?

Stein AD, Wang M, Ramirez-Zea M, Flores R, Grajeda R, Melgar P, Ramakrishnan U, Martorell R. Exposure to a nutrition supplementation intervention in early childhood and risk factors for cardiovascular disease in adulthood: evidence from Guatemala. *Am J Epidemiol 2006*; 164:1160-1170.




# Conclusion

Interventions designed to address nutrient deficiencies and ameliorate stunting that are targeted at pregnant women and young children are unlikely to increase cardiovascular disease risk later in life and may instead lower the risk.

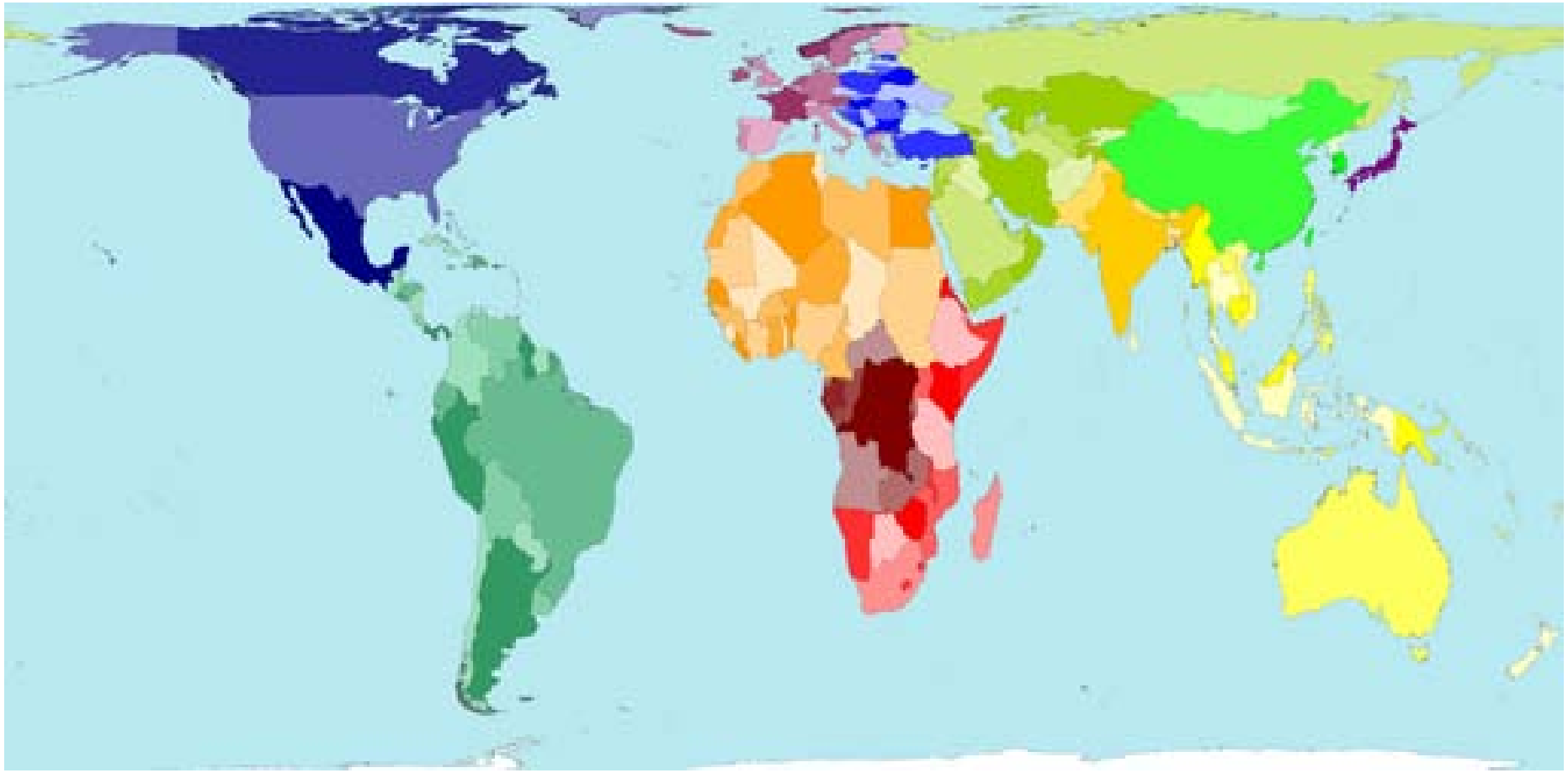
THE LANCET


# COHORTS

Consortium of Health Orientated Research in Transitioning Societies

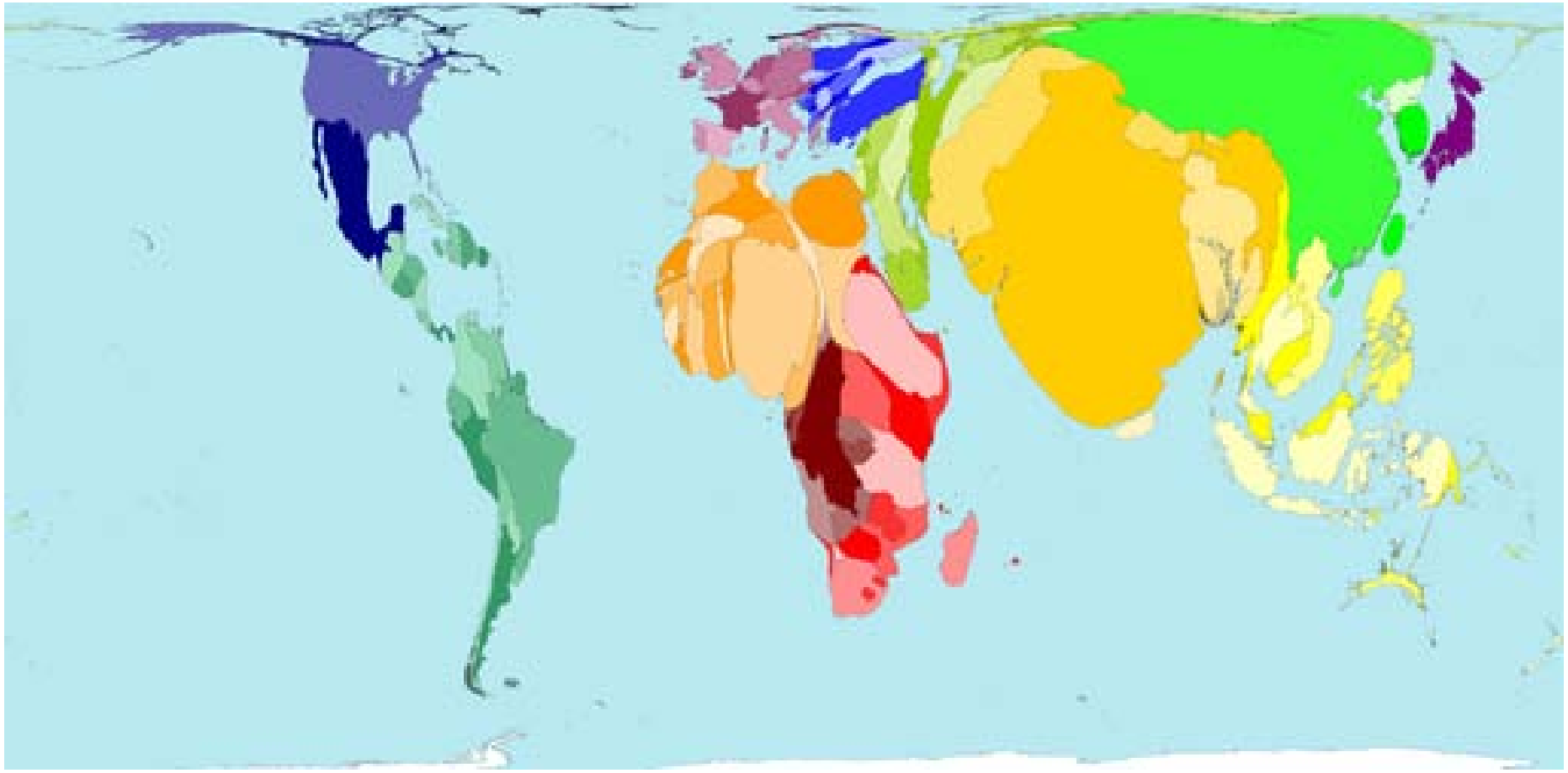
Brazil Guatemala India Philippines South Africa

# Land area



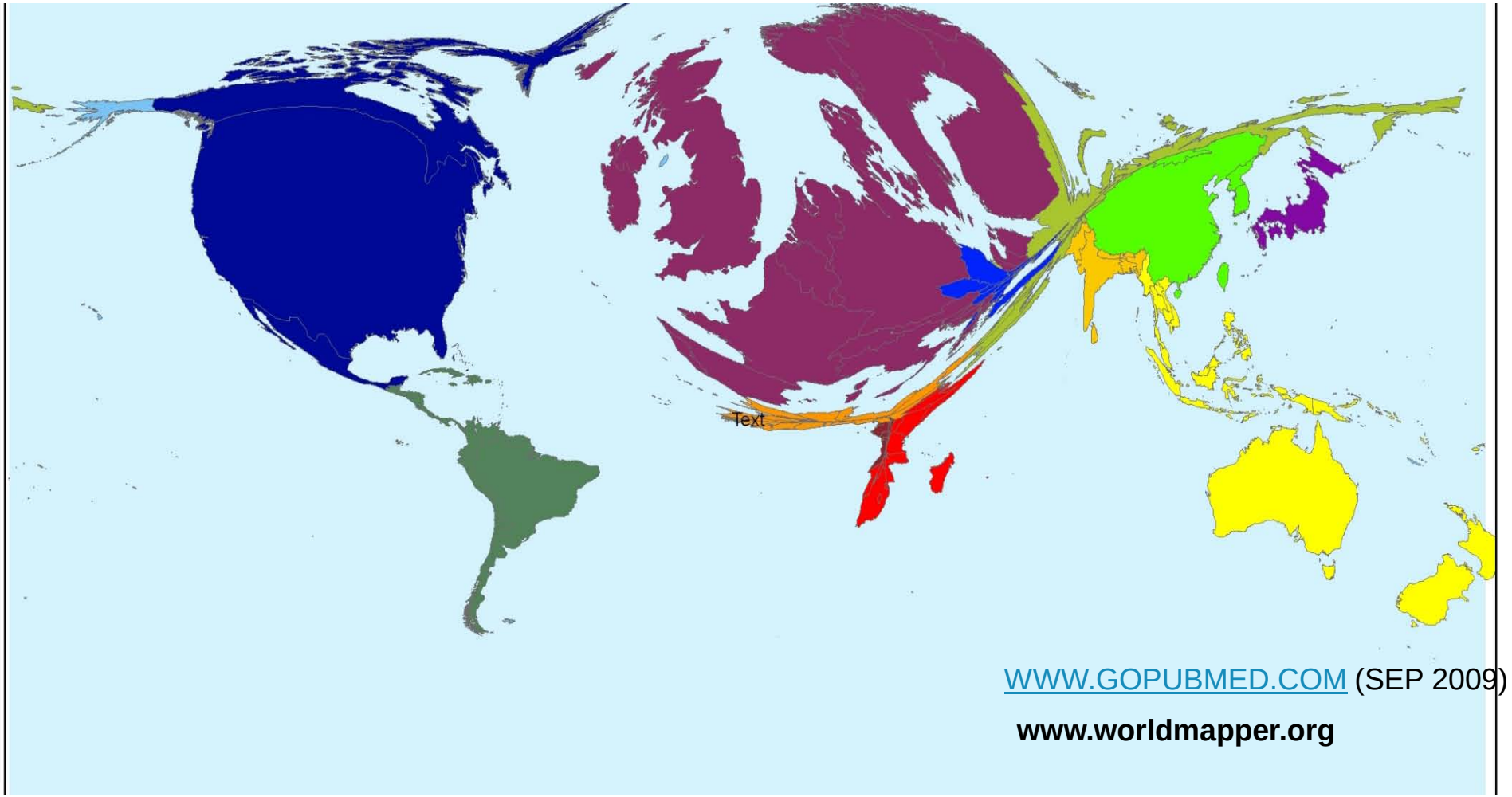
Source: www.worldmapper.org

# Total births, 2000



Source: www.worldmapper.org

# Birth cohort publications




WWW.GOPUBMED.COM (SEP 2009)

**www.worldmapper.org**

# Why do we need cohorts in LMICs?

- Higher frequency of some exposures (and lower frequency of others)
- Different nature of some exposures
- Different confounding patterns
- Marked social disparities within LMIC cohorts
- LMIC cohorts growing up under the epidemiological and nutrition transitions
  - High potential for “mismatch”

# Sample

| Study | Cohort inception | Who was enrolled? |
|---|---|---|
| Pelotas<br>Brazil | 1982 | Births during 1982. All social classes |
| INCAP Nutrition Trial Cohort<br>Guatemala | 1969-77 | Participants in nutrition supplementation intervention trial in 4 rural villages |
| New Delhi<br>Birth Cohort Study<br>India | 1969-72 | Births to married women from defined area of Delhi. Primarily middle-class |
| Cebu Longitudinal Health & Nutrition Survey<br>Philippines | 1983-84 | Births in 33 randomly selected communities of Metro Cebu; 75% urban. All social classes |
| Birth to 20<br>South Africa | 1990 | Infants from a delimited urban area (Soweto, Johannesburg). Predominantly poor, black |

Richter et al., IJE 2011

# Phase I : How do birth weight and stunting size at age 2 yr relate to young adult health and human capital ?

## Consequences for Adult Health and Human Capital


**CG Victora, L Adair, C Fall, PC Hallal, R Martorell, L Richter, HS Sachdev and Maternal and Child Undernutrition Study Group**

**(The Lancet, Jan 2008)**


# Phase II: Early growth and adult outcomes

- Human Capital
- Adult Health

# COHORTS III will focus on the physical and social environment in early childhood

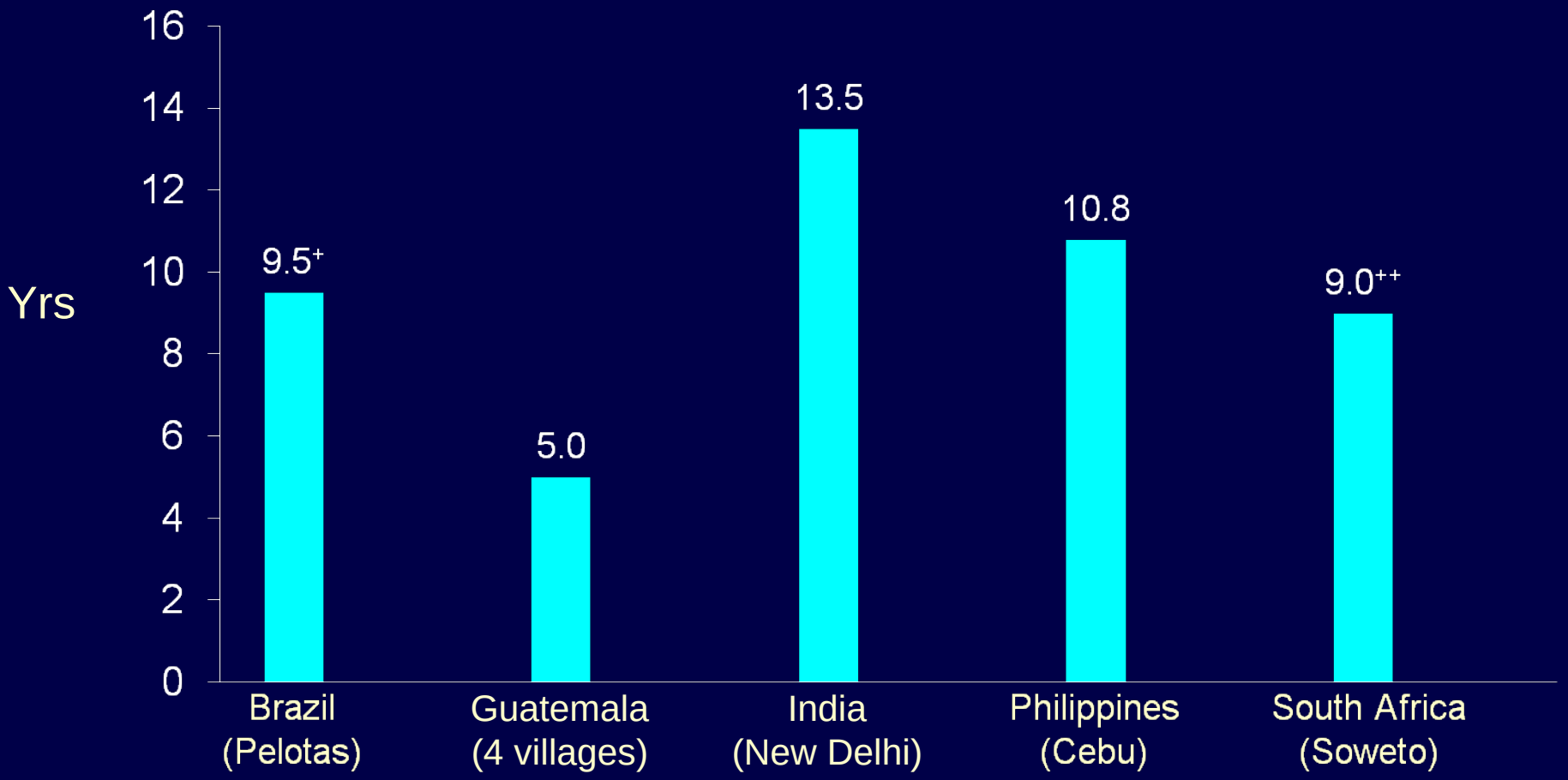
- How it relates to early childhood growth.
- Its relationship with adult indicators of health and capacity.
- How it moderates relationships between growth in the first two years of life and adult indicators of health and capacity.

# Phase II : Schooling analyses

What is the relative importance of birthweight and weight gain between 0-2 y and 2-4 y for schooling outcomes?

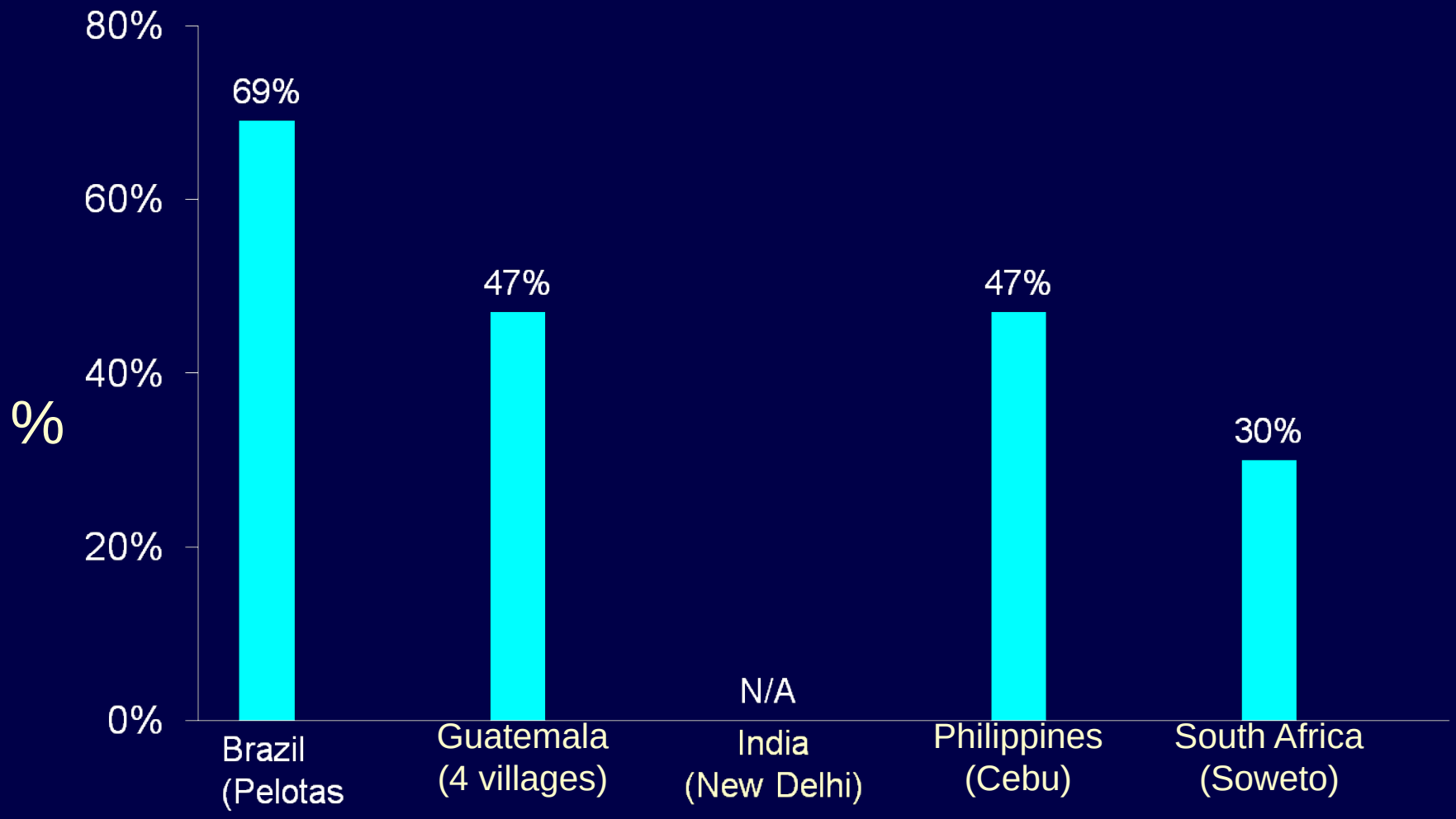
- Highest grade attained
- Ever failed a grade

# Highest grade (y) attained by study site



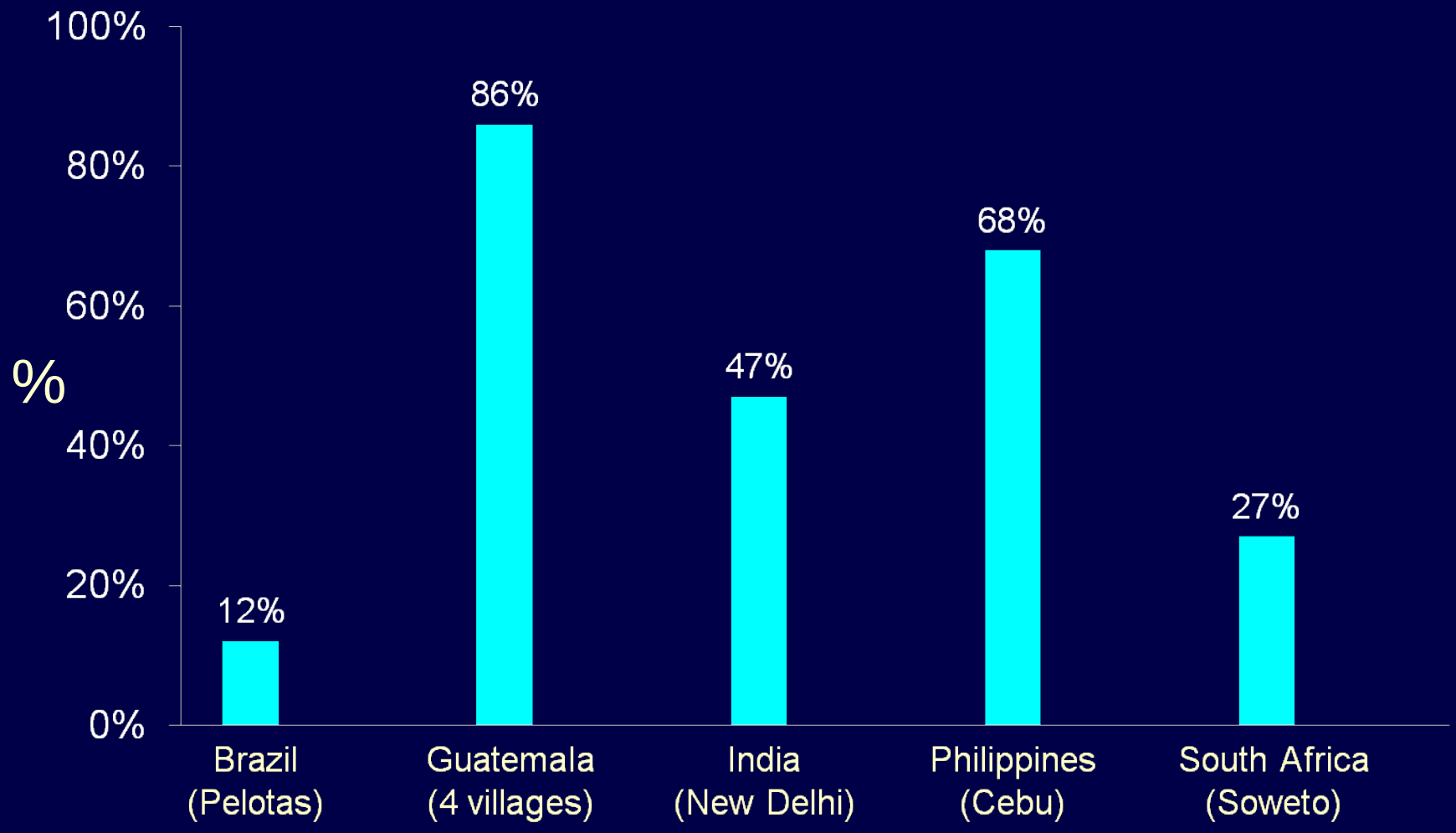

*+ 43% of participants still in school*
*++ Almost all participants in school*

# Ever failed a grade (%) by site




+ *N/A = Not Available*

# % stunted (< -2 HAZ) at 2 y, by site



# Methods

- Used conditional weight gain variables (0-2 and 2-4 y) that were uncorrelated with each other and with birthweight.
- Tested for interactions with sex and found none. Therefore, results for males and females were pooled.
- No significant interactions by site for highest grade attained and ever failed a grade. Therefore, these analyses were pooled by site.

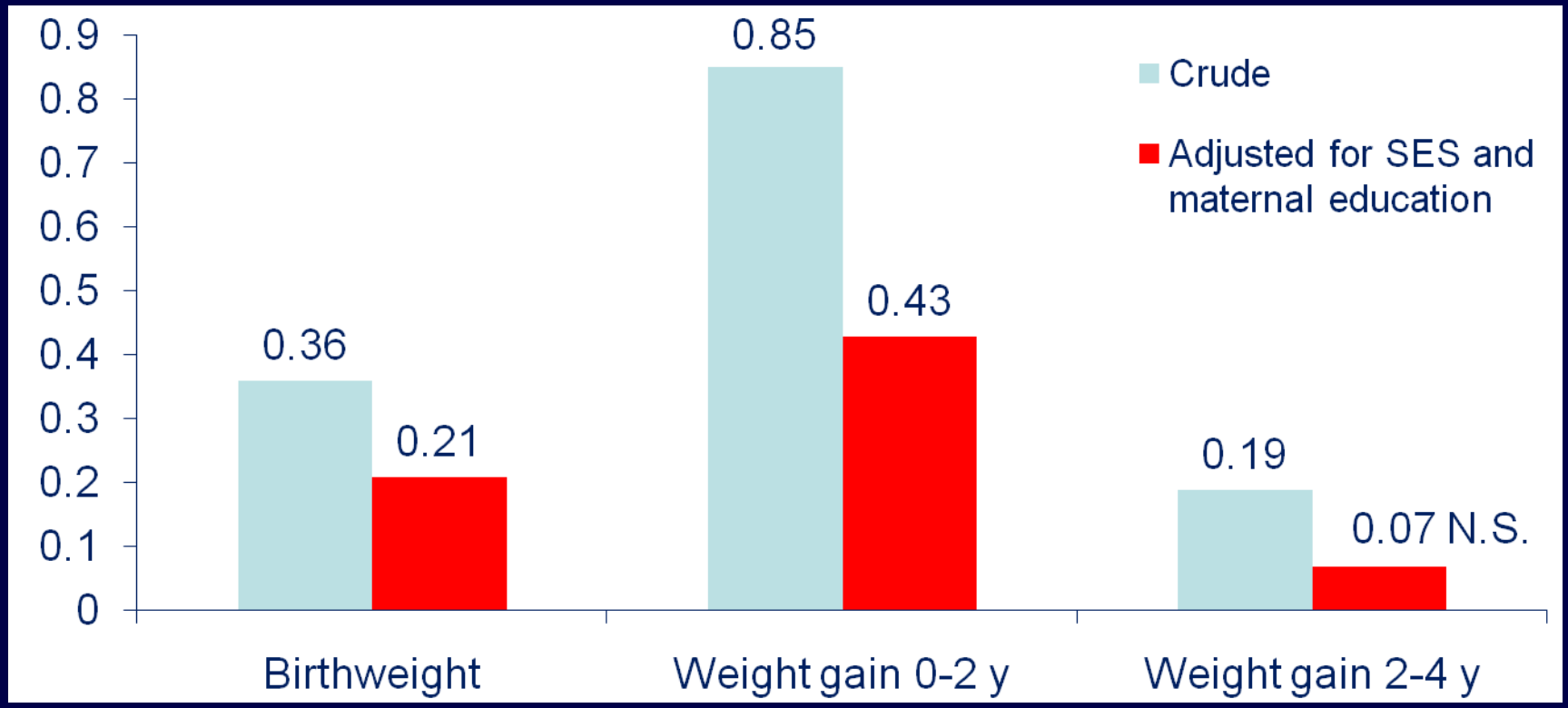
# Data availability

- Brazil , Guatemala and the Philippines provided data for all schooling outcomes.
- Data for *highest grade attained* were not included for South Africa because virtually all were still in school, providing little variability.
- Only *highest grade attained* was available for New Delhi.
- Weight measures were available for all sites. Birth length was not available for South Africa and Brazil . Used weight measures as the exposure variables.

# Statistical models

- The basic model adjusted for site (except for age at school entry) and sex.
- The fully adjusted model also included household socioeconomic status (when participants were children), maternal years of schooling and whether the subject was still in school (for highest grade attained).

# Years of increased schooling associated with a standard deviation shift in birth weight and conditional weight gain (0-2y and 2-4y) in 5 cohort studies




One standard deviation (z) of
birth weight =0.5 kg
weight gain (0-2 y) = 0.7 kg
weight gain (2-4y) = 0.9 kg

*Martorell et al., 2010*

# Reduced probability of failing a grade associated with a standard deviation shift in birth weight and conditional weight gain (0-2 and 2-4 y) In 5 cohort studies

| | Reduction in probability in failure | |
|---|---|---|
| Variable (z) | Crude | Adjusted + |
| Birthweight | 11% | 8% |
| Weight gain 0-2 y | 21% | 12% |
| Weight gain 2-4 y | 5% | 2% (N.S.) |

*+ Adjusted for maternal schooling and SES status (Martorell et al, 2010)*

# Conclusions about schooling

- Growth from 0-2 y had the strongest associations with schooling, followed by birthweight.  Growth from 2-4 y had little relationship to schooling.

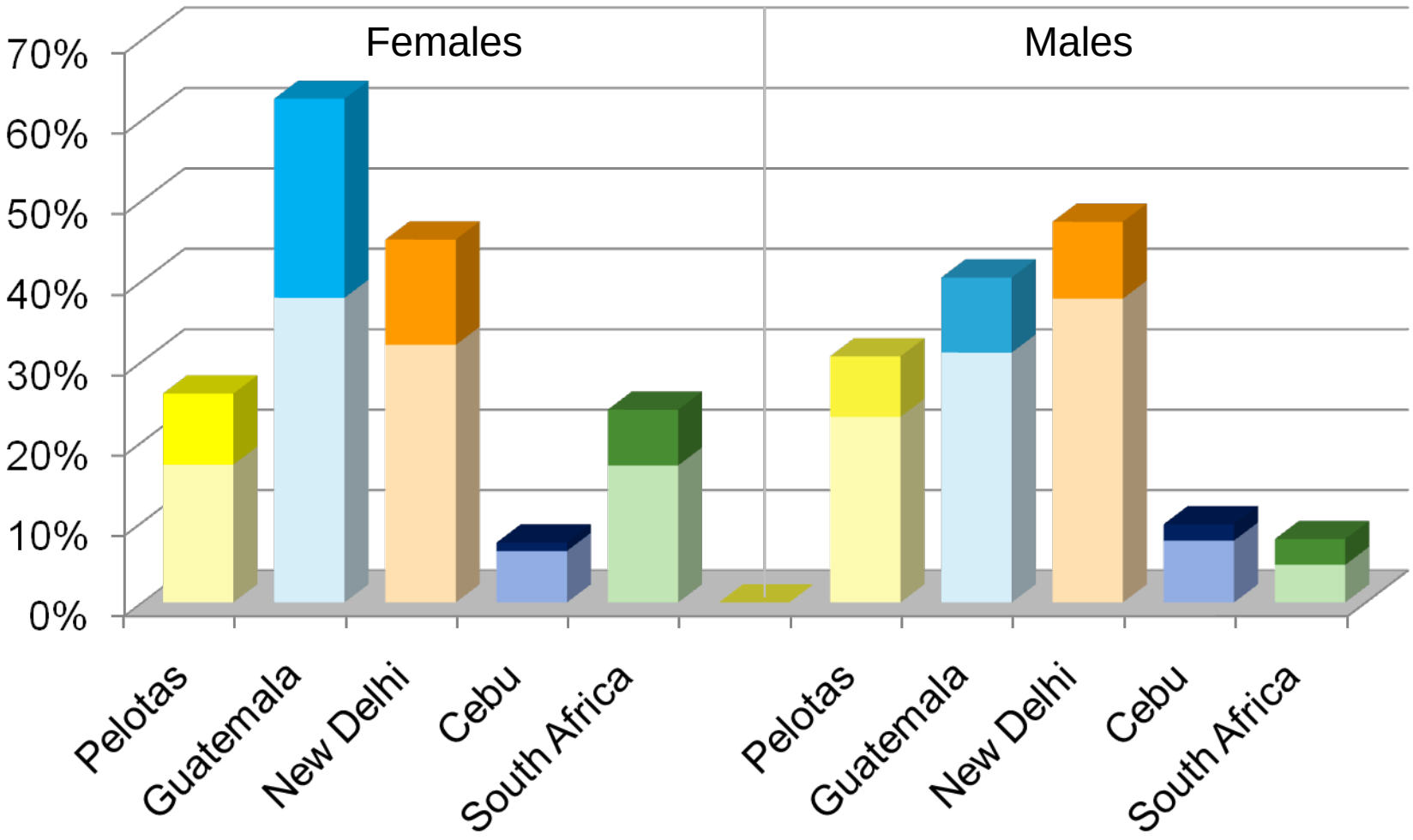
- Catch-up growth form 0-2 yin smaller babies benefits schooling.

# Is there a trade off between human capital and adult health if investment is made in improving nutrition during gestation and the first two years of life?

- " Promotion of good nutrition in early life is essential for health later in life because either undernutrition or overnutrition can cause lifelong, irreversible damage" Cesar Victora (Lancet, Oct 2009).

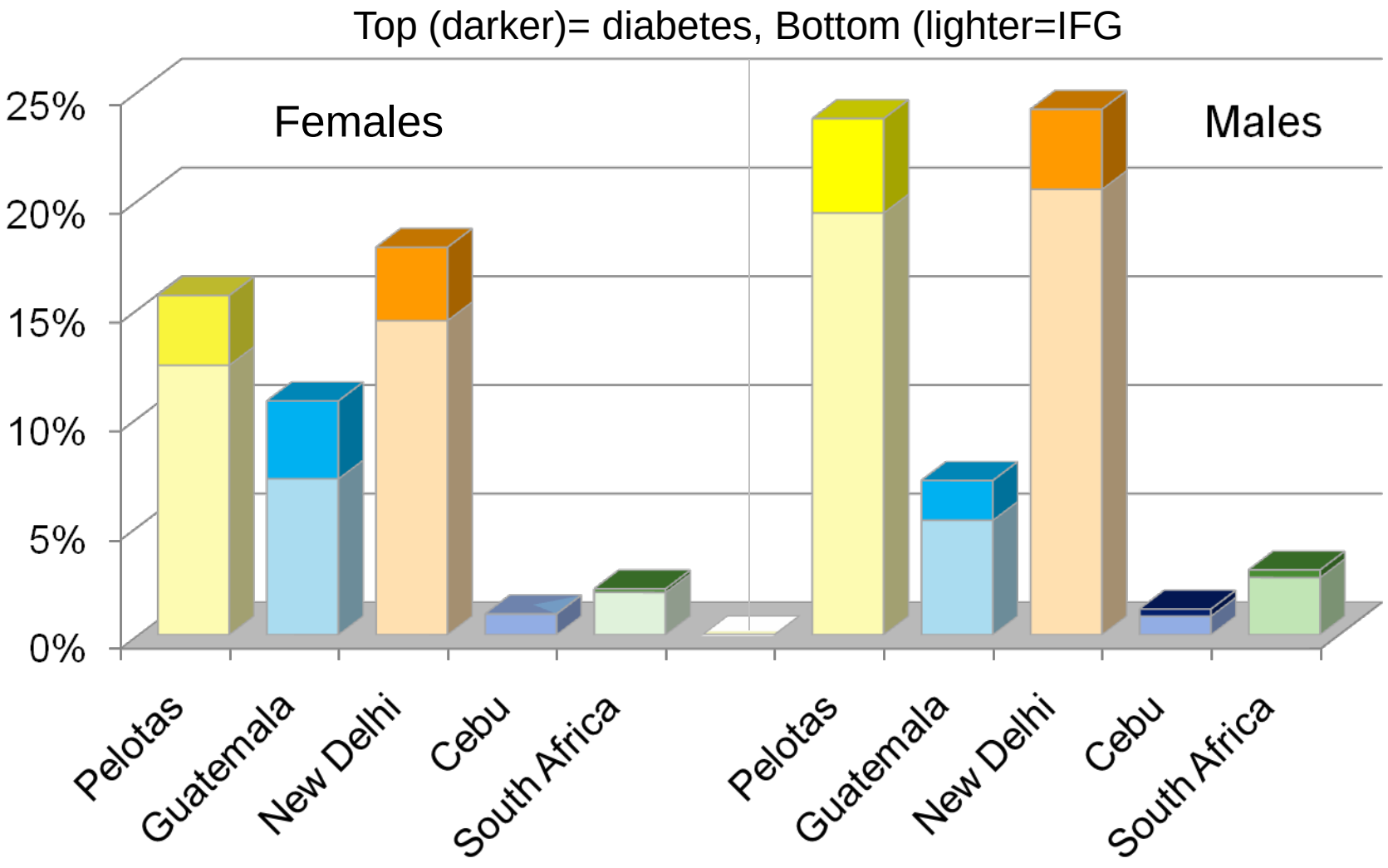
- "..interventions in early life aimed at essential short term gains, such as infant survival, could have longer term effects on individuals throughout their life-course , and such outcomes might not always be beneficial" Gluckman et al (Lancet, May 2009).

# Prevalence of overweight (BMI>25*) and obesity (BMI>30*)

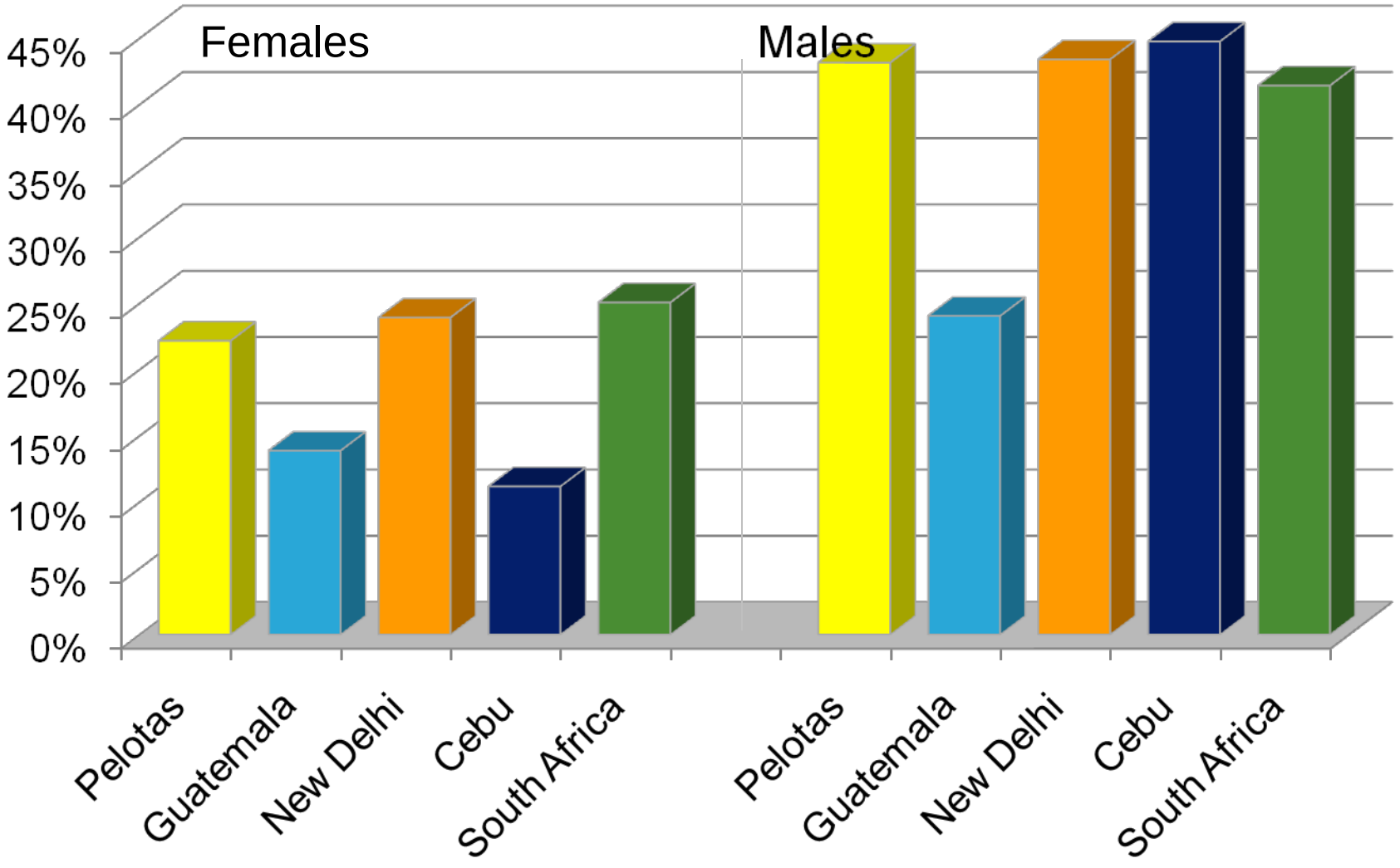



* or >IOTF cupoint if age<18

# Prevalence of impaired fasting glucose (>6.1 mmol/ml) or diabetes (>7.0 mmol/ml)



# Prevalence of Pre-Hypertension + Hypertension (SBP>130 or DBP>85)



# Cardiometabolic outcomes

| | Logistic Regression Models | | | Linear Regression Models | |
|---|---|---|---|---|---|
| | Diabetes (OR, 95% CI) | IFG+diabetes (OR, 95% CI) | P/HTN (OR, 95% CI) | Fat mass (effect size) | Lean mass (effect size) |
| BW | 0.88 (0.76-1.01) | **0.92** (0.86-0.99) | 0.95 (0.90-1.01) | **0.15** (0.14-0.16) | **0.26** (0.25-0.27) |
| 0-24 | **0.80 (0.68-0.95)** | 0.97 (0.89-1.05) | **1.12** (1.06-1.18) | **0.32** (0.31-0.33) | **0.41** (0.39-0.42) |
| 24-48 | 0.93 (0.79-1.10) | 0.99 (0.92-1.07) | **1.19** (1.13-1.26) | **0.34** (0.33-0.36) | **0.36** (0.35-0.37) |
| 48-adult | **1.30 (1.14-1.48)** | **1.29** (1.20-1.38) | **1.63** (1.54-1.72) | **0.74** (0.73-0.75) | **0.68** (0.67-0.69) |

Outcomes regressed on CW in 4 age periods, adjusted for sex, site and SES covariates

# Conclusions about analyses of weight gain, and adult body composition, blood pressure, IFG/ diabetes)

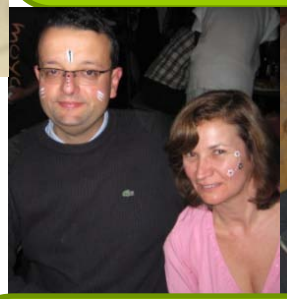
- *Early childhood weight gains* are less detrimental than late childhood/adolescent weight gains, and can even be beneficial for some outcomes…*likely because early weight gain is more related to higher* ***lean mass***

- Later weight gains are consistently associated with adverse outcomes… *likely because they are associated with greater gains in* ***fat mass***

- There are beneficial effects of weight gain for short-term morbidity and mortality, as well as for long-term gains as schooling.

## Pelotas Cohort Study

*Cesar G. Victora, Pedro C. Hallal, Fernando C. Barros, Bernardo L Horta and Denise P Gigante*
Universidade Federal de Pelotas



## New Delhi Birth Cohort Study

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## COHORTS analysis funded by the Wellcome Trust

## Birth to Twenty

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*Shane A. Norris, Daniel Lopez and Mathew Mainwaring*
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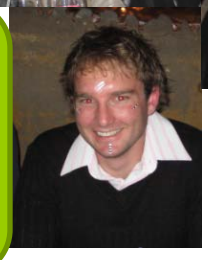

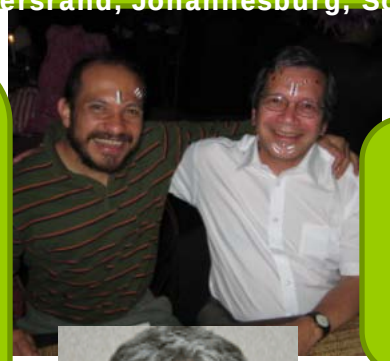

## INCAP Nutrition Trial

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## Cebu Longitudinal Health and Nutrition Survey

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Office of Population Studies Foundation, University of San Carlos, Cebu, Philippines
*Chris Kuzawa and Thom McDade*
Northwestern University
*Darren Dahly*