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

Reynaldo Martorell
Emory University

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
COHORTS
Consortium of Health Orientated Research in Transitioning Societies
Brazil Guatemala India Philippines South Africa
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.

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)

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

Birth Year

1962
Children too old for exposure from 0–36 m

1969
Children exposed from 0–36 m

1974
Children too young for full exposure from 0-36 m

1977

Intervention period
Double-difference estimate for exposure from 0–36 months of age

Average outcome for those exposed to \textit{atole} 0–36 m completely

Average outcome for those exposed to \textit{fresco} 0–36 m completely

Average outcome for those NOT exposed to \textit{atole} 0–36 m completely

Average outcome for those NOT exposed to \textit{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+++ 

---


++ 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.)?
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.
Land area

Source: www.worldmapper.org
Total births, 2000

Source: www.worldmapper.org
Birth cohort publications

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

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

- **Brazil (Pelotas)**: 9.5$^+$
- **Guatemala (4 villages)**: 5.0
- **India (New Delhi)**: 13.5
- **Philippines (Cebu)**: 10.8
- **South Africa (Soweto)**: 9.0$^{++}$

+$^{+}$ 43% of participants still in school
$^{++}$ Almost all participants in school
Ever failed a grade (%) by site

- Brazil (Pelotas): 69%
- Guatemala (4 villages): 47%
- India (New Delhi): 47%
- Philippines (Cebu): 47%
- South Africa (Soweto): 30%

+N/A = Not Available
% stunted (< -2 HAZ) at 2 y, by site

- Brazil (Pelotas): 12%
- Guatemala (4 villages): 86%
- India (New Delhi): 47%
- Philippines (Cebu): 68%
- South Africa (Soweto): 27%
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

<table>
<thead>
<tr>
<th>Variable (z)</th>
<th>Reduction in probability in failure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
</tr>
<tr>
<td>Birthweight</td>
<td>11%</td>
</tr>
<tr>
<td>Weight gain 0-2 y</td>
<td>21%</td>
</tr>
<tr>
<td>Weight gain 2-4 y</td>
<td>5%</td>
</tr>
</tbody>
</table>

+ 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 cutpoint if age<18
Prevalence of impaired fasting glucose (>6.1 mmol/ml) or diabetes (>7.0 mmol/ml)

Top (darker)= diabetes, Bottom (lighter)=IFG

Females

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

Females

Males

Pelotas, Guatemala, New Delhi, Cebu, South Africa
## Cardiometabolic outcomes

<table>
<thead>
<tr>
<th></th>
<th>Logistic Regression Models</th>
<th>Linear Regression Models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Diabetes (OR, 95% CI)</td>
<td>IFG+diabetes (OR, 95% CI)</td>
</tr>
<tr>
<td></td>
<td>BW</td>
<td>BW</td>
</tr>
<tr>
<td></td>
<td>0.88 (0.76-1.01)</td>
<td>0.92 (0.86-0.99)</td>
</tr>
<tr>
<td></td>
<td>0.92 (0.86-0.99)</td>
<td>0.97 (0.89-1.05)</td>
</tr>
<tr>
<td></td>
<td>1.12 (1.06-1.18)</td>
<td>1.19 (1.13-1.26)</td>
</tr>
<tr>
<td></td>
<td>1.30 (1.14-1.48)</td>
<td>1.29 (1.20-1.38)</td>
</tr>
</tbody>
</table>

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.