The early life environment and the intergenerational transmission of health in developing countries

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Invited talk in the Health session at the IGC conference in ISI Delhi, December 2010.

Introductory note

My brief for this invited talk was to discuss my own research on intergenerational health and to draw from it lessons for policy makers concerned with health in *India* (in 30 minutes).

This talk does not attempt therefore to provide a comprehensive survey of the literature, or a detailed description of any one of my papers.

It makes ad hoc excursions to link the research described to contemporary issues in India.

Importance of early life investments

- Growing evidence that investments made during critical periods of development draw larger returns.

- The foetal and early childhood years are critical
  - Barker 1992, Almond & Currie, 2010

  - Birth weight as a proxy for *in utero* investments.
  - Alternatively, epidemic, famine, recession in early life
  - Case et al., 2005; Almond 2006, Black et al. 2007, Cunha & Heckman 2007; Currie, 2009

Importance of early life investments in girls

- Benefits of investment in early childhood health may extend not only into adulthood but, through mothers, into the next generation.

- Conditions in the mother's birth year may induce developmental changes that impact outcomes of her offspring

  - Reduced weight gain, hypertension; restricted uterine and ovarian size: Barker and Osmond 1987; Barker 1992; Drake and Walker 2004; Gluckman and Hanson 2005

  - Fung and Wei, 2009; Bhalotra, 2010; Bhalotra and Venkataramani, 2010, Akresh, Bhalotra, Leone and Osili (in progress).

Implications

- This is an under-researched mechanism

- It suggests a non-genomic pathway for the intergenerational transmission of health.

  - Links literature on early childhood investments to literature on intergenerational persistence in health and socio-economic status and, thereby, inequality.

Policy implications

- Maternal and child health interventions focus on health during pregnancy, failing to recognise that foetal and child health depends on the mother's stock of health, accumulation of which begins in her childhood.

- Evidence of intergenerational spillovers relevant to a full accounting of the payoff to investments in the health of girls and women.

- The primacy of mother's health is pertinent in developing countries many of which are characterized by systematic under-investment in girls and women.
    - Osmani and Sen (2003)

layout

- In a bunch of research papers that are recently completed or in progress, I explore the links in the causal chain that runs across generations.

- The following slide specifies the relationships of interest.

- The rest of the talk provides a brief overview of selected relevant findings from my research.

Relationships of interest

The early life origins of health

- *Adult (mother) health= f_1 (childhood environment)*   *..(1)*

The intergenerational transmission of health

- *Child health= f_2 (mother's health)*   *..(2)*

Intergenerational payoff to investments in girls - from (1) & (2)

- *Child health= f_3 (mother's birth environment)*   *..(3)*

Gradients of the intergenerational transmission of health   *..(4)*

- *Child health= f_4 (mother's health*child's birth environment)*

The early life origins of health

Adult health= f (childhood environment)

Relation to previous work

- Epidemics, famine- natural experiments

    – Large shocks may have different effects given nonlinear technology
    – Large shocks may induce multiple changes incl. policy changes, making mechanisms non-specific

- We look at the impact of infectious disease using a policy experiment towards identification

    – Infectious disease is the health challenge in developing countries today.
    – Control of infectious disease was the source of unprecedented gains in life expectancy in richer countries in the 20th century.

(1) Medical innovation: impacts on SES, disability, fertility

- Sulfa drugs (anti-microbial sulfonomides)- USA- 1937
- First pharmaceuticals effective at treating infectious diseases.

- Time series 1925-43 show a trend break in 1937 for sulfa-treatable diseases- e.g. pneumonia, meningitis (JLS 2010)

- JLS attribute a 25 % decline in maternal mortality and a 13 % decline in pneumonia and influenza mortality between 1937 and 1943 to sulfa.

What we do

- We compare cohorts born just before and just after the arrival of sulfa drugs (*pre v post*), exploiting variation across *treated v untreated* diseases in states with *high v low* pre-intervention mortality. [IV]
  - Bleakley 2007: *post*base.*

- Focus on pneumonia, maternal mortality.

- Control for mortality from untreated diseases
  - TB, diarrhea control for impvts in sanitation and poverty
  - Cancer and heart disease control for trends in medical innovation and hospital construction.

- Possibly the first evidence of the *long run (and intergenerational)* returns to medical innovation

Effect sizes

A state with the mean pre-sulfa pneumonia mortality rate saw a post-sulfa education increase of 0.25 years, an income increase of 4%, a decrease in work disability of 2% points..

Influenza & pneumonia death rate pre/post 1937: 1.1 − 0.79

Large effects relative to say, Almond (2006)

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Smaller effects for maternal mortality.

Bhalotra and Venkataramani 2010. *The Long-Run Impacts of Biomedical Innovation: Evidence from the Sulfa Drug Era*. Forthcoming AEA talk; recent ISI talk.

Mechanisms- infections like pneumonia

Infectious disease results in the body redirecting nutritional resources from physical and mental growth to fighting infection.

Long run outcomes are particularly sensitive to exposure in early childhood because

(a) rapid growth- greater nutritional demands

(b) immune system not fully developed

Pneumonia was the leading cause of neonatal death in the pre-sulfa era (44% v 8% all-age). Similar in developing countries today; accounts for ~20% of under-5 deaths (Bhutta 2007)

Maternal mortality

Maternal mortality rates fell with sulfa because of control of puerperal sepsis, a post-birth infection.

Likely paths for impact on offspring are

- Increased investment in *girls* as their life expectancy improves (Jayachandran and Lleras-Muney, 2009; Albanesi and Olivetti, 2010)
- Increased investment in *both genders* as more mothers survive

India -Maternal mortality has improved in the last two decades (Bhat 2002) but there remains considerable scope for improvement: 67% of births occur at home.

(2) Infectious disease and IQ

- Mexico- National Clean Water Program in 1991-$1 b in 3 yrs
- Diarrheal disease mortality dropped sharply within a year

- We look for impacts on IQ in tests taken at age 15 [etc.]

- Why IQ?   Eppig et al. 2010. Flynn 1987.

- *post*base*season* identification strategy.

- Bhalotra and Venkataramani (in progress). *IQ consequences of early life exposure to infectious disease*

Sharp increase in population with access to chlorinated water

53% in 1990 to 90% in 1992
Also, reduction of use of waste water for irrigation

National Clean Water Program: Chlorination
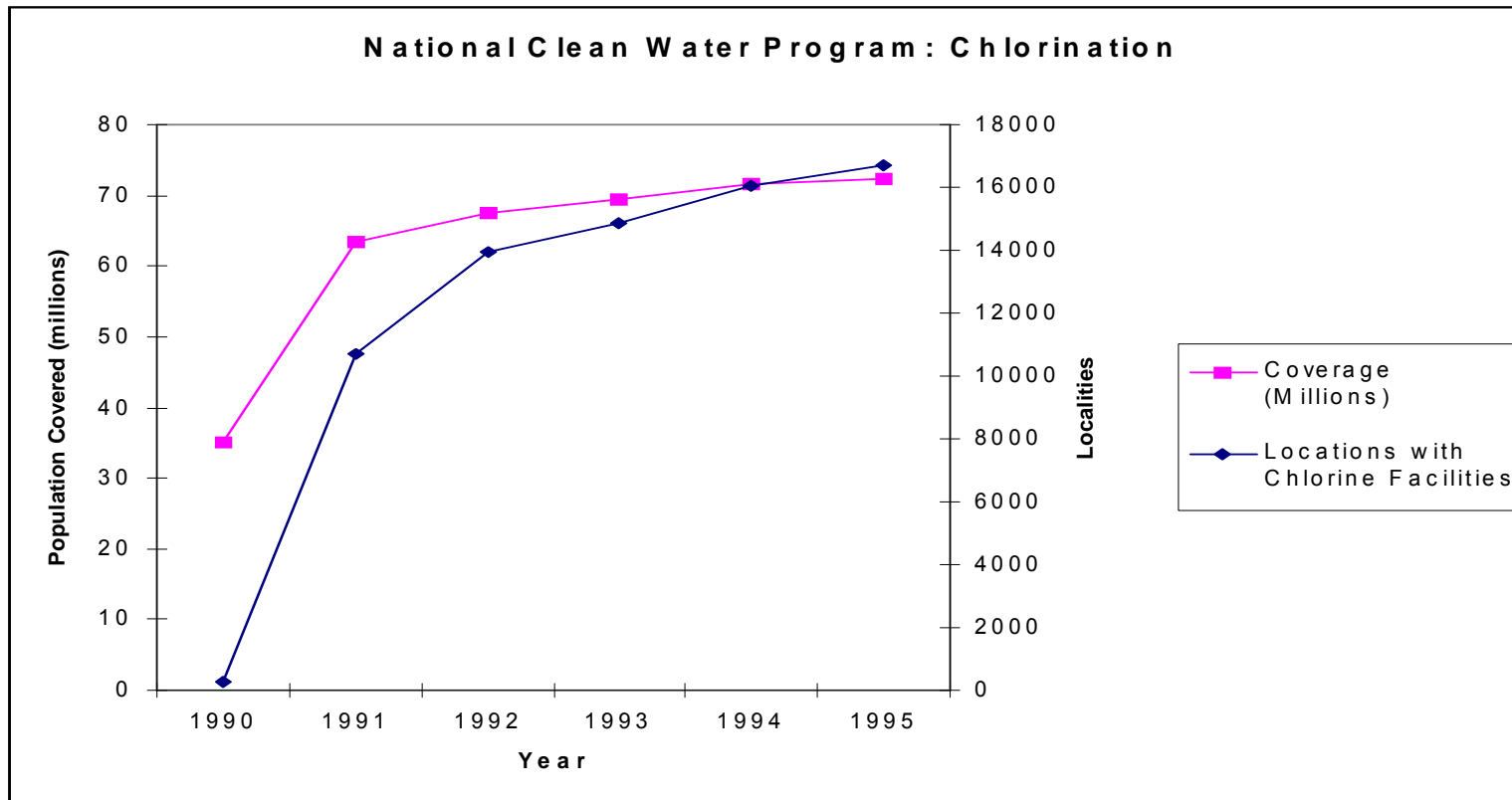
(3) Early life net nutrition: impact on height at maturity

- Indian DHS- 2 rounds, 1 includes men.
- Adult cohorts 1950-85
- Match in indicators of the birth environment.

Bhalotra 2007 *Wuthering heights: birth shocks and stature amongst Indian men and women.*

Related: Deaton 2007, Bozzoli et al. 2010

Results

Neonatal mortality in the birth year of the individual reduces their final height (men and women).

Neonatal mortality stronger than infant or under-5 mortality.

– Suggests importance of maternal health, conditions in utero, antenatal care, birth spacing and place of delivery.

– Over time, neonatal mortality has declined more slowly than infant or child mortality.
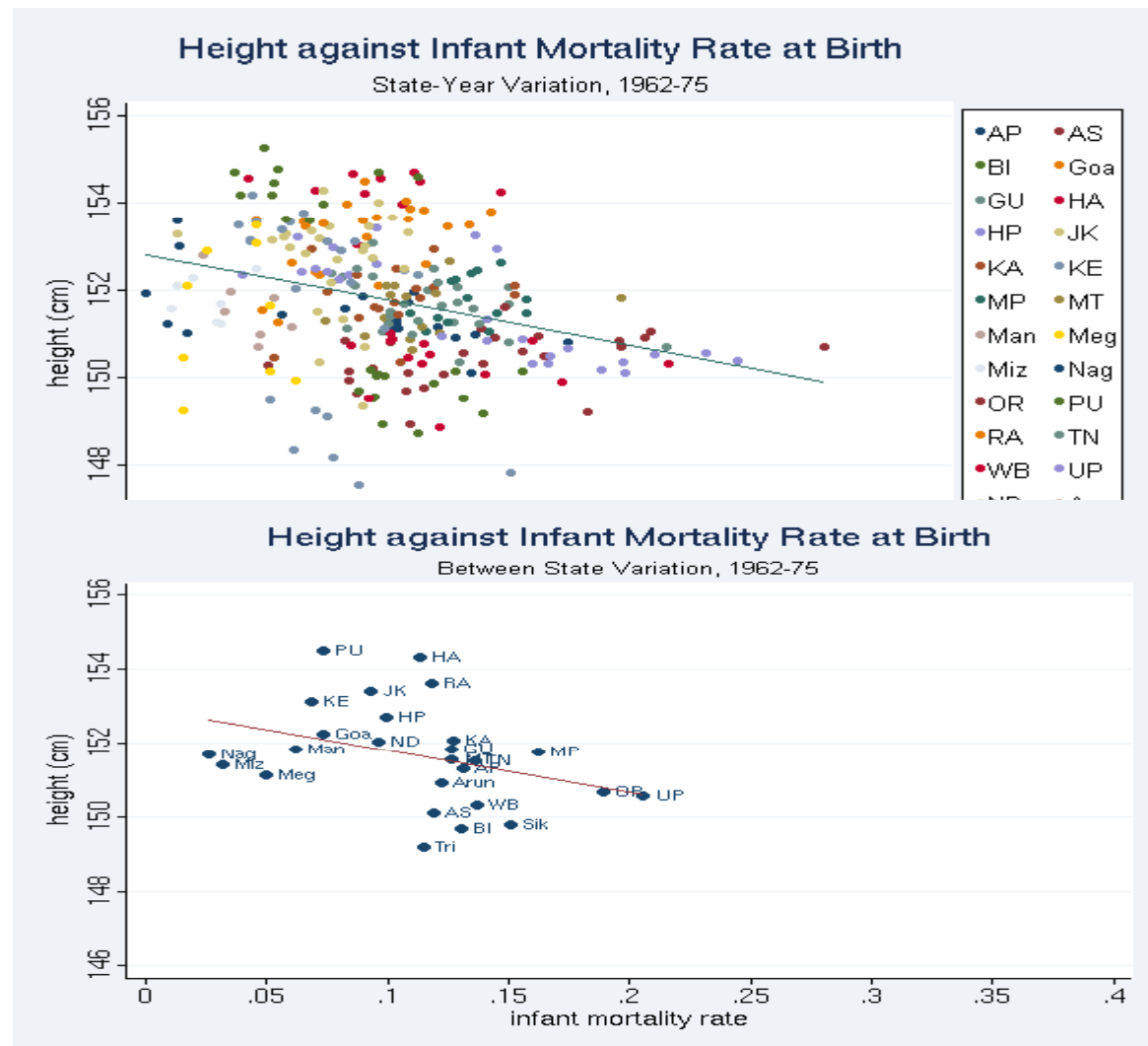
Results contd.

Height of men and women is decreasing in fertility, female illiteracy and, conditional on this, in the log ratio of female to male illiteracy.

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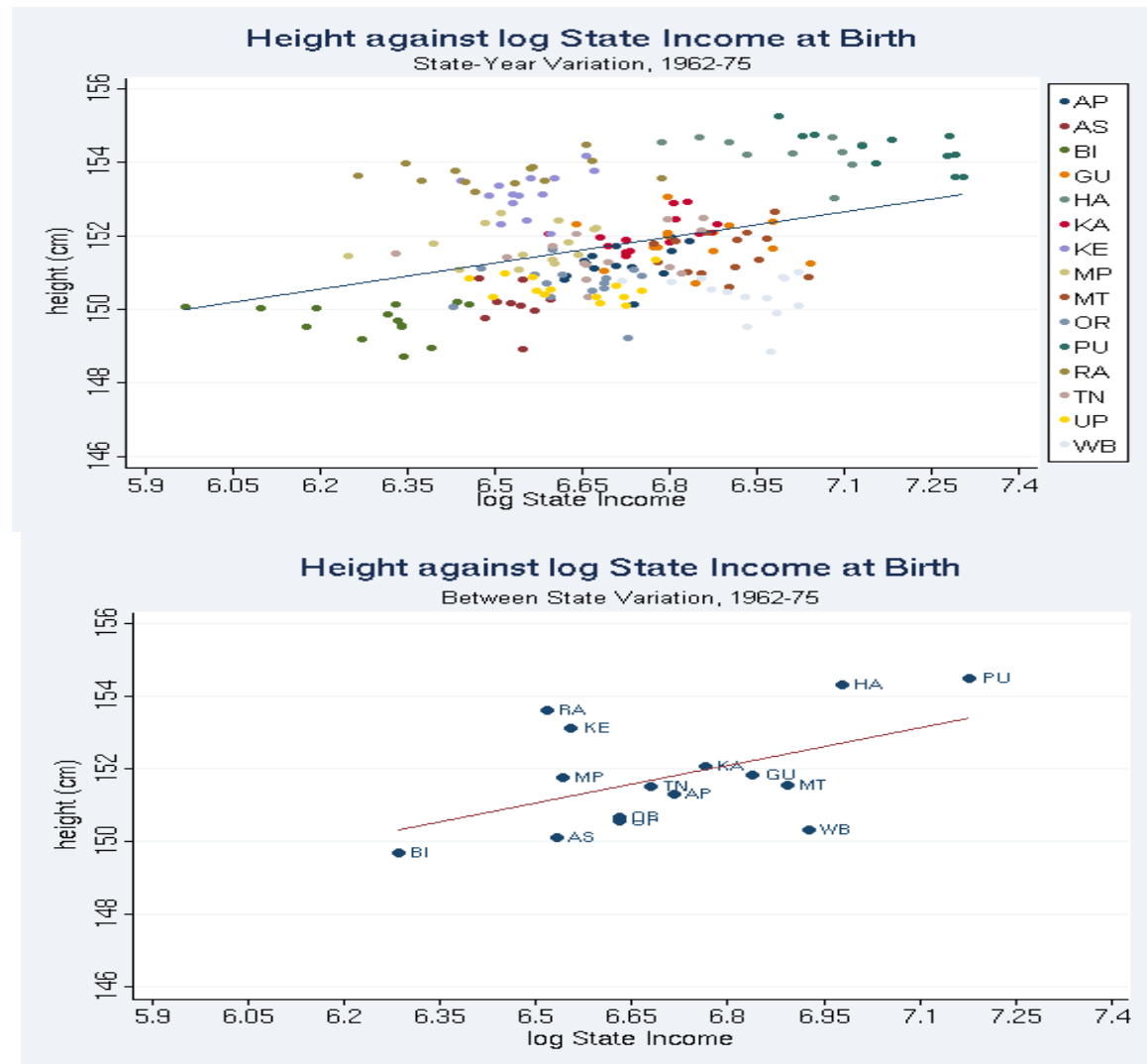For women but not men, height is sensitive to income and rainfall shocks at birth.
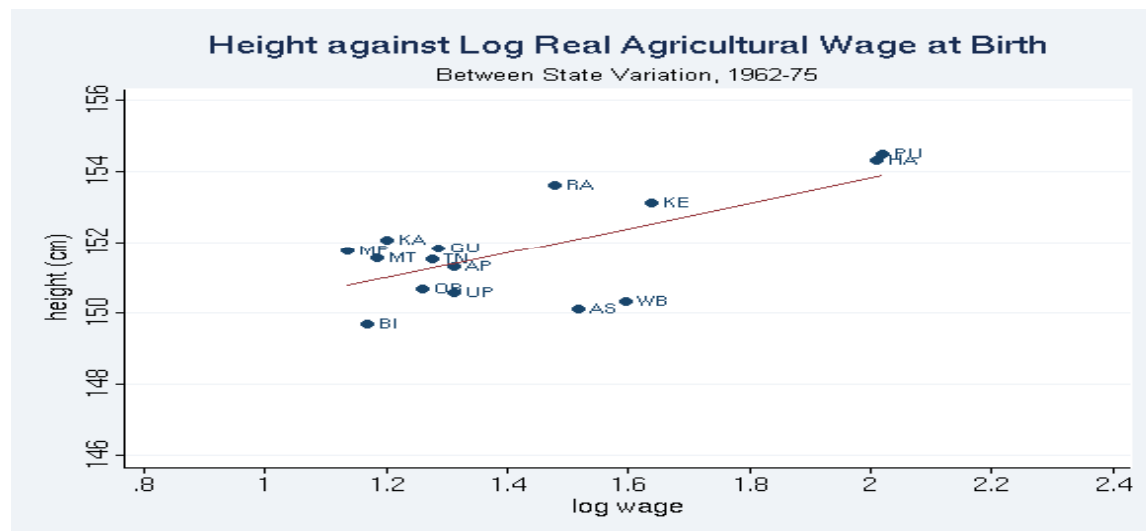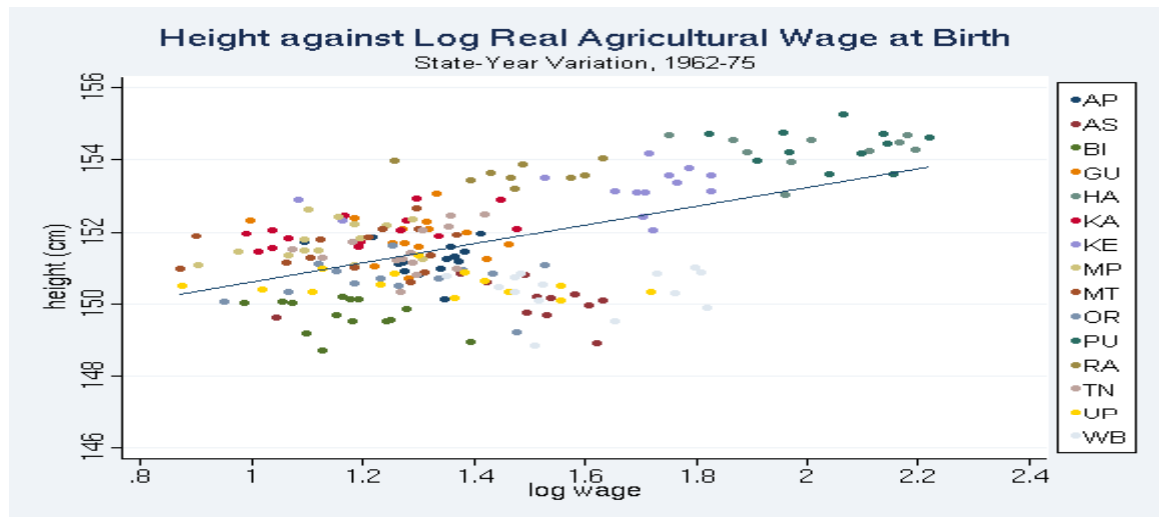
Infant Mortality
Overall & Between Variation

State Income
Overall and Between Variation

Height against log State Income at Birth
State-Year Variation, 1962-75

Height against log State Income at Birth
Between State Variation, 1962-75

Agricultural Wages

Height against Log Real Agricultural Wage at Birth
State-Year Variation, 1962-75

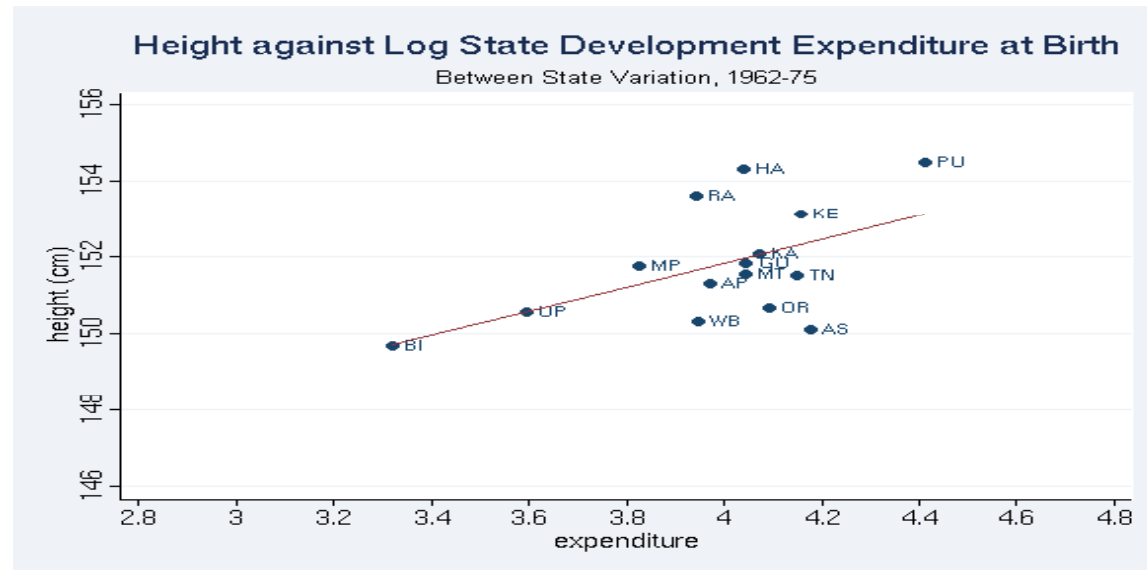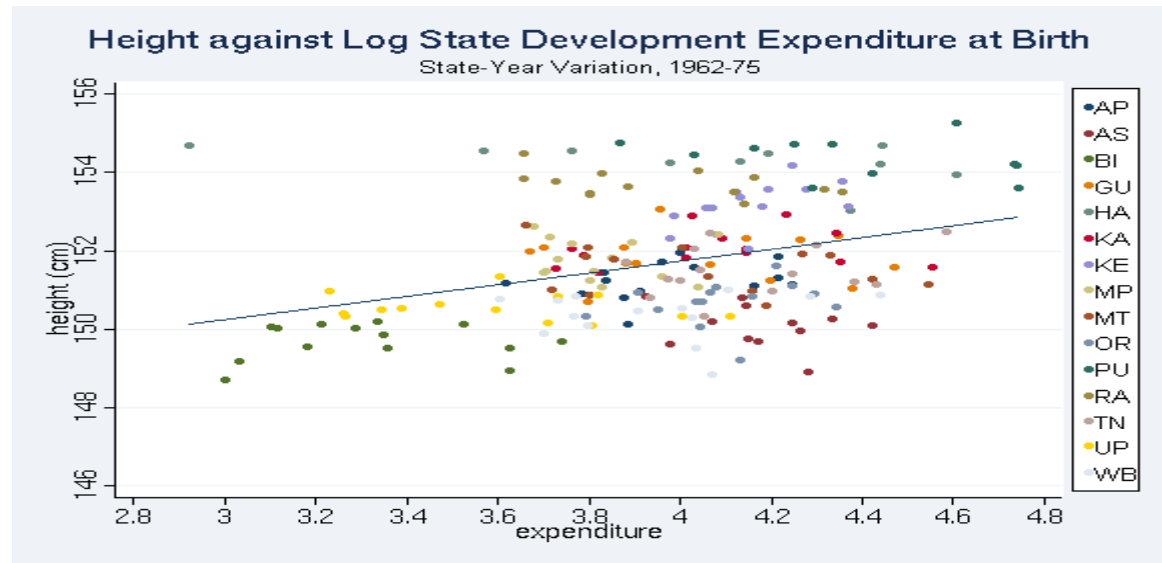Height against Log Real Agricultural Wage at Birth
Between State Variation, 1962-75

State Development Expenditure
Overall and Between Variation

The intergenerational transmission of health

Child health= f (mother's health)

Height

- Use mother's height as a measure of her stock of health.

  - Adult height reflects infection and nutrition in early life
    Bhalotra 2007, Deaton 2008, Bozzoli et al. 2010, Case and Paxson 2008, 2010

  - Height correlated with health and life expectancy:
    Galton 1886, Waaler 1984

- We also investigate BMI, anemia status

Child health

- Child health is indicated by one of birth weight, height, neo, infant or under-5 mortality

- Low birth weight (and stunting) portentous of adult health. Black and Devereux, 2010.

- Similarly, survivors amongst cohorts born into an environment of high mortality experience earlier morbidities and lower life expectancy. van den Berg et al. 2006.

Data

Comparable micro-data on 2.24 m. children born of 0.6 million mothers in 38 developing countries during 1970-2000.

$$C_{imjt} = \alpha + \beta H_m + X'_{im}\lambda + \gamma_{jt} + \varepsilon_{imjt}$$

β is the intergenerational correlation of health

- Bhalotra and Rawlings 2010, *Intergenerational transmission of health in developing countries: the penalty of gender inequality?* Journal of Public Economics.

- Bhalotra 2008. *Intergenerational health transmission in India: mothers, fathers and the state.*

Selected findings

- Average effect size: A one standard deviation (7.13 cm) gain in mother's height is associated with close to a 0.73%-point reduction in infant mortality risk, which is about 7.6% of the average mortality rate in the sample.

- Gains for improvements below the mean> for improvements above the mean.

- Low v high BMI. Both may indicate under-nutrition.

Non-parametric estimate of the relationship between infant mortality & mother's height.

1.47 is 10th percentile- relation <u>strongest for lowest 10% of height</u>.
1.56m is 50th percentile- where curve flattens.
1.7m is 95th percentile- where curve tends upwards.

Predicted infant mortality against height
Random sample of 20% of observations
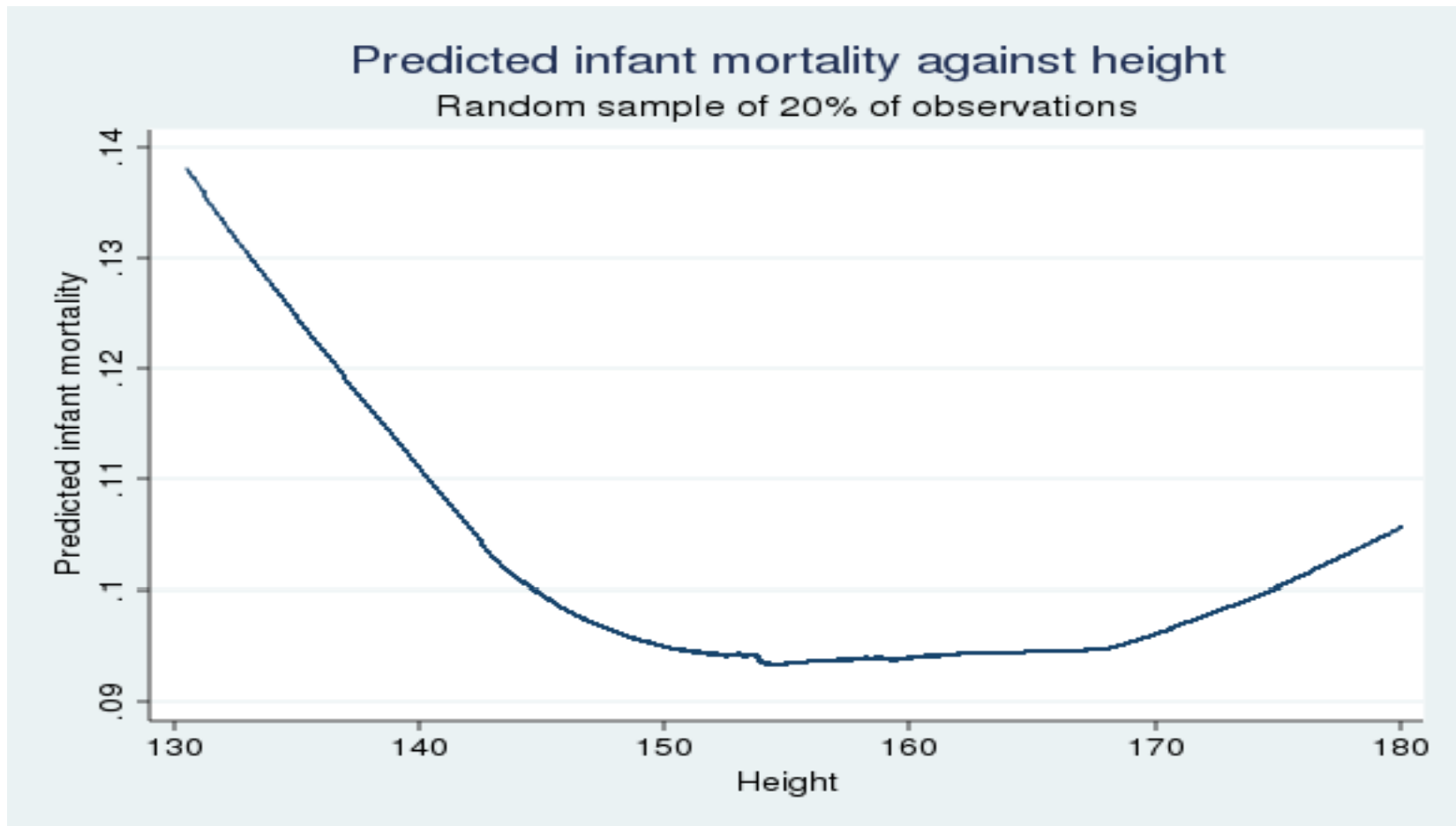
Country-specific lowess plots

Greater cross-country variation in child health amongst shorter women. Since endowment transmission should not vary across countries but investment can, this suggests SES effects on gradient for shorter women.

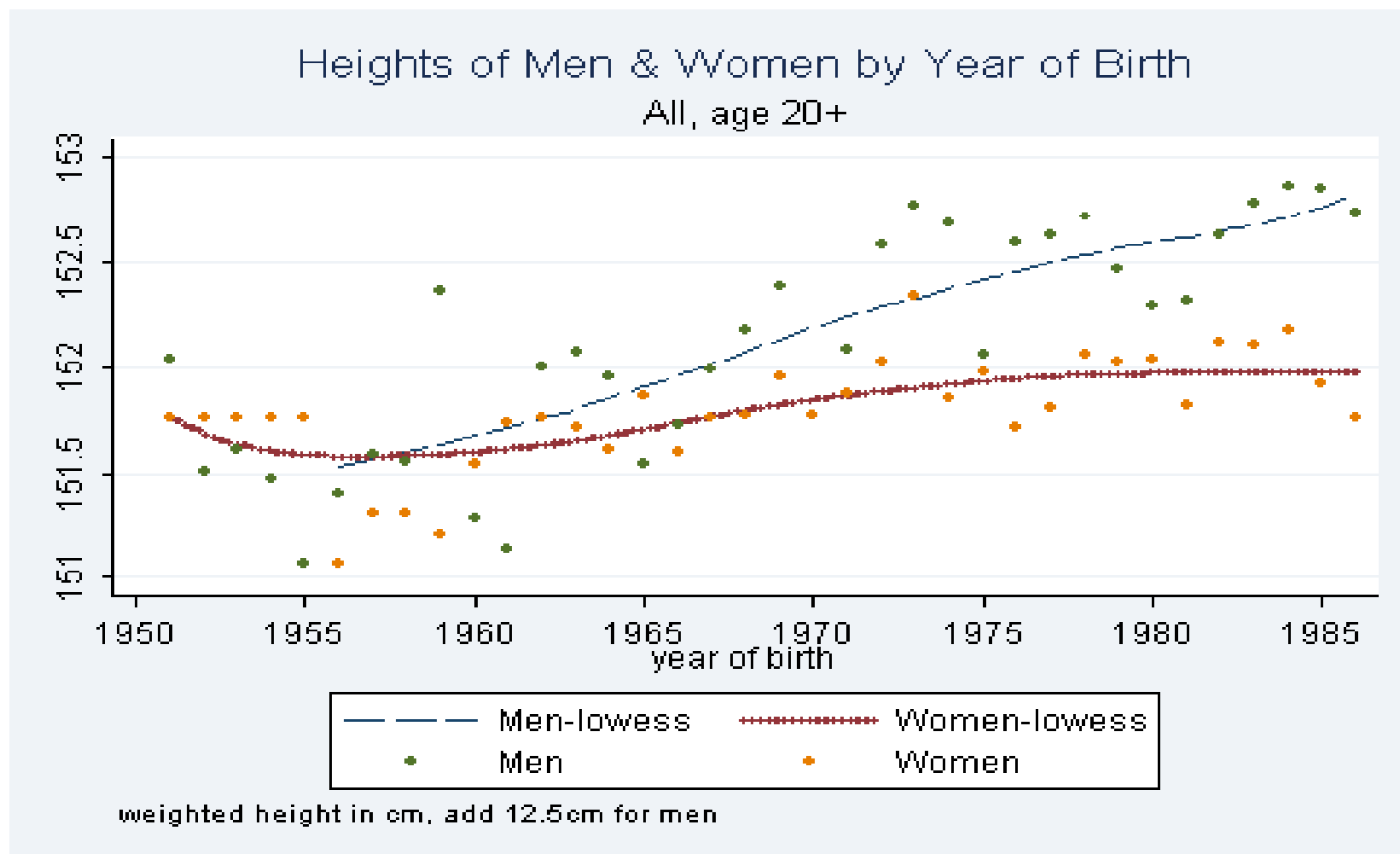Predicted infant mortality against log height
38 Developing Countries
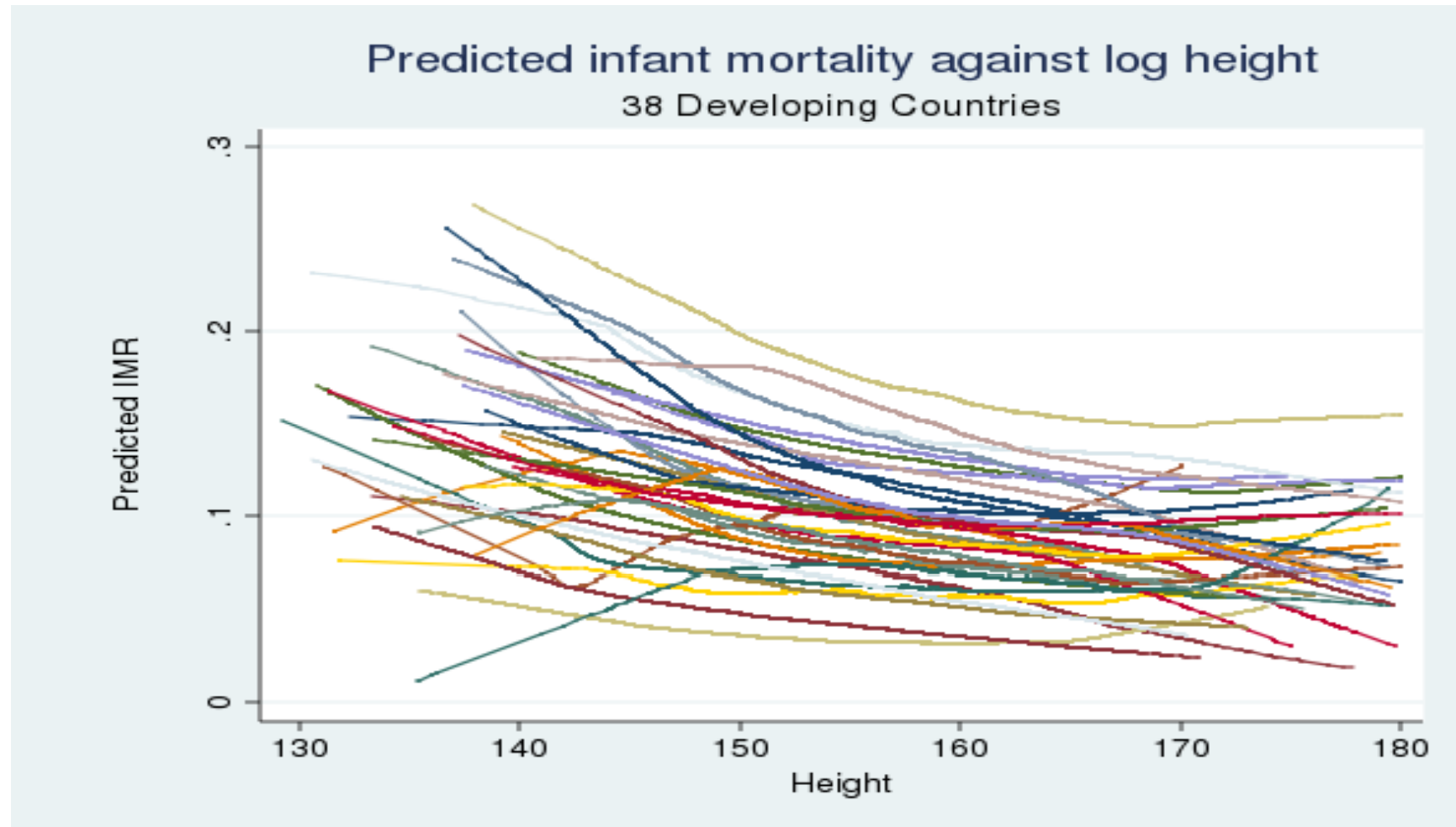
India

- Indian women are amongst the shortest in the world.
- Relatively high prevalence of low-BMI and anemia
- Indian babies are exceptionally small, mean b-weight 2.7kg.
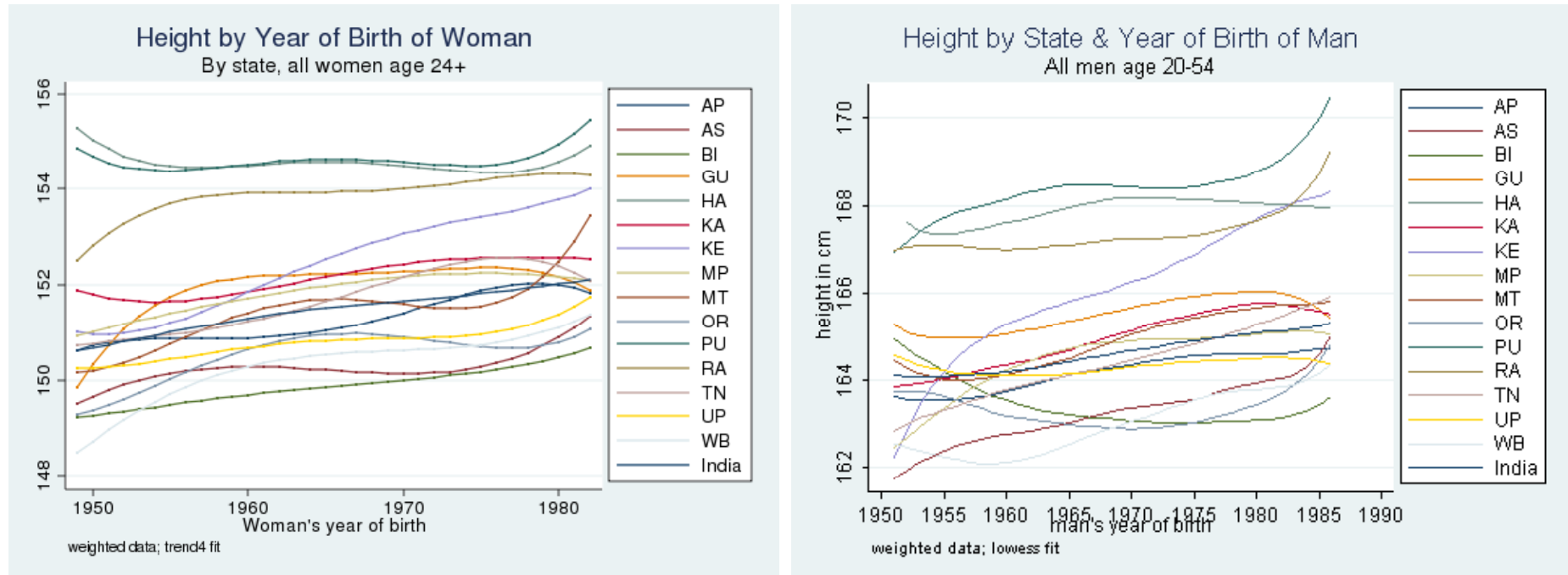- Infant mortality rate in the period 1970-2000 averages at ~10%

- Women gained height 1950-1965 but slowed 1965-1980. Bhalotra 2007
- Women gained height less rapidly than men. Deaton 2008.
- Unique to Hindu women. Muslim women have grown faster than their male counterparts. Bhalotra 2007
- Son preference? Implications for next generation sons and daughters. Bhalotra, Valente and van Soest 2009.

- Bhalotra 2007. *Little Women*. Mimeograph.
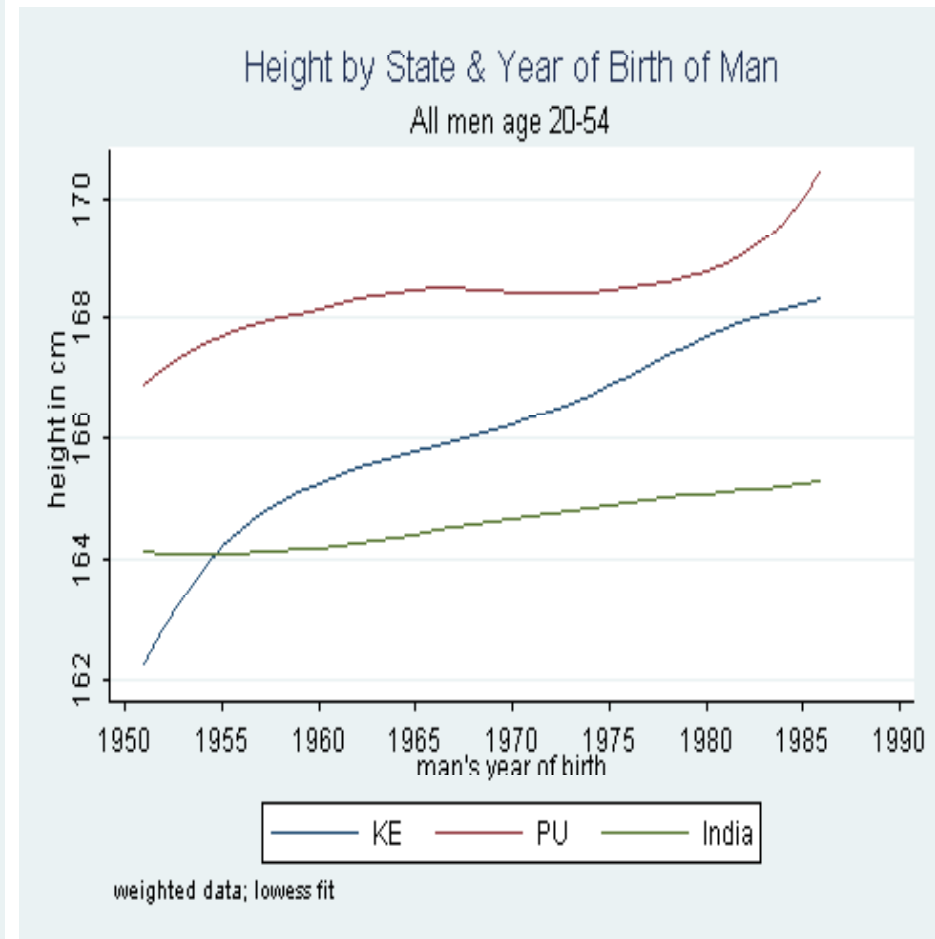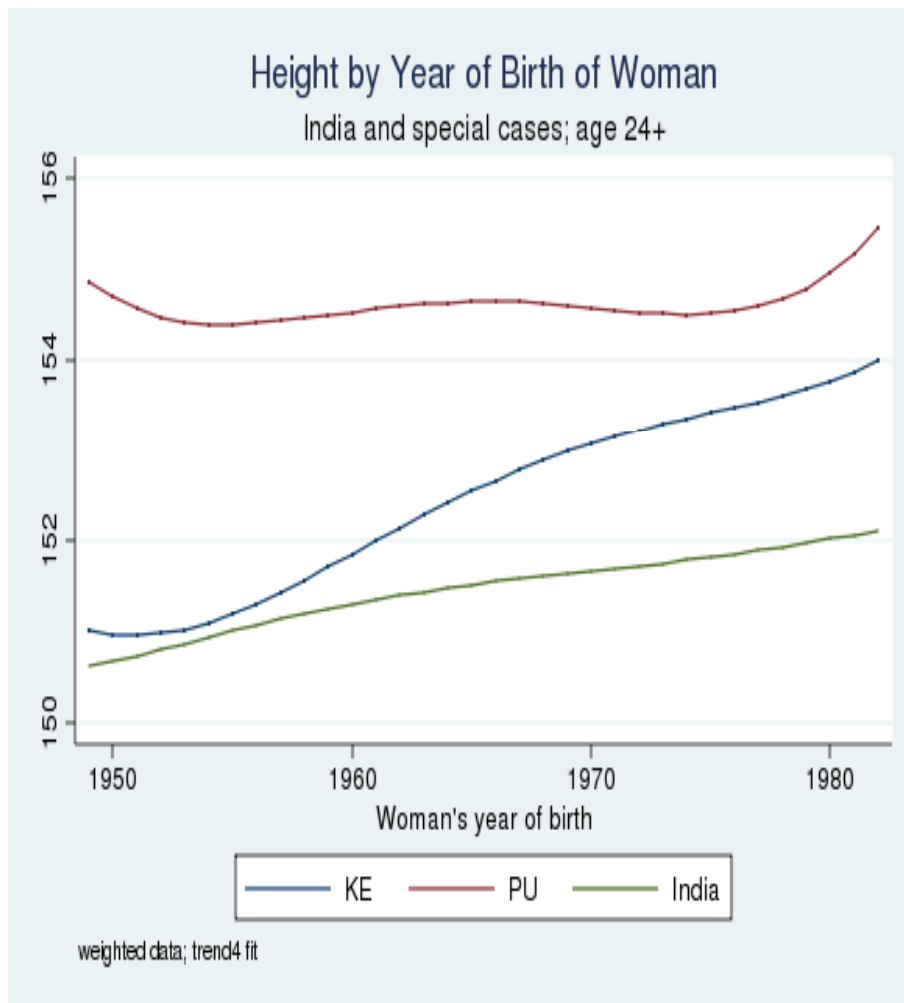
Height gain: Indian women and men

Heights of Men & Women by Year of Birth
All, age 20+

Height trends by state

Height by Year of Birth of Woman — By state, all women age 24+ (weighted data; trend4 fit)

Height by State & Year of Birth of Man — All men age 20-54 (weighted data; lowess fit)
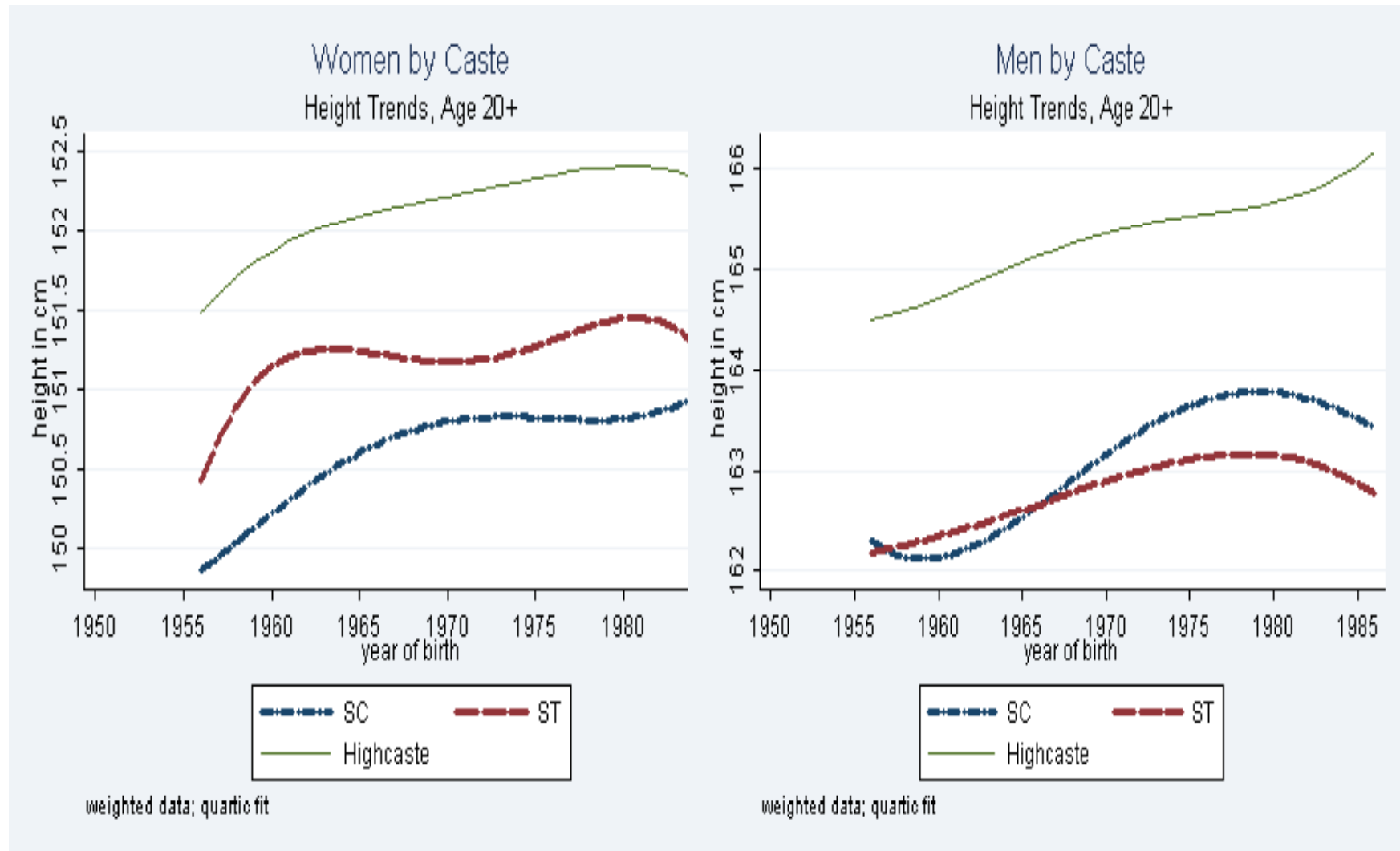
- Height differs quite persistently across states, range of 6-8 cm.
- Growth is most rapid, for men and women, in Kerala.
- In Punjab, women don't grow at all but men grow a lot.

Kerala and Punjab

Height by Year of Birth of Woman
India and special cases; age 24+

KE — PU — India

weighted data; trend4 fit

Height by State & Year of Birth of Man
All men age 20-54

KE — PU — India

weighted data; lowess fit

Caste advantage larger for men

Education advantage larger for men

Uneducated & Educated Men & Women
Height Trends, Age 20+

weighted data; quartic fit
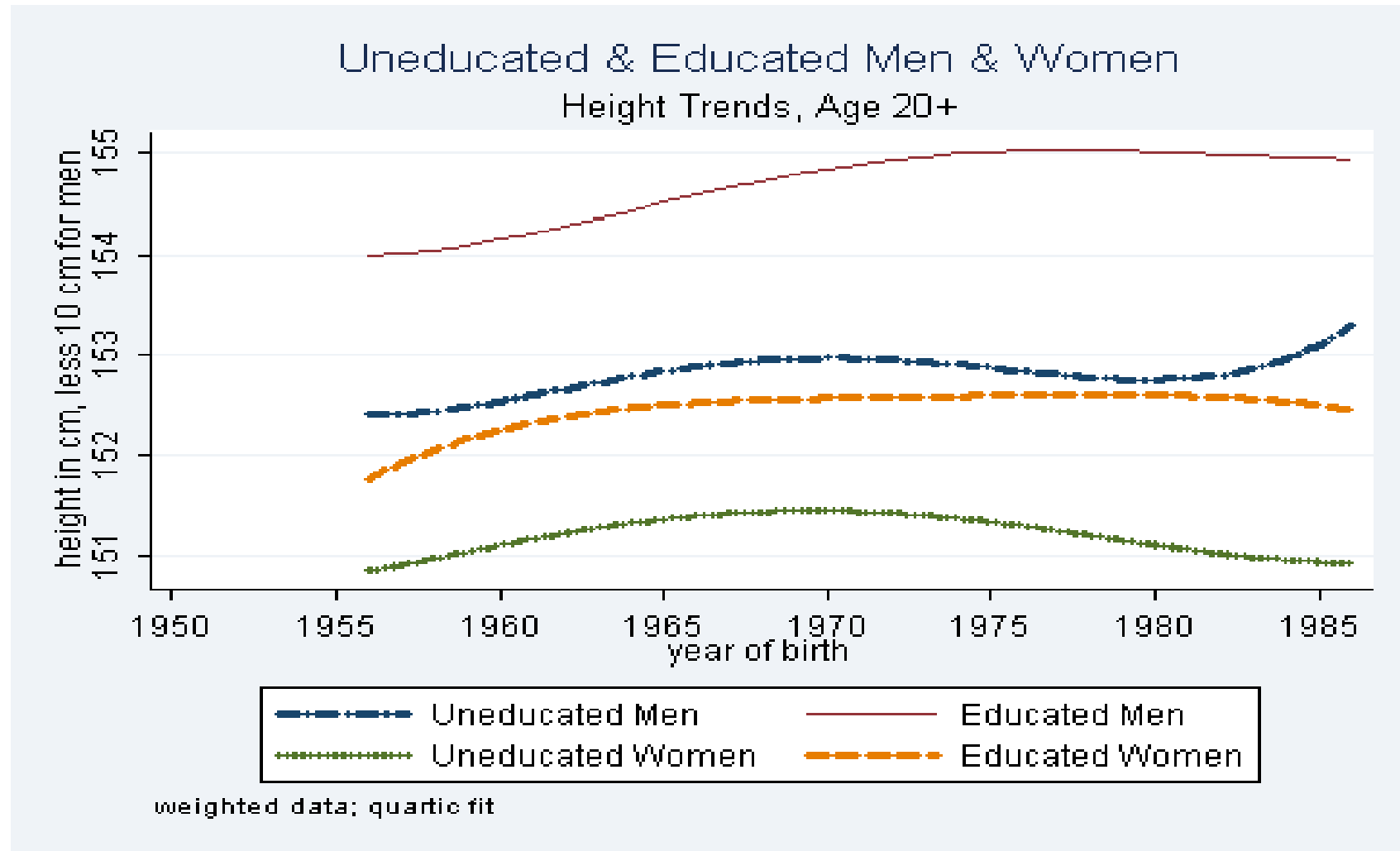
Intergenerational payoff to investments in girls

Child health= f (mother's birth environment)

The reduced form

$$C_{imjt} = \alpha + \beta E_{j(t-a)} + X'_{im}\lambda + \gamma_{jt} + \varepsilon_{imjt}$$

Indicator for child health regressed on indicators of infectious disease environment in mother's birth year* birth region.

Controls for child birth year*birth region, mother's age at birth and individual heterogeneity.

66 developing countries * 31 cohorts. [similar- Indian states]

Bhalotra 2009: *The intergenerational spillover of early life conditions.* Forthcoming AEA (Denver) presentation.

Results

- Scarring: mother's born into a high mortality environment have children who suffer higher mortality risk. Selection at right tail. Similar for income.
  - Reproductive mortality

- Women born in adverse environments delay fertility. Conditional on their education. Evolutionary? Age at menarche?
  - Fertility transition

Not aware of previous similar evidence

Age at (first) marriage in India
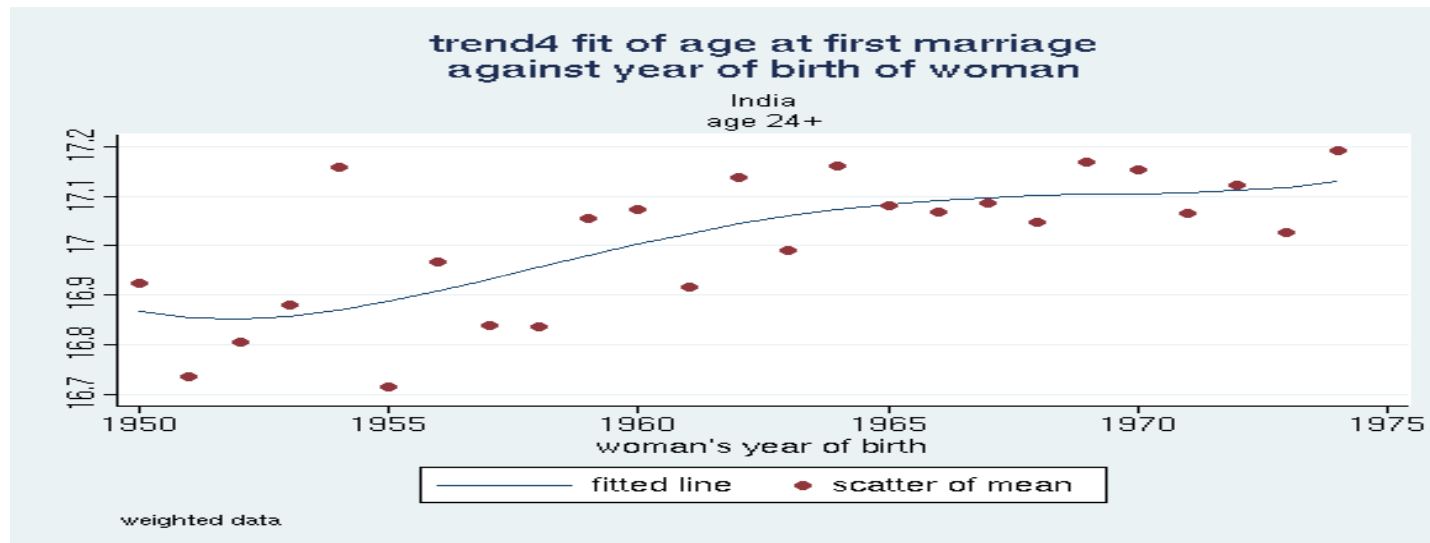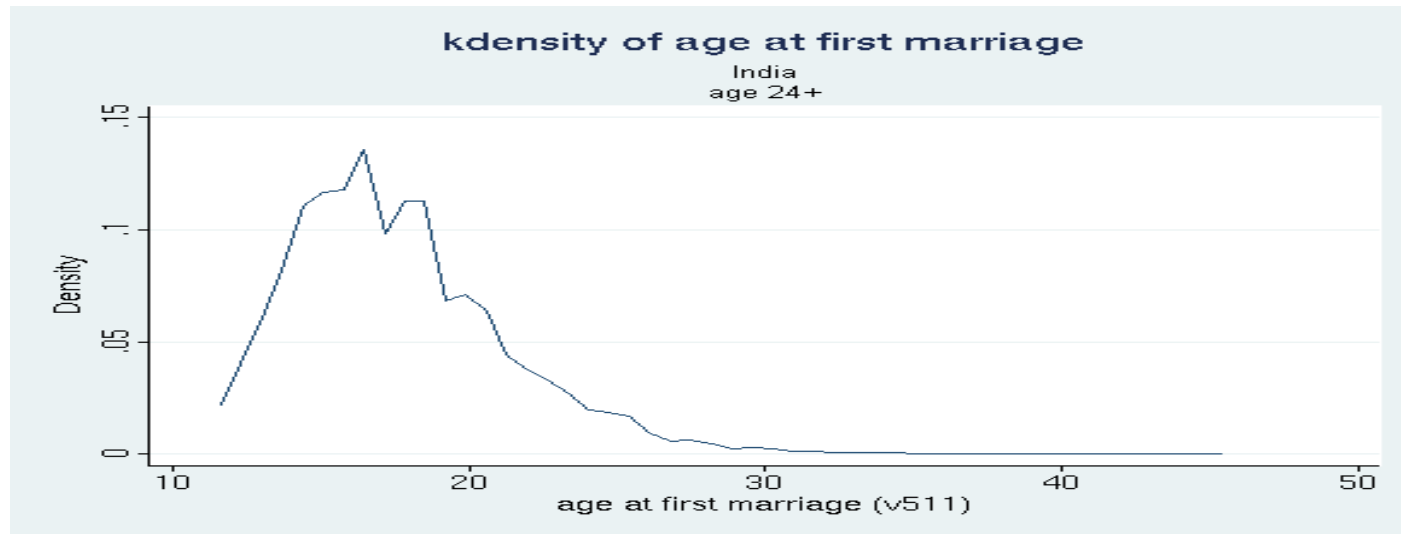
Teenage pregnancy

- High prevalence of teenage pregnancies in developing countries- under-studied

    – Wider literature- more on consequences for mother than for child. In rich but not in poor countries, teen births are out of wedlock.
    – Mixed evidence on health consequences for child: selection on SES

- India: 56% of Indian women giving birth in 1970-2000 have their *first* birth by the age of 18.

- 22% of all births are to women under the age of 18.

- Bhalotra and Sanhueza (in progress). *Education reform, teenage pregnancy and birth weight in Chile.*

Gradients of the intergenerational transmission of health

Child health= f_3 (mother's health*child's birth environment)

Gradients of transmission

- To what extent do conditions in the *child's* birth year attenuate the intergenerational transmission of health?

or

- To what extent is the impact of the early life environment on child health mediated by the mother's health? .. environment-endowment interaction

- Include interactions of maternal health with environmental conditions in the child's birth year.
- Allow non-linearity in mother's health in the level and gradient.

Bhalotra and Rawlings 2009. *Gradients of the intergenerational transmission of health in developing countries.*

Gradients model

$$C_{imjt} = \tau(H_m \cdot y_{jt}) + \alpha_m + \gamma_{jt} + X'_{imjt}\lambda + e_{imjt}$$

micro panel nested in macro panel.

α_m are mother fixed effects.

y is an indicator of SES. Direct effect of y captures difference in health outcomes for siblings born in different economic conditions (e.g Bhalotra 2010; Baird et al 2010)

τ is the gradient of the intergenerational health correlation. It indicates whether the environment exerts stronger effects for children of shorter women given their endowments.

We expect $\beta<0$, $\alpha<0$ and $\tau>0$. [identification in previous work]

Volatile environments

- Income volatility in developing countries is endemic.
  - Pritchett 2000. Aids identification & underlines empirical relevance.

- Sharp fluctuations in public health provision.
  - Public spending in richer countries tends to rise in bad times (Lane 2003, Cutler et al. 2007) but in poorer countries it tends to decline (Woo 2005, Bhalotra 2007).

- Mother's education does not fluctuate over time for a given cohort of women but we can exploit variation in the average education of mothers in the child's cohort.

Effect sizes (absent mother FE)

- An additional year of own mother's education reduces correlation by 5.4%; secondary education & urban residence together eliminate any penalty from having a short mother

- An additional year of average mother's education is associated with a 17% decline in the intergenerational coefficient.
    - Note the much larger effect associated with the average rather than the individual mother- externalities?

- A one s.d. increase (9.7%) in GDP reduces intergenerational persistence by 20%.

- A one s.d. increase (22%) in DPT and measles immunization rates results in a 16 to 19% decline in the intergenerational correlation of health.

- The gradients are two to three times as large for mothers with height in the tail as for taller mothers.

- The interaction coefficients are enlarged upon controlling for mother level unobserved heterogeneity
  - Reinforcing investments by parents?

Previous studies of the gradient

Conley & Bennett 2001
Currie & Moretti 2007.
Almond & Chay 2006

Findings:

- Mother's education, income, public services attenuate the correlation.

- Attenuation is strongest amongst less healthy women, indicated in the first study as low birth weight and in the second as black.

No evidence for developing countries where greater prevalence of poor health and low wealth; lower mobility but greater returns.

Health mobility

- 1970-2000- period of momentous change and turbulence in the economic and health environment.

- Parts of Latin America and Asia experienced periods of unprecedented growth, while large parts of Africa exhibited negative growth.

- The health environment directly altered by new technologies and nationwide interventions including the Expanded Immunization Programme initiated in 1974 and rolled out over the next two decades.

- Many countries saw gains in life expectancy of greater than twenty years during 1960-2000 (Maddison, 2004).

- However, by the early 1990s, HIV-AIDS was reversing gains in Africa (Soares, 2006).

Cohort trends in the intergenerational correlation of health

- We estimate an erosion of 20-30% per decade in the regression coefficient relating child mortality to mother's height.
- This falls to 10-30% after adjusting for the rise in the relative inequality of mother's height and child mortality
- Looks impressive esp in view of the record of limited income and education mobility. But-

- The average trend is driven by twice the improvement in Latin America.
- Largely no trend in Asia
- Intergenerational persistence, especially for neonatal mortality, has increased in Africa.

Longer run development

Compare intergenerational correlation coefficient for cohorts born 20 years apart in contrasting growth regimes.

Exploit diversity of growth experiences across developing countries-.

- 38 countries- 3 regimes: 9 negative growth, 14 positive growth and 15 insignificantly small growth.
- Average income growth in 1970-2005 varies from -3% in Nicaragua to 3% in Egypt

Consistent with attenuating effects of wider economic development, β declines faster in countries with positive economic growth than in other countries. (18% v negative)

Cross-country relationship of β & growth
slopes of -0.027*, -0.020*

Intergenerational correlation coefficient against average GDP, by country
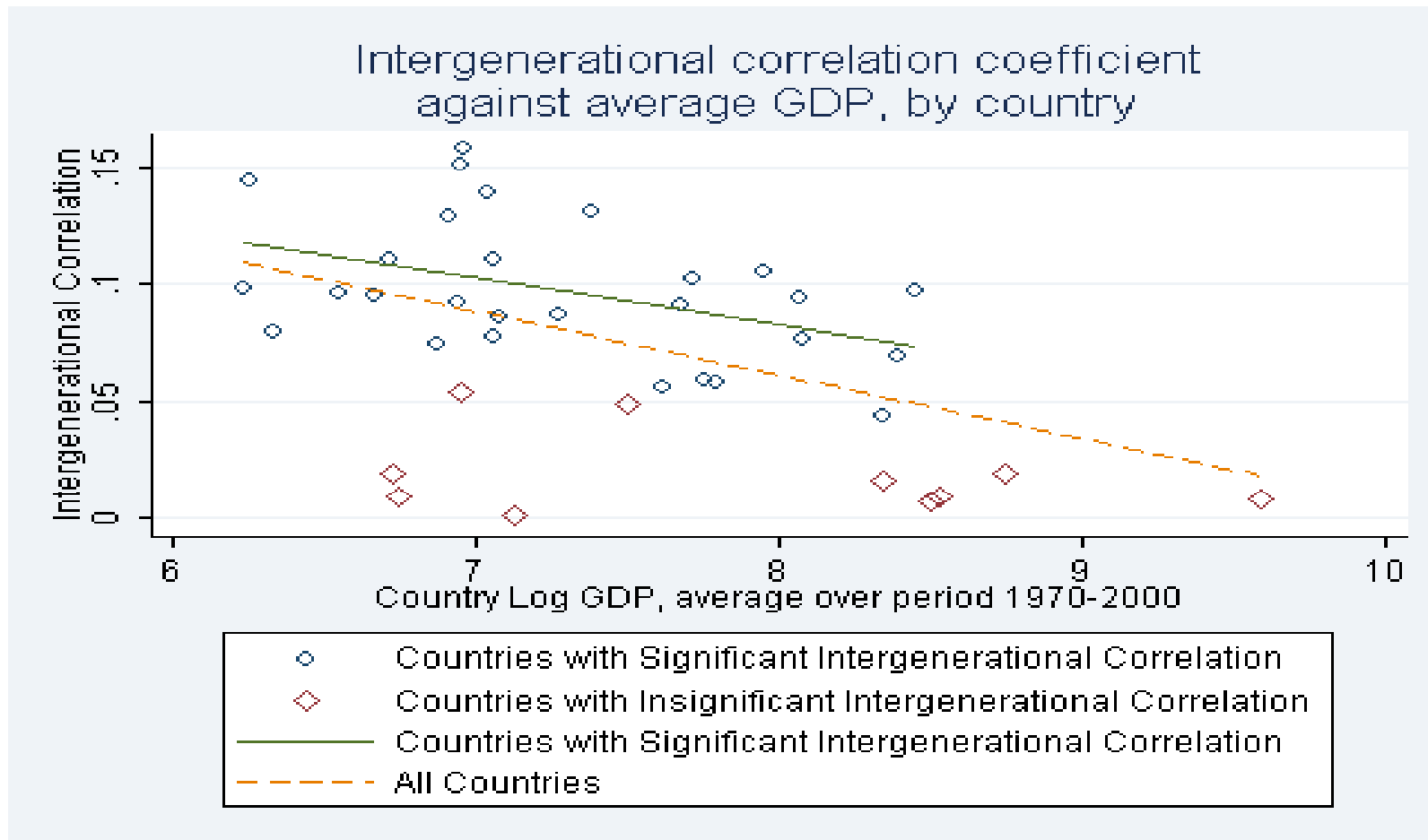
Some thoughts to guide policy

- The payoff to investments in girl health are s.t. an intergenerational multiplier

- The scourge of infectious disease has long run and intergenerational impacts on indicators of health and economic status.
  - Infectious disease is a complex of poor nutrition, contaminated drinking water and poor sanitation. Cutler et al. 2006: 30 v 1%
  - Early life health insults impair *cognitive* development as well as predicting later life morbidities.

- Infection and other aspects of their health and SES environment interact with the child's endowment, proxied by their mother's stock of health.

Some open questions for India

- Evaluation of maternal and child health programmes- e.g. neonatal pneumonia/sepsis

- Universal immunization programme

- Health insurance- RSBY, Kerala

- Water quality interventions

- Did the Bihar growth miracle lead to improved health?

- India provides an excellent laboratory for analysis of interventions

- Federal structure exploited to conduct some of the first natural experiments in the USA

I'll stop here

Do send comments and questions to
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Some of the papers cited are at
http://www.efm.bris.ac.uk/www/ecsrb/bhalotra.htm