# Impact on Child Development

## Learning, growth and long run benefits

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# Efficacy of deworming treatments: Meta-analysis of RCTs, single-dose cure rates

| | *Ascaris* | *Trichuris* | Hookworm |
|---|---|---|---|
| **Albendazole** | 88% | 28% | 72% |
| **Mebendazole** | 95% | 36% | 15% |

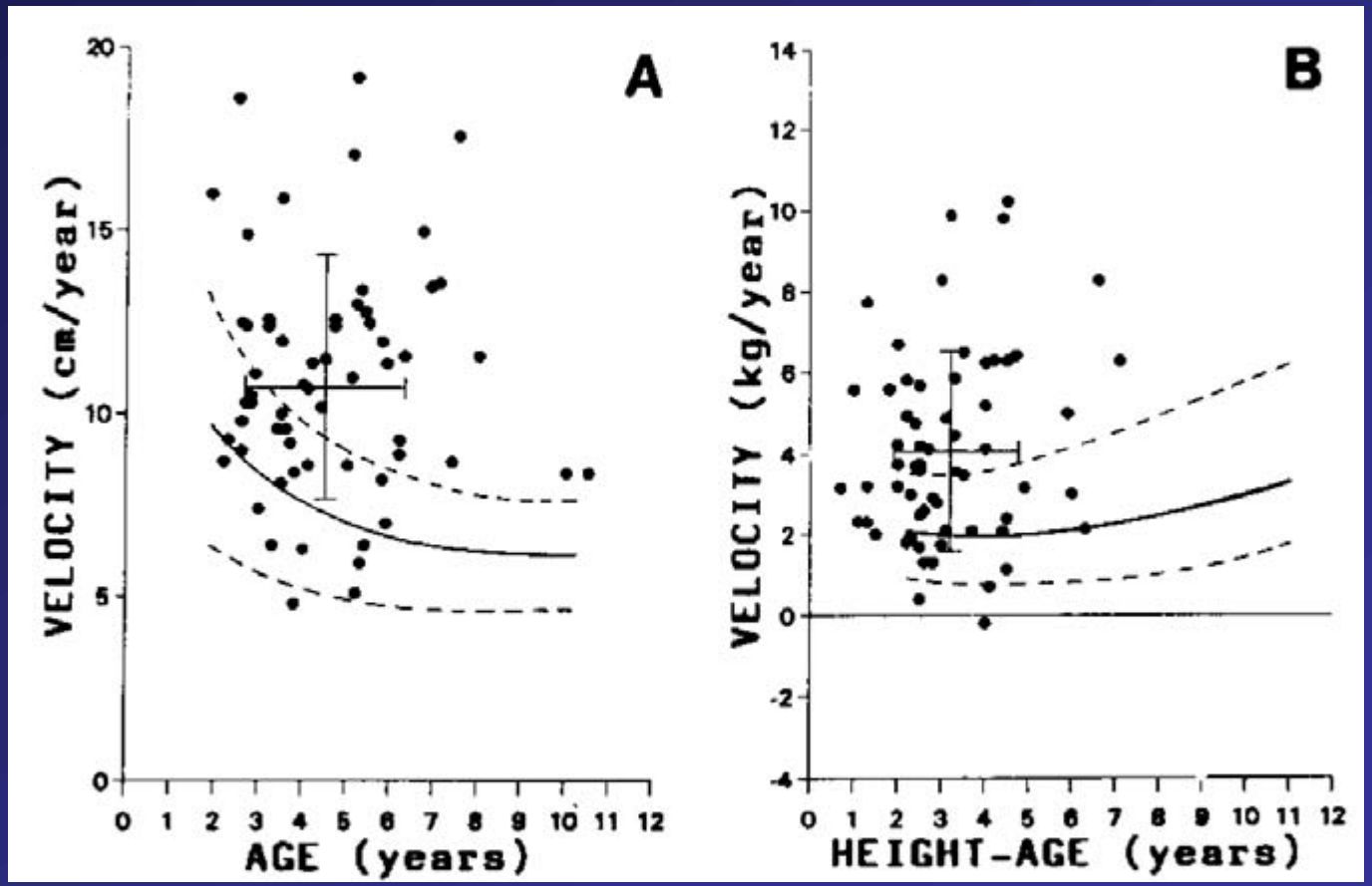
*Source*: Keiser and Utzinger 2008

# Benefits of Deworming

- Physical growth
- Learning and education
- Externalities
- Long run economic benefits

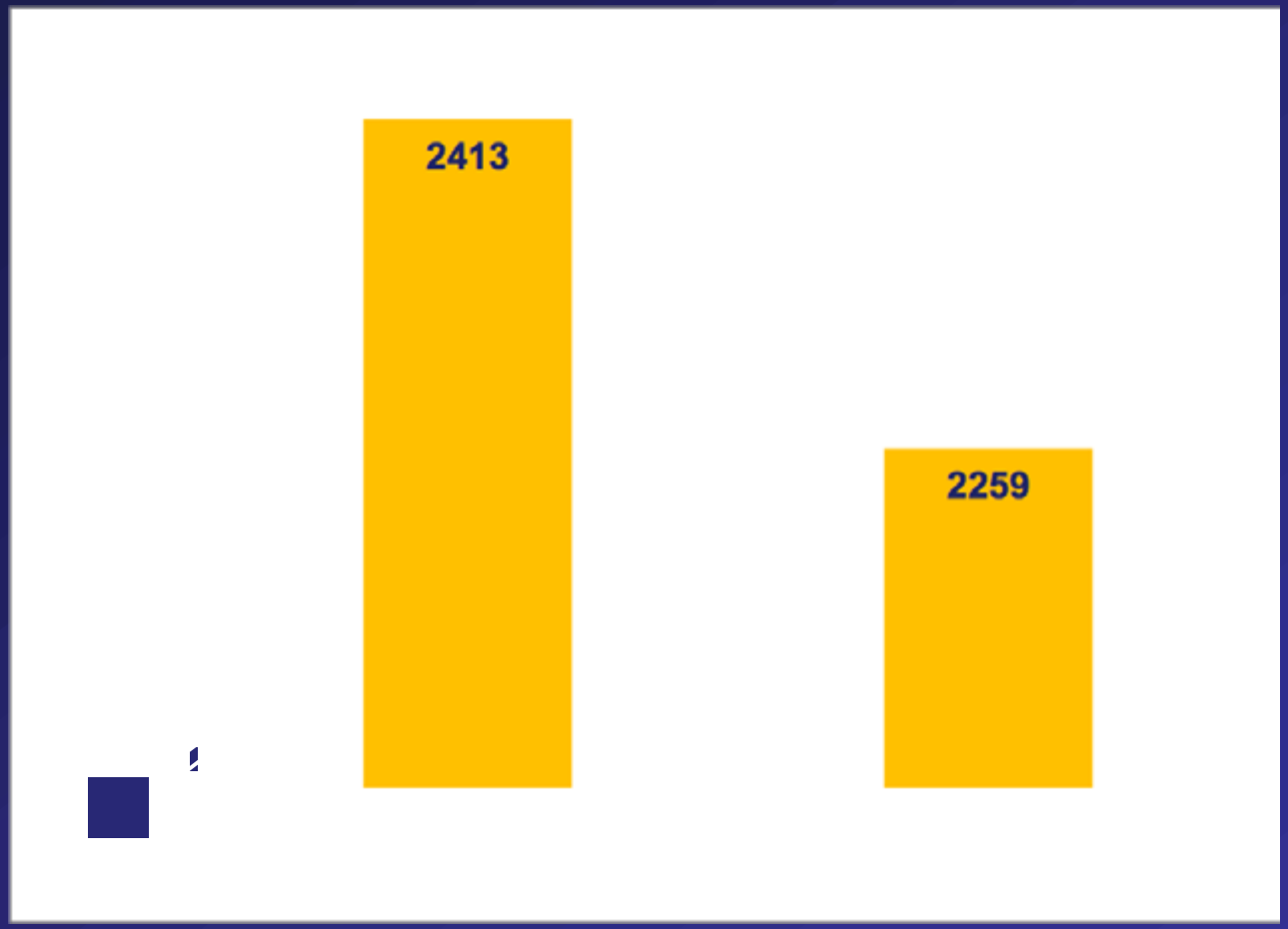
# Physical Growth

# Following deworming, children experienced mean height and weight velocities 2 SD above the growth standard




*Source*: Cooper *et al*. 1995

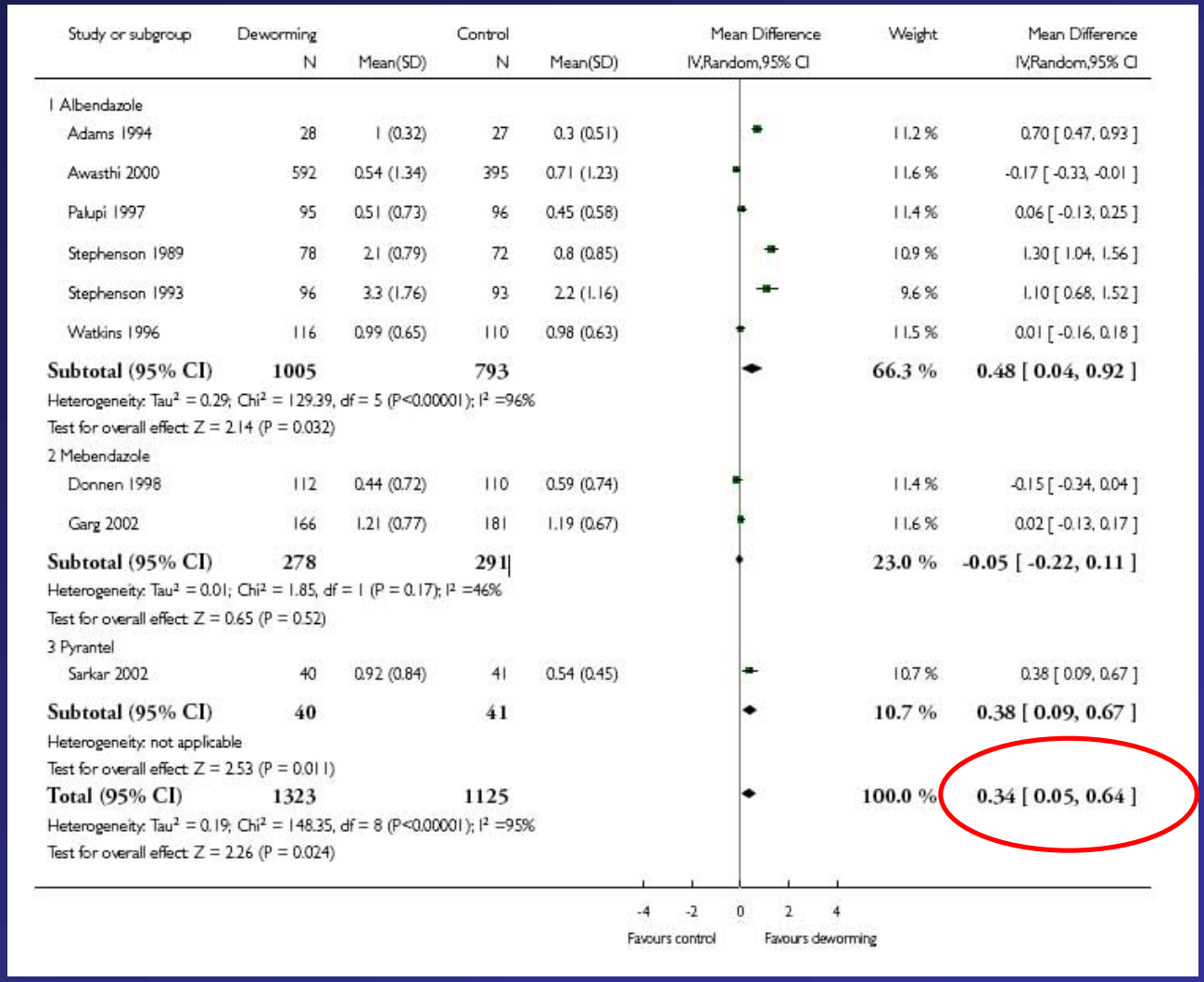
# Twice-yearly deworming of preschoolers was associated with a 10% extra gain in weight




treatment children gained 154 g extra weight (95% CI 96 to 214, $p < 0.01$)

*Source*: Alderman *et al*. 2006

# Weight gain in children after one round of deworming: Cochrane review results



| Study or subgroup | Deworming N | Mean(SD) | Control N | Mean(SD) | Mean Difference IV,Random,95% CI | Weight | Mean Difference IV,Random,95% CI |
|---|---|---|---|---|---|---|---|
| 1 Albendazole | | | | | | | |
| Adams 1994 | 28 | 1 (0.32) | 27 | 0.3 (0.51) | | 11.2 % | 0.70 [ 0.47, 0.93 ] |
| Awasthi 2000 | 592 | 0.54 (1.34) | 395 | 0.71 (1.23) | | 11.6 % | -0.17 [ -0.33, -0.01 ] |
| Palupi 1997 | 95 | 0.51 (0.73) | 96 | 0.45 (0.58) | | 11.4 % | 0.06 [ -0.13, 0.25 ] |
| Stephenson 1989 | 78 | 2.1 (0.79) | 72 | 0.8 (0.85) | | 10.9 % | 1.30 [ 1.04, 1.56 ] |
| Stephenson 1993 | 96 | 3.3 (1.76) | 93 | 2.2 (1.16) | | 9.6 % | 1.10 [ 0.68, 1.52 ] |
| Watkins 1996 | 116 | 0.99 (0.65) | 110 | 0.98 (0.63) | | 11.5 % | 0.01 [ -0.16, 0.18 ] |
| **Subtotal (95% CI)** | **1005** | | **793** | | | **66.3 %** | **0.48 [ 0.04, 0.92 ]** |
| Heterogeneity: Tau² = 0.29; Chi² = 129.39, df = 5 (P<0.00001); I² =96% | | | | | | | |
| Test for overall effect: Z = 2.14 (P = 0.032) | | | | | | | |
| 2 Mebendazole | | | | | | | |
| Donnen 1998 | 112 | 0.44 (0.72) | 110 | 0.59 (0.74) | | 11.4 % | -0.15 [ -0.34, 0.04 ] |
| Garg 2002 | 166 | 1.21 (0.77) | 181 | 1.19 (0.67) | | 11.6 % | 0.02 [ -0.13, 0.17 ] |
| **Subtotal (95% CI)** | **278** | | **291** | | | **23.0 %** | **-0.05 [ -0.22, 0.11 ]** |
| Heterogeneity: Tau² = 0.01; Chi² = 1.85, df = 1 (P = 0.17); I² =46% | | | | | | | |
| Test for overall effect: Z = 0.65 (P = 0.52) | | | | | | | |
| 3 Pyrantel | | | | | | | |
| Sarkar 2002 | 40 | 0.92 (0.84) | 41 | 0.54 (0.45) | | 10.7 % | 0.38 [ 0.09, 0.67 ] |
| **Subtotal (95% CI)** | **40** | | **41** | | | **10.7 %** | **0.38 [ 0.09, 0.67 ]** |
| Heterogeneity: not applicable | | | | | | | |
| Test for overall effect: Z = 2.53 (P = 0.011) | | | | | | | |
| **Total (95% CI)** | **1323** | | **1125** | | | **100.0 %** | **0.34 [ 0.05, 0.64 ]** |
| Heterogeneity: Tau² = 0.19; Chi² = 148.35, df = 8 (P<0.00001); I² =95% | | | | | | | |
| Test for overall effect: Z = 2.26 (P = 0.024) | | | | | | | |

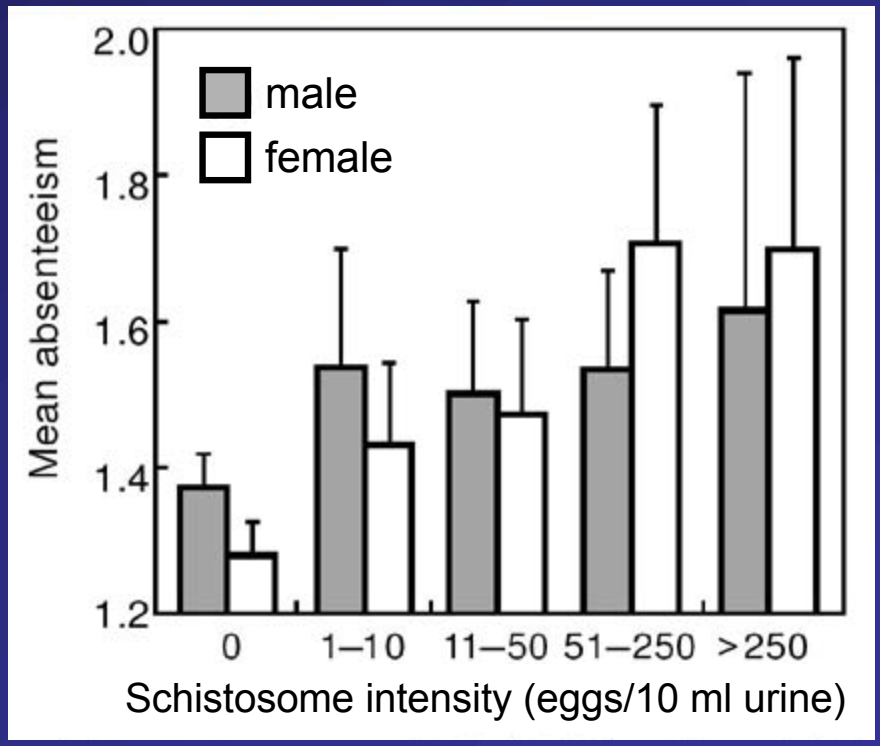
-4 -2 0 2 4

Favours control Favours deworming

*Source*: Taylor-Robinson, Jones, and Garner 2007

# Learning and Education Benefits

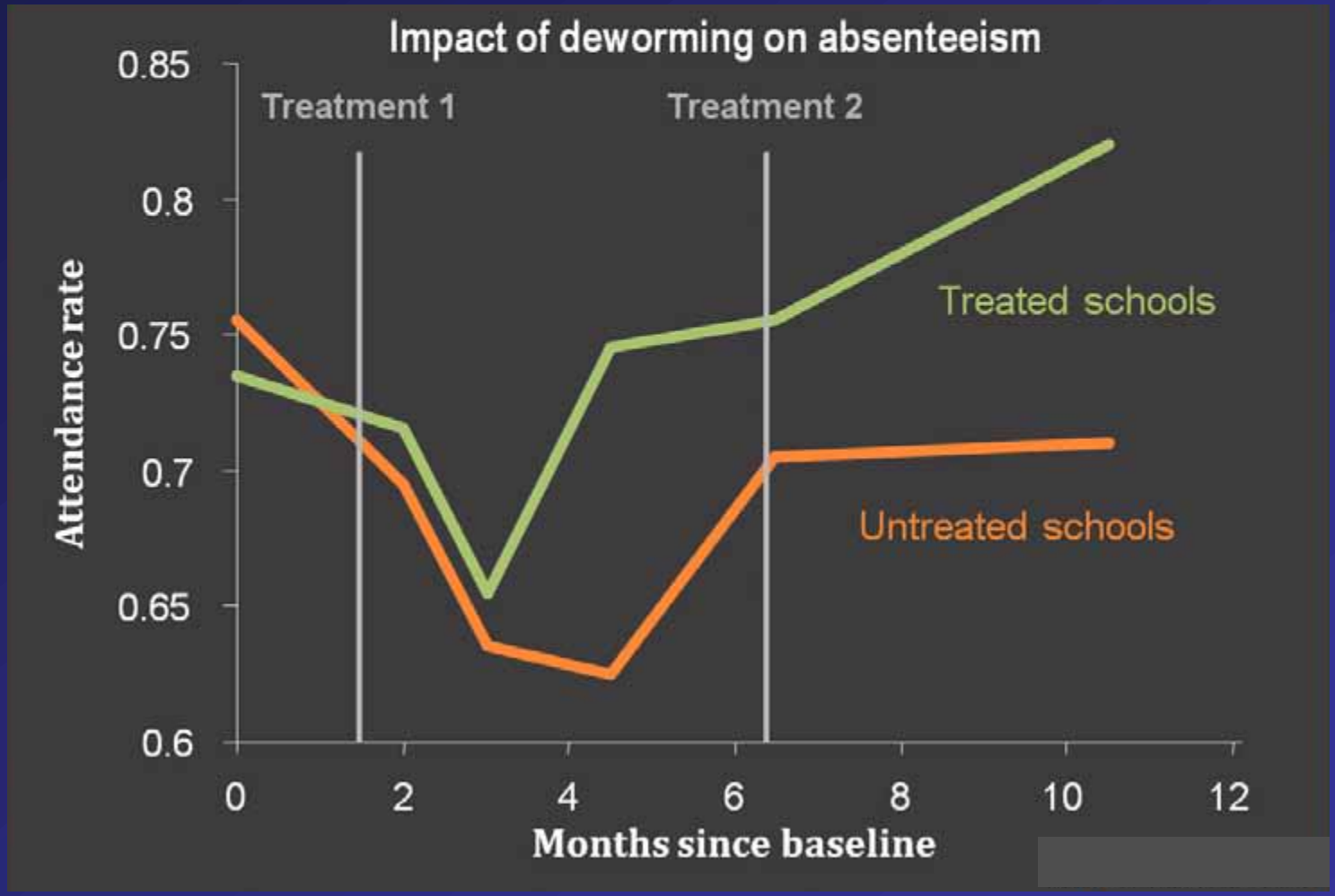
# Schoolchildren infected with worms were absent more frequently than those uninfected




*Source*: Nokes and Bundy 1993

*Source*: de Clercq *et al*. 1998

# Deworming increased school participation by 7% and decreased absenteeism by 25%




*Source*: Miguel and Kremer 2000

# Short-Run Impacts

- At one year mark 25% of pupils had serious worm infections in treated schools, 52% in untreated
- Significant gains in height, self-reported health
- School absence falls one quarter (7 percentage points)
- Reduced re-infection, school absence among
  - untreated children in treatment schools
  - children in schools within 6 km
- Cost/year of increased school participation = $3.50.
- Take up 75% when treatment was free; 18% under cost-sharing.

*Source*: Miguel and Kremer 2004

# Pre-deworming, areas of high hookworm infection in the American South had lower school attendance

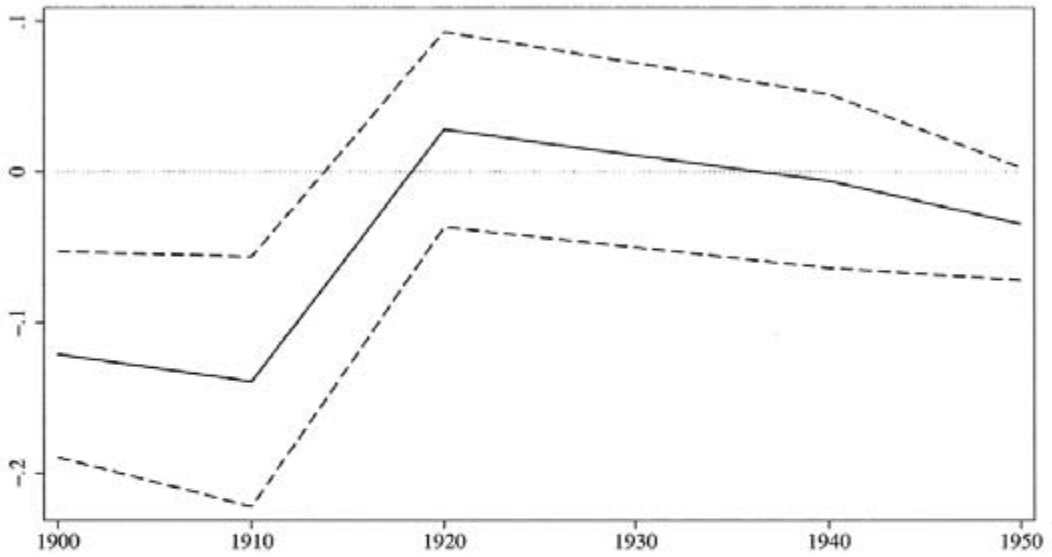



FIGURE II

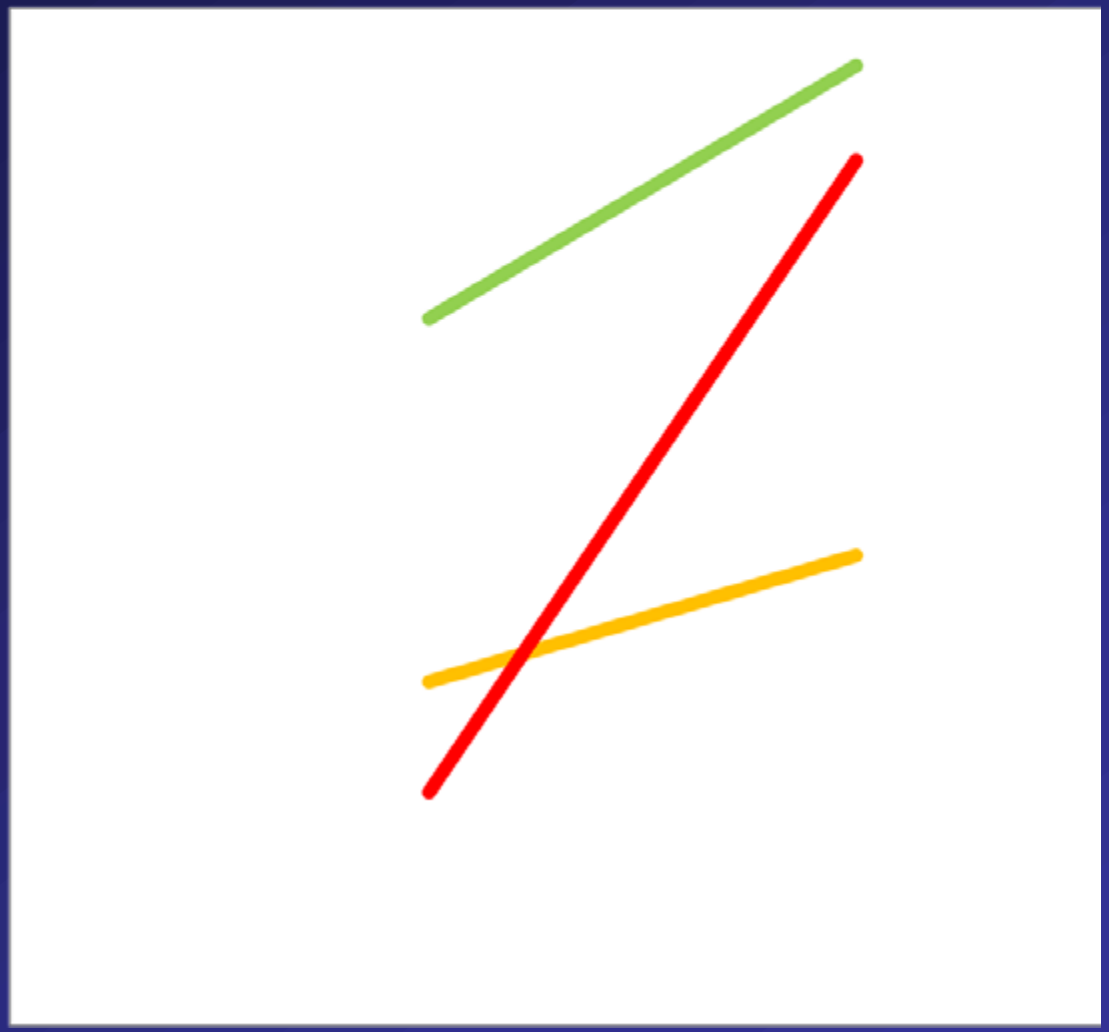
Hookworm Eradication and School Attendance, 1900–1950

The *y* axis plots the year-specific coefficients on the circa-1913 hookworm-infection rate (solid line), plus the RSC-confidence intervals (dashed lines). The *x* axis is the Census year. The sample consists of all native-born white and black children in the IPUMS between the ages of 8 and 16 in the RSC-surveyed geographic units for 1900, 1910, 1920, 1940, and 1950. For each year, the coefficients are estimated in a regression of a school-attendance dummy on preintervention hookworm infection and demographic controls. Confidence intervals are constructed using standard errors that are clustered on SEA.

# Following deworming, school attendance in these areas surged and converged with attendance in other areas

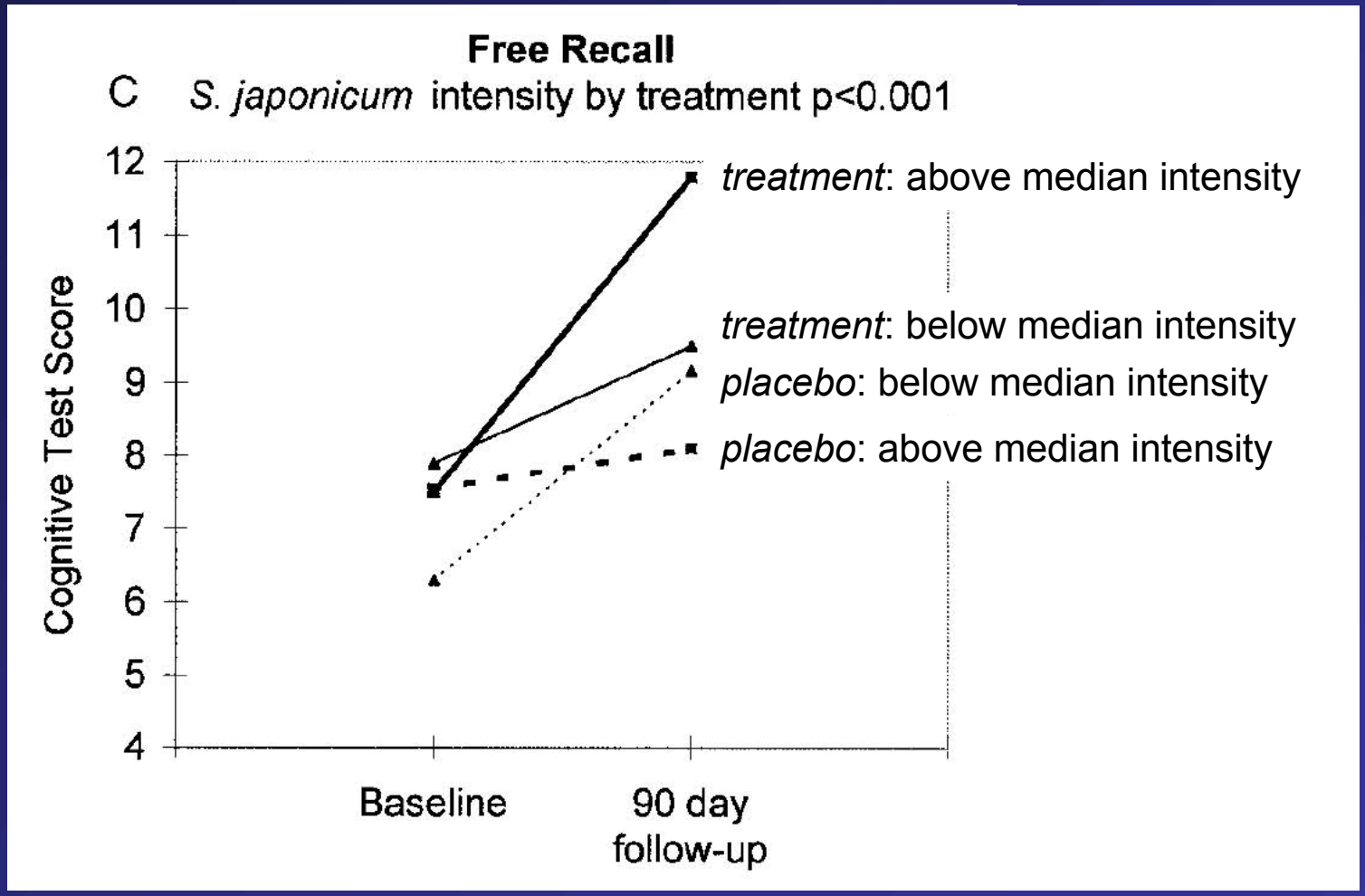
*Source*: Bleakley 2007

# Treated children improved in cognitive scores over those who remained infected, catching up to those who were uninfected



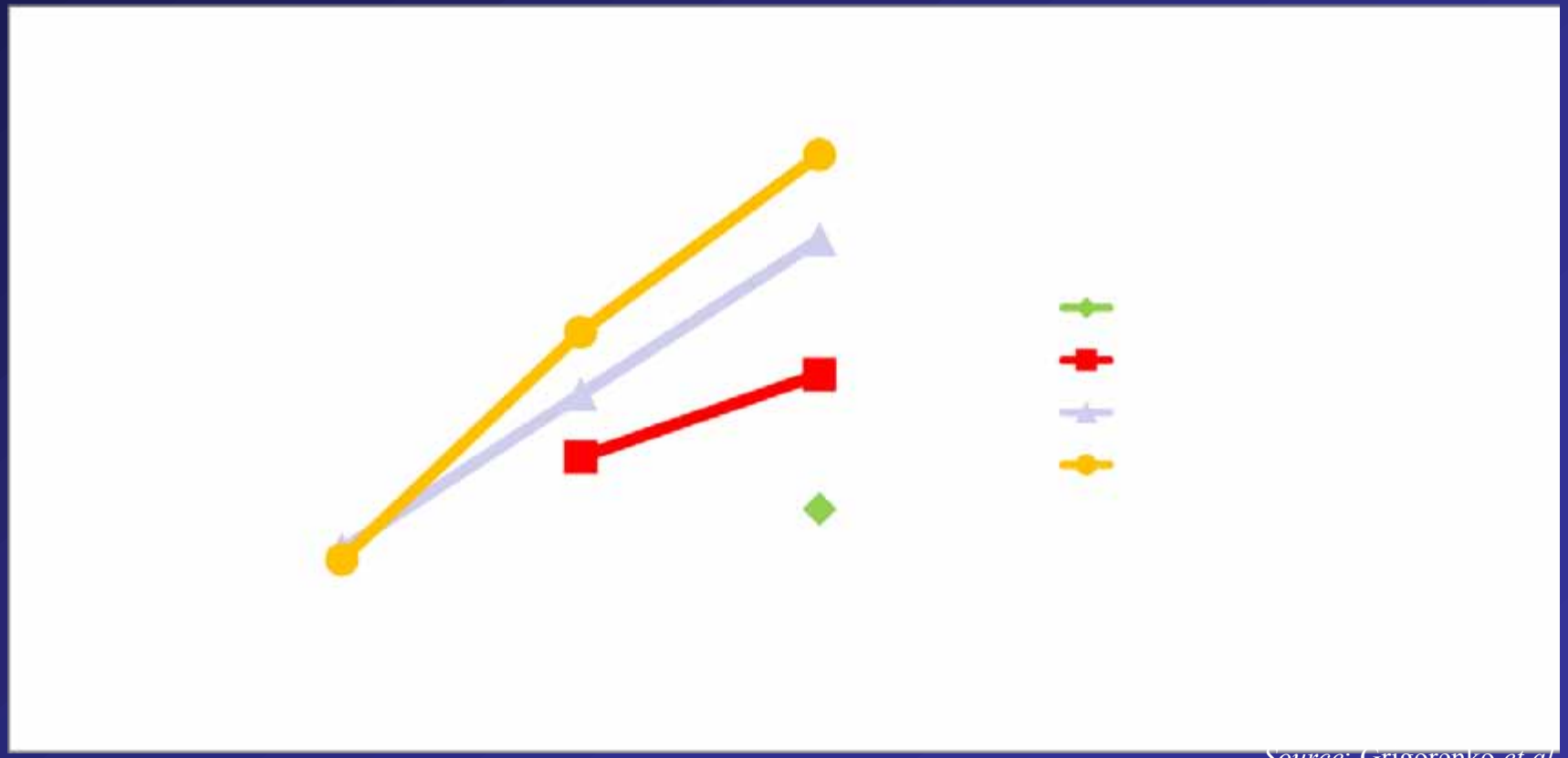
*Source*: Nokes, McGregor, and Bundy 1992

# Children with higher intensity schistosome infections experienced significantly greater improvements in cognitive scores




*Source*: Nokes et al. 1999

# The longer the deworming and school health treatment, the greater the improvements in skills for following instructions and the quicker mastery of the skills



*Source*: Grigorenko *et al*. 2007

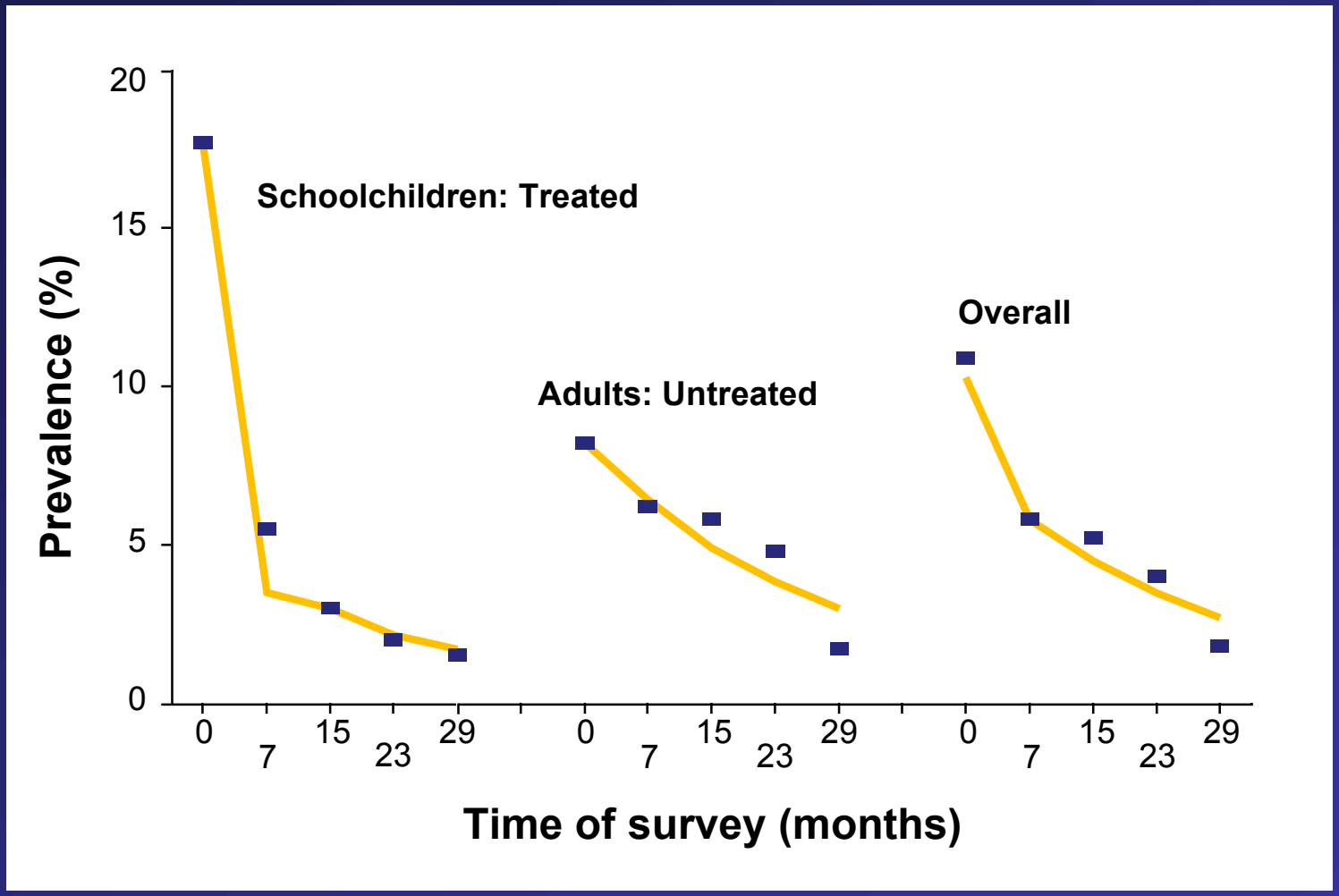
# Highly prevalent conditions affect school-age children's health and education

| | Prevalence | Total cases (millions) | IQ points lost per child | Lost years of schooling (millions) |
|---|---|---|---|---|
| **Worms** | 30% | 169 | 3.75 | 201 |
| **Stunting** | 52% | 292 | 3 | 284 |
| **Anemia** | 53% | 298 | 6 | 524 |

*Source*: Jukes *et al*. 2008

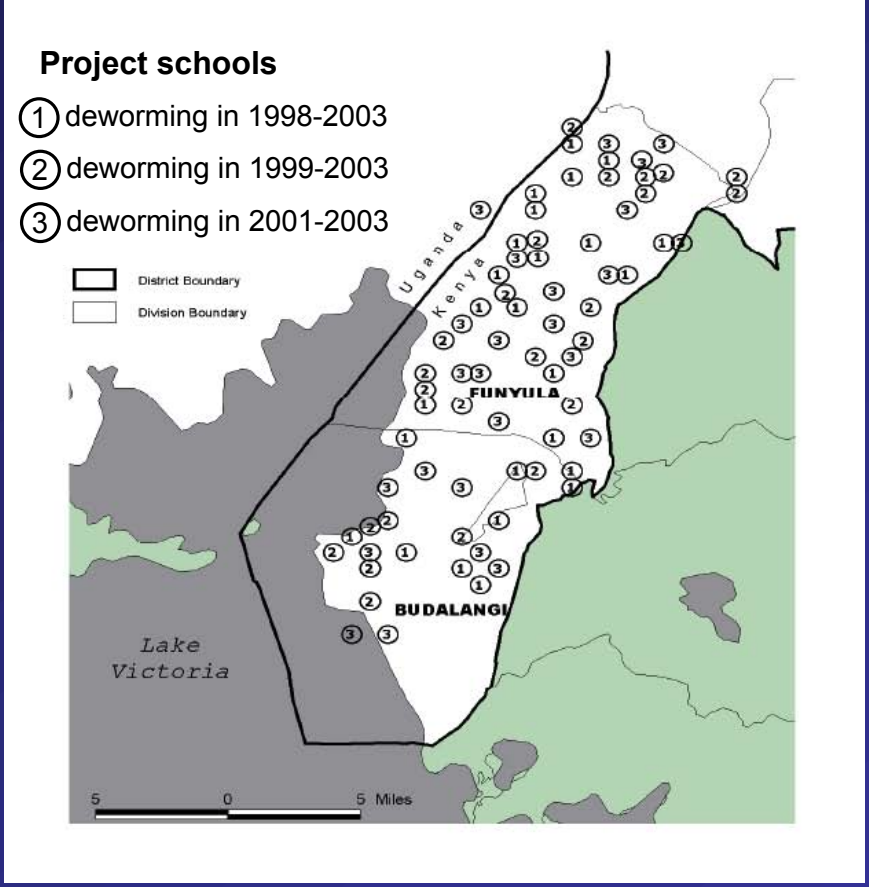
# Externalities

# With mass school-based deworming, adult worm burden also fell by nearly 50%




*Source*: Bundy *et al*. 1990

# Spillovers in Kenya resulted in a 23% reduction in moderate-to-heavy worm infections among children in schools not directly receiving deworming




*Source*: Miguel and Kremer 2004; Miguel 2011

# School-based deworming resulted in spillovers for younger children, including improvements in cognitive performance equivalent to half a year of schooling. Effects were twice as large for children with siblings in school.

Table 4: All results 2010 and 2009, main effect

| | Outcome | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Height | | Stunting | | PPVT | | Raven's Matrices | | Cognitive PC1 | |
| | All | w/sibs | All | w/sibs | All | w/sibs | All | w/sibs | All | w/sibs |
| **Deworming Indicator** | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Before age 2 | 0.271 | 0.188 | -0.011 | -0.031 | 0.148* | 0.307** | 0.233*** | 0.378** | 0.182** | 0.288** |
| | (0.265) | (0.49) | (0.014) | (0.024) | (0.083) | (0.134) | (0.069) | (0.15) | (0.081) | (0.128) |
| Observations | 13700 | 3057 | 13670 | 3053 | 2183 | 494 | 2184 | 493 | 2123 | 474 |
| $R^2$ | 0.684 | 0.69 | 0.038 | 0.039 | 0.268 | 0.295 | 0.133 | 0.173 | 0.27 | 0.309 |

Note: in the table above, the excluded group is the cohort whose community was dewormed during their second year of life or later. Standard errors are clustered at the school-cohort level; gender×age and data collection year fixed effects are included. All cognitive outcomes are standardized (variance=1). Columns marked "w/sibs" are restricted to respondents who had at least three older siblings attend the same primary school.

*Source*: Ozier 2010

# Long run benefits

# Worms at Work: Long-run Impacts of Child Health Gains

Sarah Baird
Joan Hamory Hicks
Michael Kremer
Edward Miguel

# Long-run Impacts: Data and Measurement Strategy

- Kenya Life Panel Survey (1998-2009)
- 7,530 people in baseline deworming sample
- By 2007-2009 survey round, most 20-26 years old
- 85% effective tracking rate among those still alive
- Modest differences in treatment ~2.5 years of add'l treatment, only 75 schools

*Source*: Baird *et al*. 2011

# Long-run Impacts: Health and Education

- Self-reported health improved, no significant BMI, height changes
- Primary school participation, 1998-2001, increased by 0.129 years ($p<0.01$)
- Years enrolled in school, 1998-2007, increased by 0.279 years ($p<0.1$)
- More grade repetition, not grade completion
- Test score mean effect increase by 0.1 s.d. ($p<0.1$)
  - includes 1999 test, passed primary school exam, and 2007-09 English test
  - no cognitive gain on Raven's matrix

*Source*: Baird *et al*. 2011

# Long-run Economic Impacts

- As adults, treatment group ate 0.1 more meals/day ($p<0.01$)
- Their neighbors also ate 0.08 more meals/day ($p<0.01$)
- Work hours rose 12% (1.76 hours, $p<0.10$)
  - Effect concentrated among those with positive hours (2.4 hours/week, $p<0.05$)

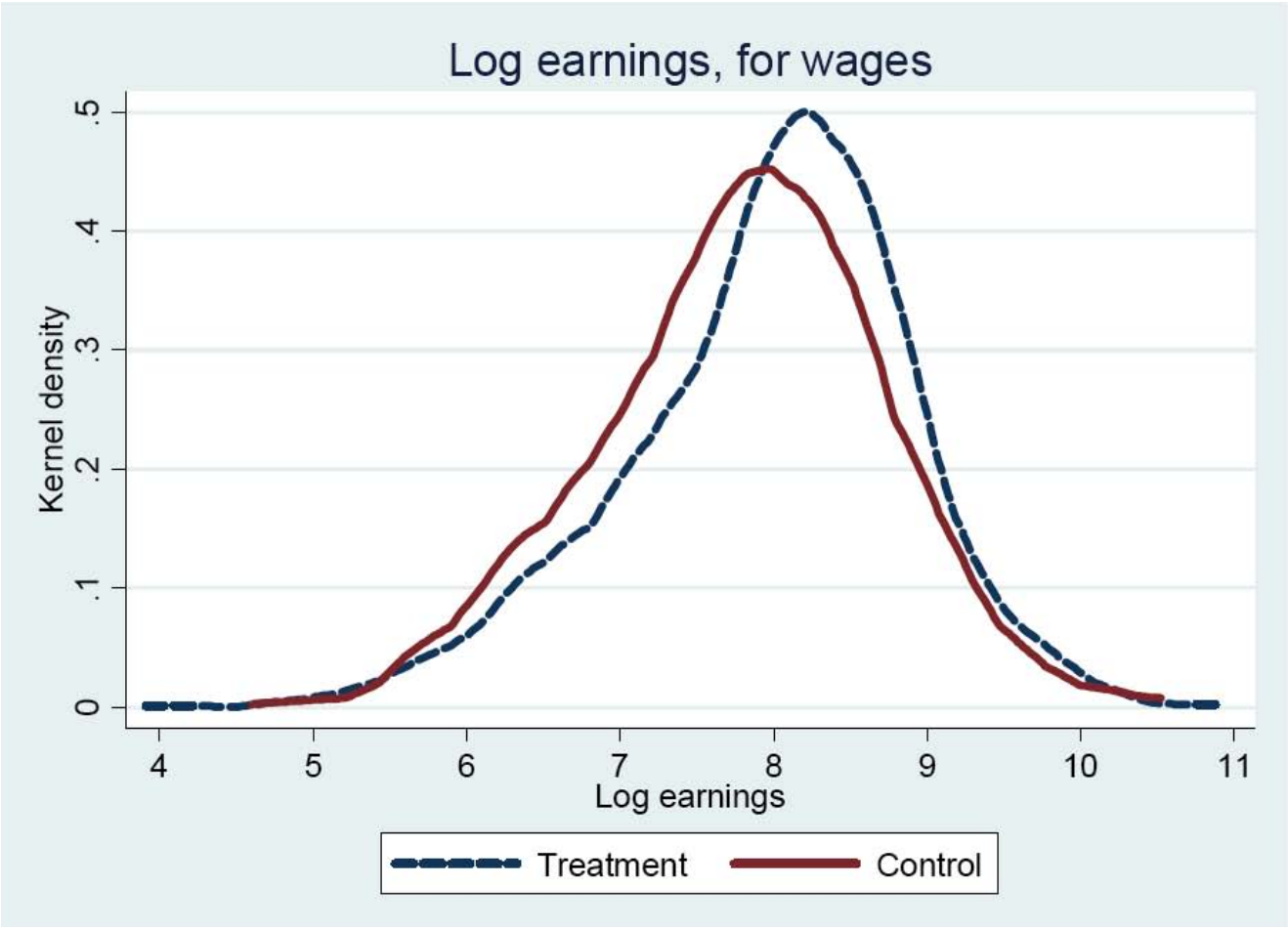
*Source*: Baird *et al*. 2011

# Disaggregating Economic Impact

- Look among wage earners, self-employed, farmers
- Strongest effects among wage earners
  - Work 5.2 more hours per week
  - 0.5 fewer workdays missed each month due to poor health ($p<0.05$)
  - Earnings rose by 0.25 log points ($p<0.01$)
  - Men triple employment in manufacturing (9 p.p., $p<0.01$)
  - Women do less casual labor, domestic services (17 p.p., $p=0.11$)

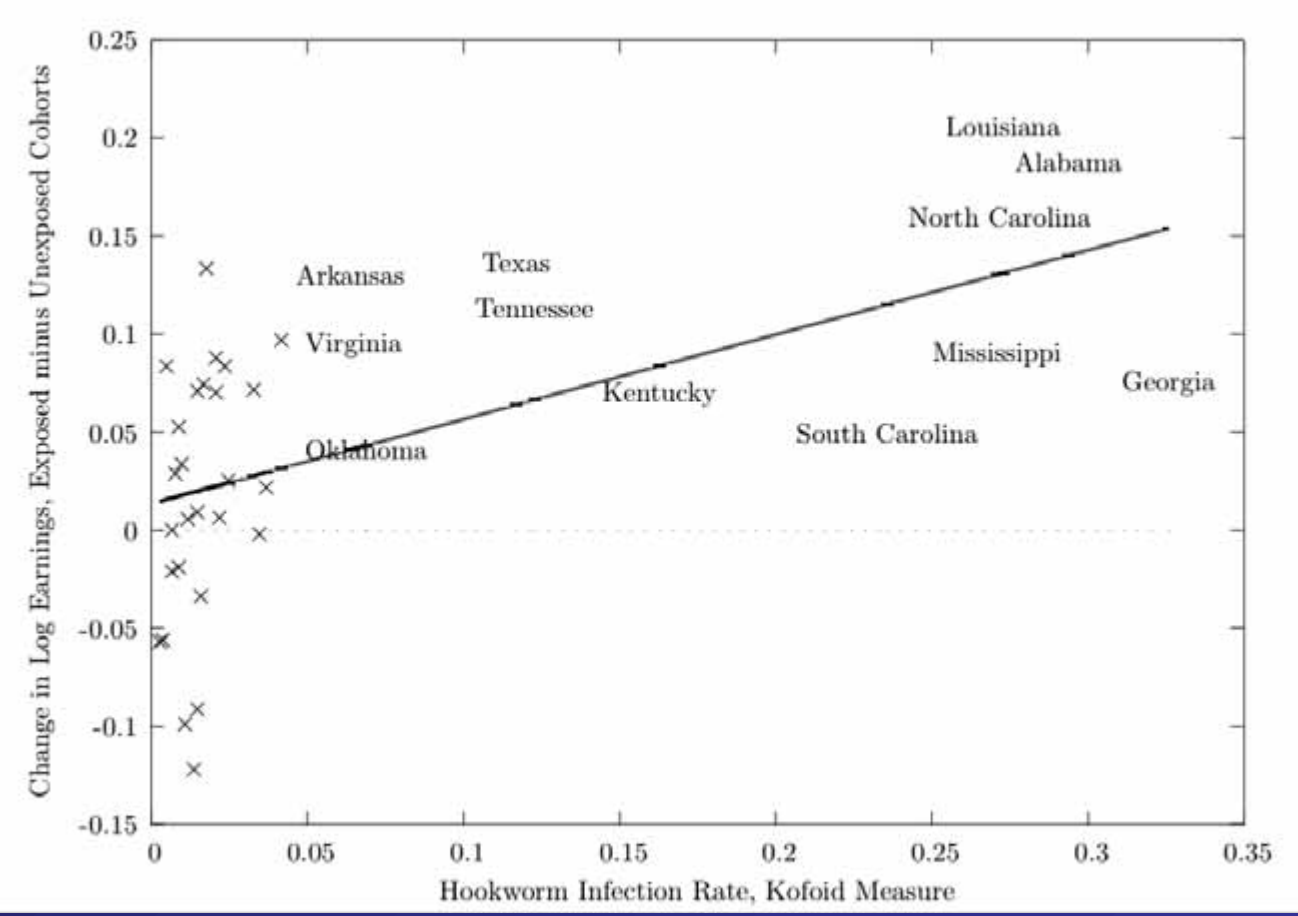
*Source*: Baird *et al*. 2011

# Average adult earnings rose by approximately 21 to 29% as a result of deworming




*Source*: Baird *et al*. 2011

# Areas of the American South with high pre-eradication hookworm saw faster growth in income




**Children treated for worms were 15% more likely to be literate and earned 25% more as adults**

*Source*: Bleakley 2007

# Externalities

- Positive, large and statistically significant local spillovers in terms of both meals eaten (0.080, $p<0.01$) and labor supply for those with positive hours (2.75 hours/week, $p<0.05$).

- Deworming creates an estimated 20% increase in labor earnings for wage earners within 6km (0.199, $p=0.22$ )

*Source*: Baird *et al*. 2011

# Returns

- Depends on assumptions, but estimated social financial rate of return is around 75% per year treating increased hours as gain in endowment

- Externality benefit alone sufficient to justify full subsidy

# Conclusions

- Deworming is cost efficient
- Other externalities may enhance this further (eg impacts on HIV, malaria)
- Important long run gains may not show up in measureable benefits for health or education
- Current large MDA programs (LF, trachoma, oncho) are an opportunity to explore long run benefits for these NTDs

A Global Atlas of Helminth Infections

# Mapping this wormy world


A new open-access, global information resource for public health professionals and managers of deworming programmes.

www.thiswormyworld.org