

\*\*\*PRELIMINARY: DO NOT CITE\*\*\*

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

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March 31, 2011

# Acknowledgements

- **Co-authors on this paper:** Dr. Sarah Baird, George Washington University; Dr. Joan Hamory Hicks, U.C. Berkeley; Michael Kremer, Harvard University
- **Non-governmental organization collaborators:** International Child Support (ICS) and Innovations for Poverty Action-Kenya (IPAK)
- **Funding:** NIH (#R01-TW05612, #R01-HD044475), NSF (#SES-0418110, #SES-0962614), World Bank, Social Science Research Council, Berkeley Population Center

# Child health and adult income

- **Do child health investments increase adult living standards?**

-- This question is of great interest to researchers, and of major policy importance for governments and aid donors – but solid answers remain elusive.

-- Why? There are many methodological challenges to studying this question, including non-random child health investments (i.e., sick children may have other disadvantages, such as poverty), and the near lack of panel datasets tracking children into adulthood.

# Child health and adult income

- **I will focus on the problem of worm infections in rural Kenya.**

-- 1 in 4 people are infected by intestinal worms around the globe, with massive disease burden (due to anemia, growth stunting, lethargy), especially among children in Africa (de Silva et al 2003).

-- There is also evidence that deworming treatment can reduce the likelihood of malaria infection in African children (Kirwan et al 2010).

# Water, sanitation and hygiene and adult income

- **Relevant to understanding long-run impacts of WSH programs.**
  - We focus on a program that provided deworming drug treatment, but improved hygiene and sanitation would also reduce worm loads.
  - Beyond worm infections, successful WSH programs could lead to broader health benefits by reducing diarrhea, environmental enteropathy, trachoma, etc.

# Deworming and schooling in Kenya

- **The Primary School Deworming Project in Kenya (1998-2002).**
  - 75 primary schools (30,000 children aged 6-18), with deworming treatment phased in over three years in 25 schools at a time.
  - We used a prospective experimental design, where schools are gradually “phased in” over time. This is a practical approach since real-world financial constraint often lead to staggered phase-in.
  - List randomization into: Group 1 (deworming drugs and health education in 1998-2003), Group 2 (1999-2003), Group 3 (2001-03).
  - Due to the design, on average the “treatment” and “control” groups are similar in all ways but one: the intervention.



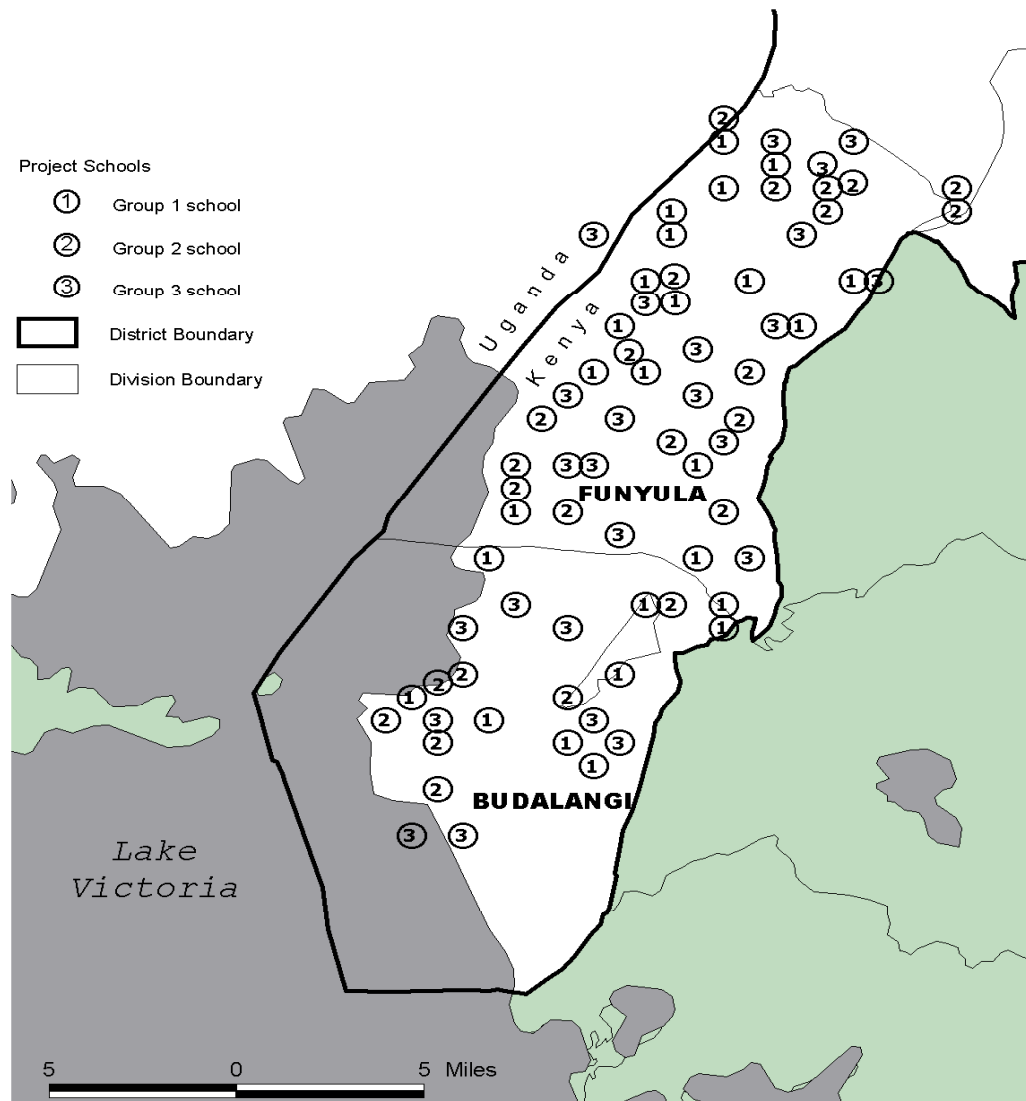
# Deworming and schooling in Kenya

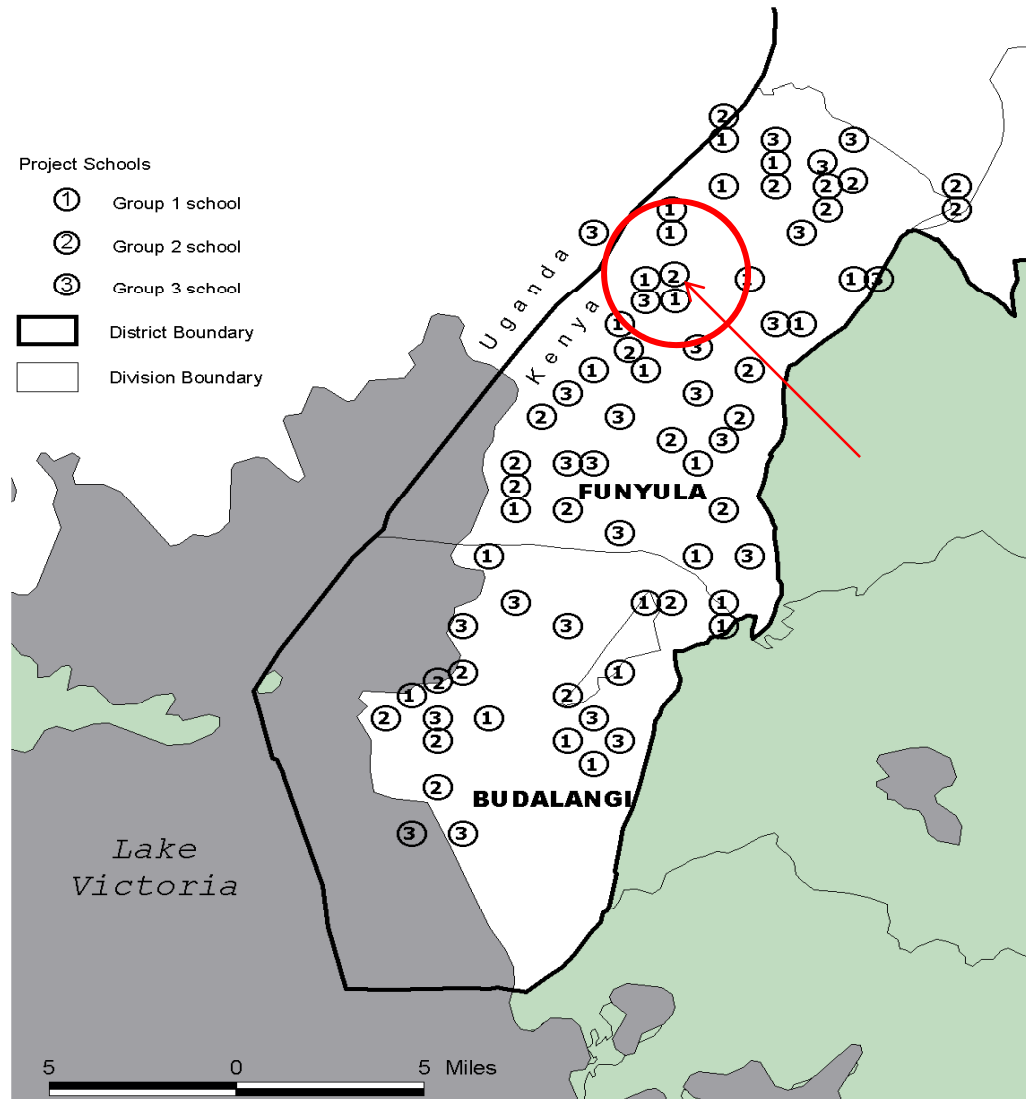
- **Earlier work: deworming led to schooling gains – at low cost.**
  - We worked in a rural district with 90 percent worm infection rates at baseline. Treatment with albendazole and praziquantel twice per year costs less than 0.50 USD per child.
  - Rates of serious worm infections fell by half, from 52% to 25%. There were also significant gains in self-reported health and height.
  - There were large gains in rates of school participation in the first two years of the project, with absenteeism falling by one quarter, or 7.5 percentage points (Miguel and Kremer 2004).

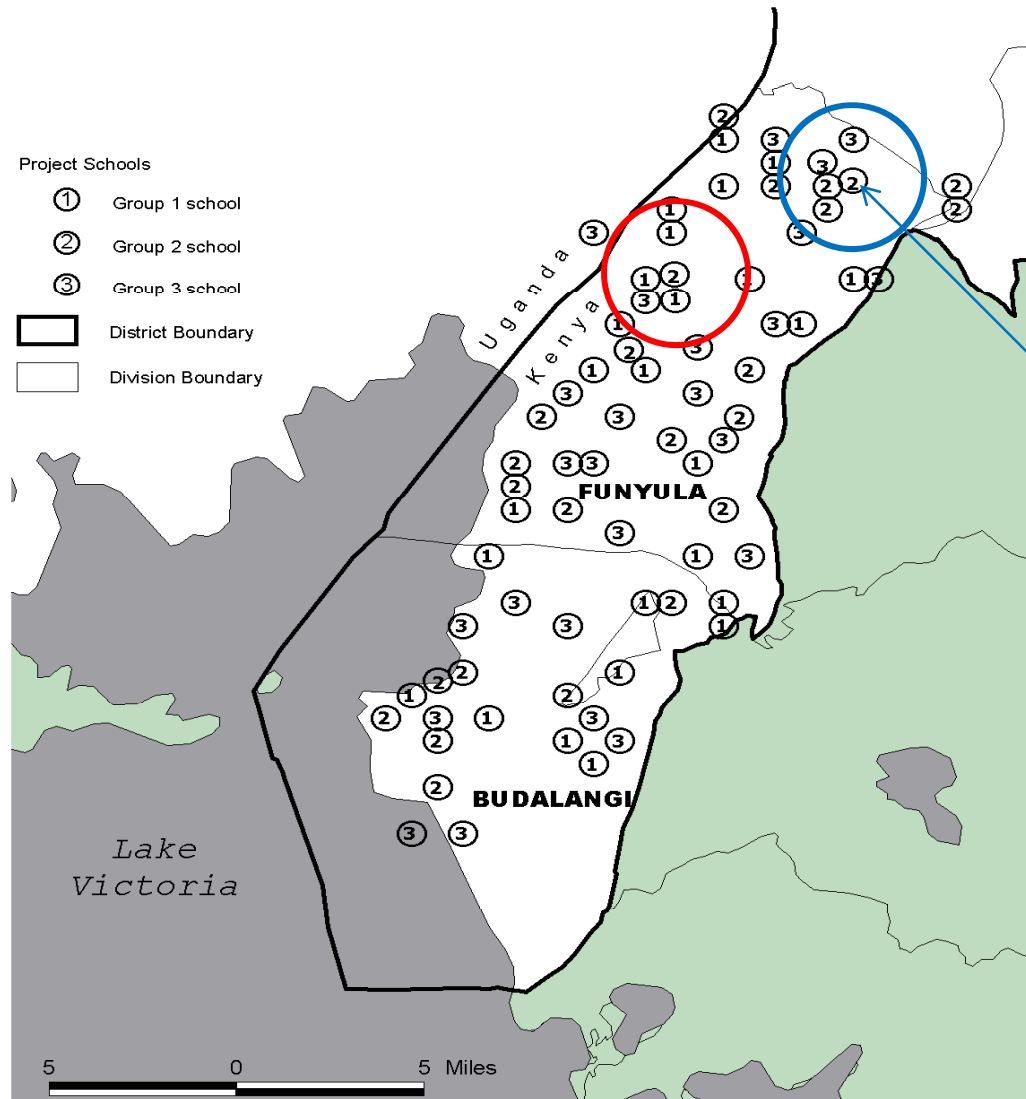


# Deworming and schooling in Kenya

- **Earlier work: deworming had broader community-wide benefits.**
  - Deworming reduced re-infection among other community members, including among untreated children in treatment schools (70% of the effect on the treated) and those living within 6 km. There were also positive “spillovers” in school attendance.







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-- Accounting for spillovers, deworming increased school participation by one year at a cost of only 3.50 USD. Miguel and Kremer (2004) argue this finding provides a strong rationale for subsidized deworming treatment.

# Assessing long-run impacts on income

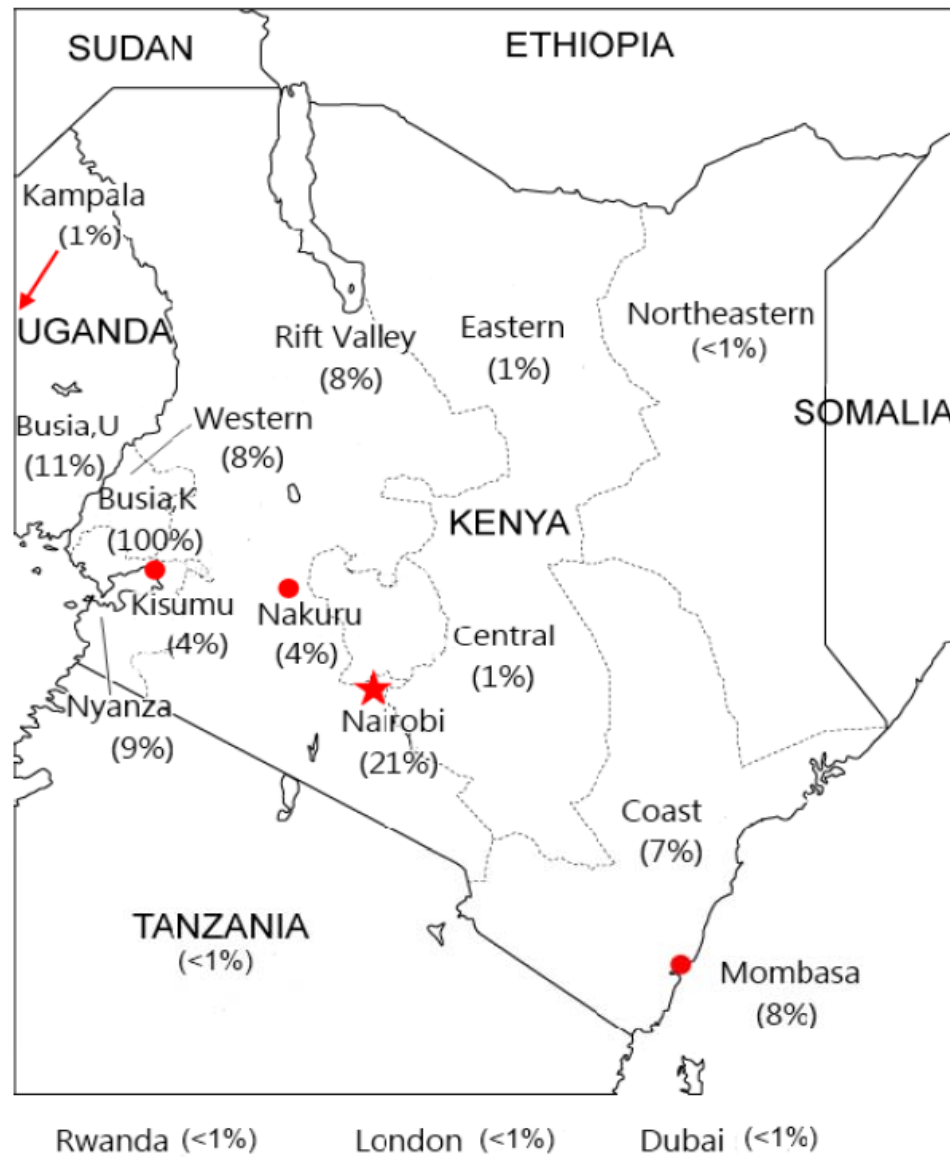
- **The Kenya Life Panel Survey (1998-2009) data project.**
  - A representative sample of 7,530 of the roughly 33,000 individuals in the baseline deworming sample were tracked over time. By the 2007-2009 survey round, most were 20-26 years old.
  - KLPS individuals were “tracked” as they moved throughout Kenya, Uganda, Tanzania – and even to London in one case! The team regularly updated contact information, often using cell phones.
  - This intensive fieldwork allowed us to track down and survey 85% of the sample (among those still alive), a very high rate for a young adult population over a decade.

**Table 1: Baseline (1998) summary statistics and PSDP randomization checks**



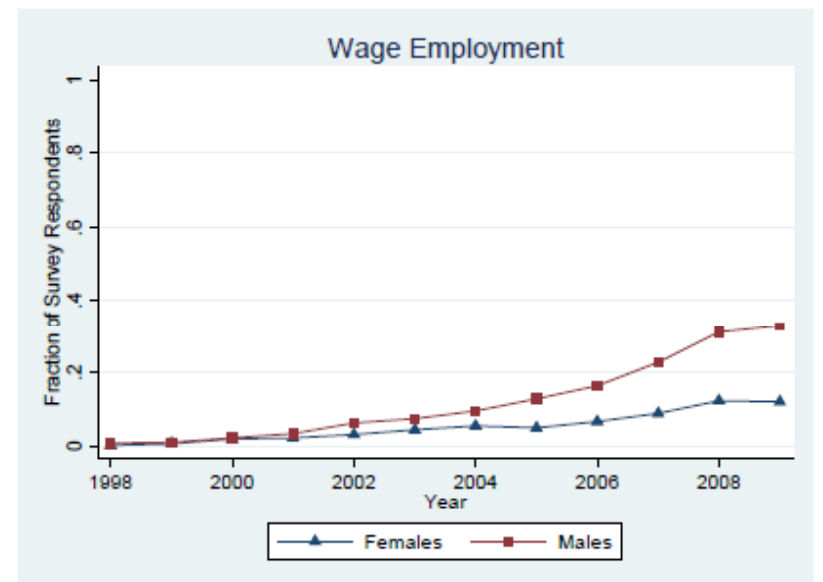
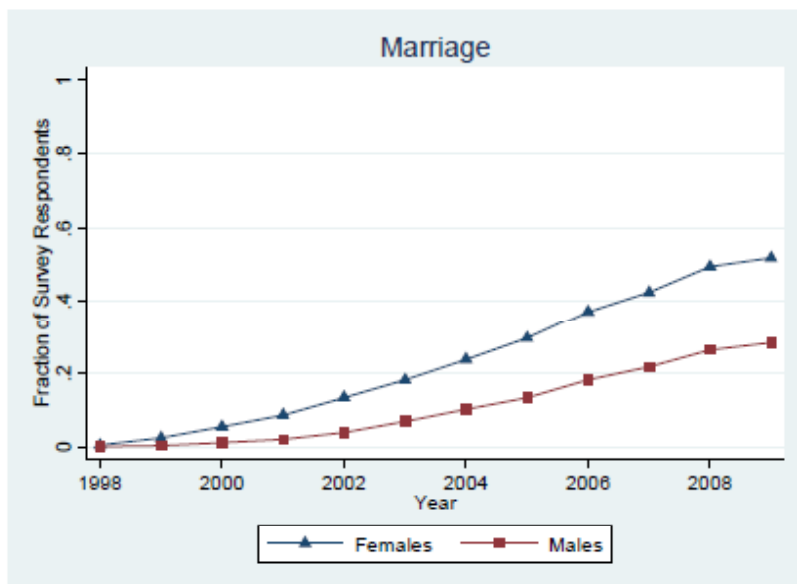
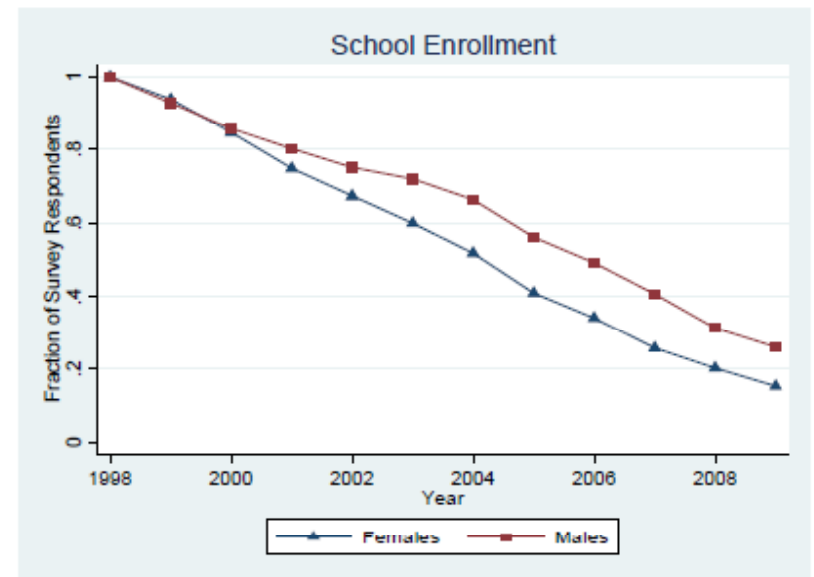
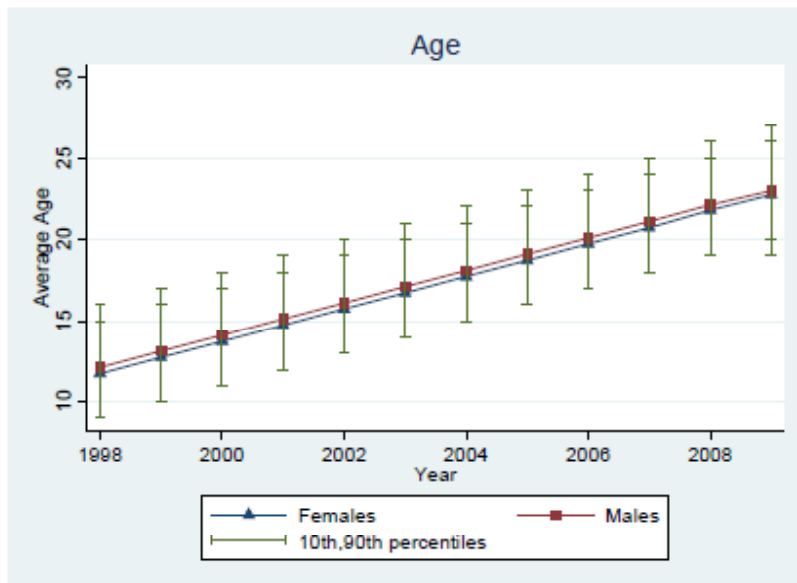
	All mean (s.d.)	Treatment mean (s.d.)	Control mean (s.d.)	Treatment – Control (s.e.)	Kolmogorov- Smirnov p-value
Female	0.470	0.469	0.473	-0.004 (0.019)	--
Grade (1998)	4.23 (1.68)	4.22 (1.70)	4.25 (1.66)	-0.03 (0.05)	0.450
Age (1998)	11.9 (2.6)	11.9 (2.6)	12.0 (2.6)	-0.04 (0.11)	0.258
Assignment to the deworming treatment group	0.678	1	0	--	--
Years of assigned deworming treatment, 1998-2003	3.31 (1.82)	4.09 (1.52)	1.68 (1.23)	2.41*** (0.08)	--
Primary school located in Budalangi division	0.370	0.364	0.381	-0.017 (0.137)	--
Population of primary school	476 (214)	494 (237)	436 (146)	58 (54)	0.307
School average test score (1996)	0.019 (0.427)	0.024 (0.436)	0.038 (0.406)	-0.013 (0.109)	0.310
Total treatment (Group 1, 2) primary school students within 6 km	3180 (917)	3085 (845)	3381 (1022)	-296 (260)	0.206
Total primary school students within 6 km	4709 (1337)	4698 (1220)	4732 (1555)	-34 (389)	0.119

Figure 2: Migration residential location map





**Figure 2: Age, School Enrollment, Marriage and Employment Patterns over 1998-2009**



# Estimating impacts in the presence of spillovers

- **The statistical strategy accounts for “spillover” effects across schools located within 6 km of deworming treatment schools.**

-- Spillovers across treatment groups imply that naïve T – C differences might understate true treatment effects (“contamination” of assignment as the control group also gains from treatment).

-- Following Miguel and Kremer (2004):

$$Y_{ij,2007-09} = a + bT_j + X_{ij,0}'c + d_1N_j^T + d_2N_j + e_{ij,2007-09}$$

where Y is a labor market outcome (e.g., earnings), T is the treatment indicator, and X are baseline controls used in the randomization or stratification during KLPS sampling, survey waves.

--  $N^T$  is the number of treatment pupils within 6 km, N is the total number of primary school pupils within 6 km. Focus on 0-6 km as in Miguel and Kremer (2004). e is the error term (clustered by school).

# Deworming impacts on education, health

- **The additional 2 to 3 years of deworming pills received by the treatment group led to persistent improvement in measures of health and education.**

-- On average, the total time enrolled in school between 1998 and 2008 rose by more than 0.3 years in the deworming treatment group ( $p < 0.05$ ), and test scores also improved by 0.1 s.d. ( $p < 0.10$ ).

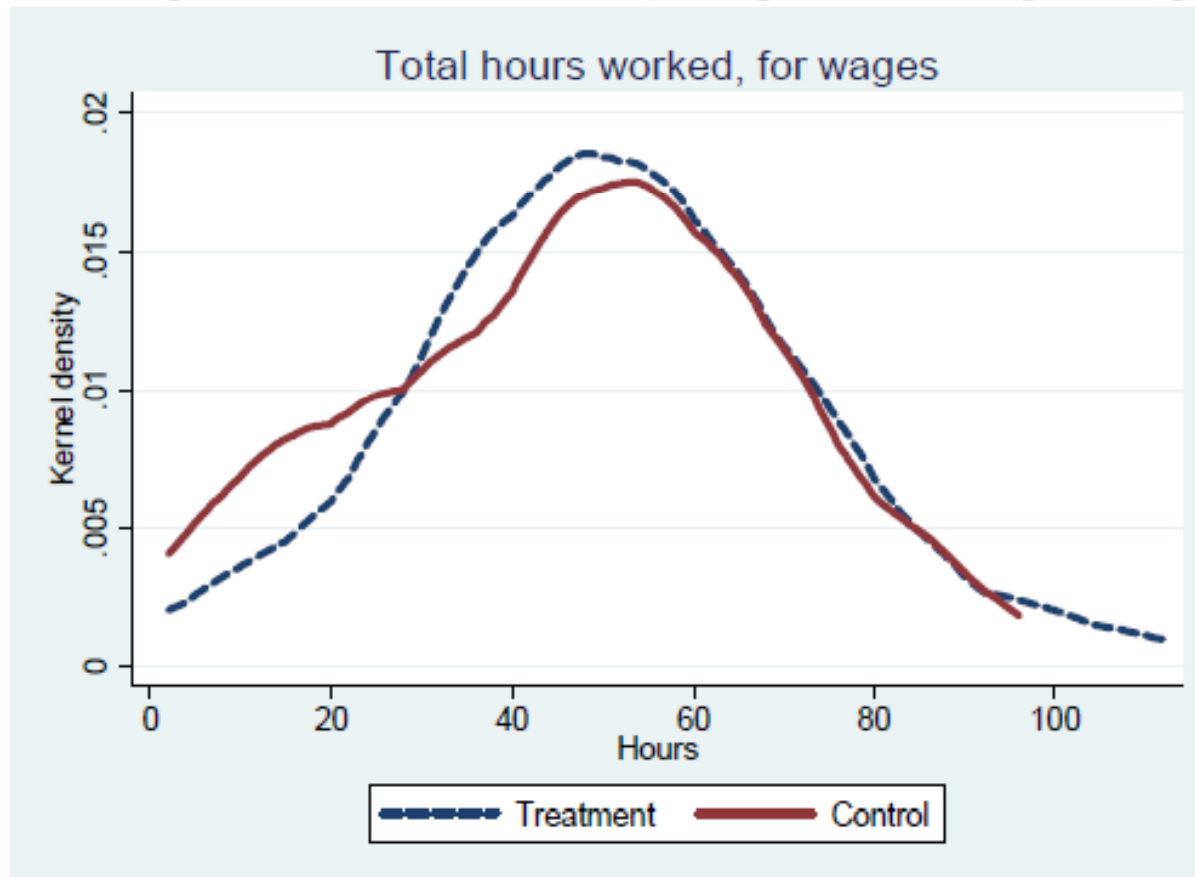
-- Self-reported health status is significantly better ( $p < 0.05$ ), as are total health expenditures, and fewer work days are lost to illness.

-- Treating worms may have generated broader child health gains: using 1999 data, we find that self reported malaria in the last week was 3.2 percentage points lower, a reduction of 14% ( $p < 0.10$ ).

## Deworming impacts on living standards

- **The additional 2 to 3 years of deworming pills received by the treatment group led to large economic benefits in 2007-2009.**
  - Deworming beneficiaries work longer hours: hours worked rose 12% ( $p < 0.10$ ), both in the full sample and among wage earners.
  - An indication of higher living standards: the number of meals eaten yesterday increased significantly in the full sample, by 0.1 meals per day on average ( $p < 0.01$ ).

Panel B: The distribution of hours worked in the last week, deworming treatment versus control (among those working for wages)



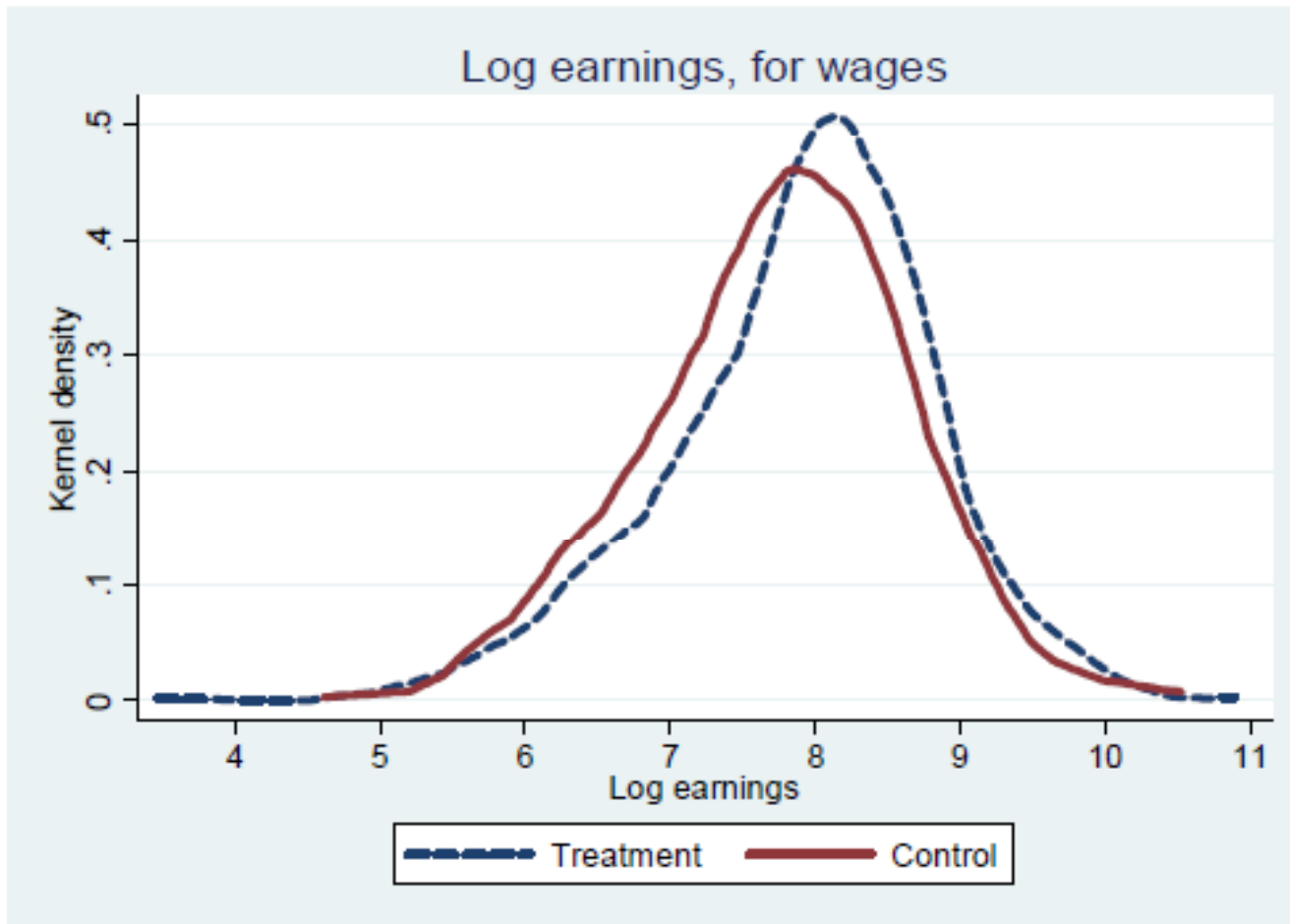
Notes: The sample used here includes all individuals who were surveyed in KLPS-2 and reported working for wages or in-kind in the last month. All observations are weighted to maintain initial population proportions.

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  - Among wage earners, income rose 20-27% in the treatment group ( $p < 0.01$ ), with similar gains for both females and males.
  - No evidence of different impacts for females or by age
  - Externality effects are positive and large but not statistically significant at traditional confidence levels.

**Figure 3:**

Panel A: The distribution of log labor earnings in the last month, deworming treatment versus control (among those with positive labor earnings)



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  - Deworming beneficiaries work longer hours: hours worked rose 12% ( $p < 0.10$ ), both among wage earners and in the full sample.
  
  - There is a large shift in employment sector, with a tripling of employment in well-paid manufacturing jobs (for men,  $p < 0.01$ ), and much less casual labor and work in domestic services (for women).



# Deworming impacts on living standards

- **Further gains among the self-employed – but not in agriculture.**

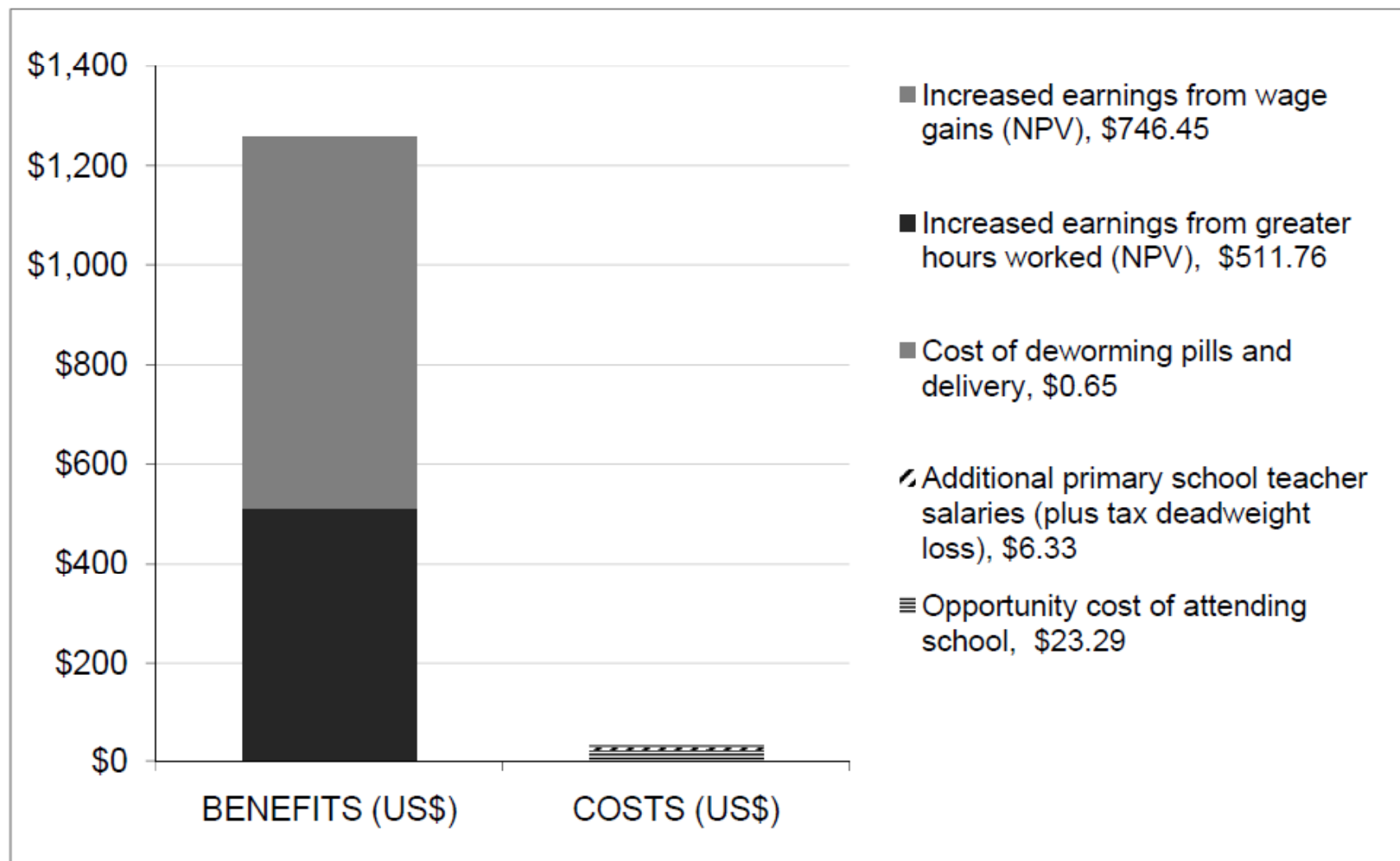
-- The self-employed have higher reported profits and hire more employees, with a mean effect size of 0.175 s.d. ( $p < 0.05$ ).

-- There are no detectable impacts on agricultural sales, land area cropped, technology adoption, or hours worked. Roughly half the sample works in agriculture. Measurement of individual productivity in subsistence agriculture is challenging.

# Deworming as a human capital investment

- **The return on deworming investments is extraordinarily high, even under conservative assumptions.**
  - Benefits: higher labor market earnings in the treatment group.
  - Costs: (i) deworming pills and delivery; (ii) the opportunity cost of time spent in school and not working (especially for teenagers); and (iii) the cost of additional teacher salaries to maintain class sizes at pre-deworming levels.
  - The overall benefit-cost ratio is 25:1 (!) Considering externalities (which we ignore) would increase earnings gains by over 50%, and could alone justify fully subsidizing deworming drugs.
  - The internal rate of return is 18 to 22% per annum. Real interest rates in Kenya are <10%, so this is a very profitable investment.

**Figure 4:** Labor market returns of childhood deworming treatment




Notes: These are the undiscounted sum of benefits and costs over the schooling years and 40 year working life of sample individuals.

# Investing in the future: school health programs

- **The bottom line: childhood deworming in Kenya not only improved school participation in the short-run, but also led to higher labor market earnings a full decade later.**
  - One implication: health investments for children above age 0-3 can still have large impacts on future living standards.
  - While the income gains from treating worms cannot begin to eliminate the gap between Kenya and rich countries like the U.S., gains of 20% are meaningful for people living near subsistence.
  - Policy implication: the national primary school deworming program Kenya launched in 2009, treating 3.6 million children, will likely have large future economic benefits at modest cost.

# Results of multivariate regression analysis

Explanatory variables:		Dependent variable:		
		Ln(Total labor earnings, past month) (standard errors)		
		(1)	(2)	(3)
	Deworming Treatment indicator	0.193** (0.077)	0.187** (0.076)	0.253*** (0.093)
	Deworming Treatment pupils within 6 km (in '000s), demeaned			0.199 (0.168)
	Total pupils within 6 km (in '000s), demeaned			-0.098 (0.127)
	Additional controls	No	Yes	Yes
	R <sup>2</sup>	0.064	0.176	0.182
	Observations	710	710	710
	Mean (s.d.) in the control group	7.86 (0.88)	7.86 (0.88)	7.86 (0.88)