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Worms at Work: Long-run Impacts of a Child Health Investment
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ABSTRACT

This study estimates long-run impacts of a child health investment, exploiting community-wide experimental variation in school-based deworming. The program increased education among women and labor supply among men, with accompanying shifts in labor market specialization. Ten years after deworming treatment, women who were eligible as girls are 25% more likely to have attended secondary school, halving the gender gap. They reallocate time from traditional agriculture into cash crops and entrepreneurship. Men who were eligible as boys stay enrolled for more years of primary school, work 17% more hours each week, spend more time in entrepreneurship, are more likely to hold manufacturing jobs, and miss one fewer meal per week. We estimate an annualized financial internal rate of return of at least 32.2%.

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Introduction

This paper contributes to the literature on the impact of child health on adult outcomes.

Grossman's (1) seminal health human capital model interprets health care as an investment that increases future endowments of healthy time. Bleakley (2) further develops this theory, arguing that how the additional time is allocated will depend on how health improvements affect relative productivity in education and in labor. Pitt, Rosenzweig, and Hassan (3) – hereafter PRH – further note that time allocation will also depend on how the labor market values increased human capital and improved raw labor capacity, and that this in turn may vary with gender. They present evidence consistent with a model in which exogenous health gains in low-income economies tend to reinforce men's comparative advantage in occupations requiring raw labor, while leading women to obtain more education and move into more skill-intensive occupations.

We examine the case of intestinal worms, which globally affect approximately two billion people according to the World Health Organization (4). Worms (helminths) are spread when infected individuals deposit fecal matter containing eggs in the local environment. Intense infections lead to lethargy, anemia, and growth stunting (5-8) and may also weaken the immunological response to other infections (9, 10). Chronic parasitic infections in childhood may lead to inflammation and elevated cortisol that produce adverse health consequences later in life (11), as well as increased maternal morbidity, low birth weight, and miscarriage (12, 13).

Because treatment is safe and very cheap, but diagnosis is expensive, the WHO recommends periodic mass school-based deworming in high-prevalence areas (14). Several other bodies also highlight deworming as a cost-effective investment (15-18). In contrast, a recent Cochrane review argues that while treatment of those known to be infected is warranted, there is insufficient evidence to justify mass deworming (19). One limitation of the review is that it

focuses on studies which randomize treatment at the individual level and thus underestimates the total impact of treatment in the presence of epidemiological spillovers. Moreover, with the exception of a precursor study to the present study which found deworming increased school participation (20), none of the studies they cite examine a comprehensive measure of school participation incorporating both absence and dropout data based on direct observations, and none examine economic outcomes. Bleakley (21) estimates the community-wide impact of deworming in the early 20th century U.S. South using quasi-experimental difference-in-difference methods, finding it improved literacy and raised adult income by 17%. Extrapolating to the higher infection rates in tropical Africa, he estimates deworming could boost income there by 24% (2).

The present paper exploits community-wide experimental variation in a deworming program for children in Kenyan primary schools, combined with a longitudinal data set tracking these children into adulthood, to causally identify the effect of improved child health on later life outcomes. At the time of treatment, program participants had already passed the age window considered most critical for early childhood development, suggesting that the time endowment and time allocation effects emphasized in (1-3) may be the most relevant channels of impact. Indeed a survey conducted 1-2 years after treatment found no cognitive gains. However, consistent with (1), treatment of primary school children led to large gains in school participation, reducing absenteeism by one quarter (20). There was also evidence for epidemiological externalities: untreated children in treatment schools as well as those living near treatment schools had lower worm infection rates and higher school participation (20, 22), and children less than one-year old in treated communities showed cognitive gains in later tests (23). In the current analysis, we examine health, education, and labor market outcomes a decade later, at which point most subjects were young adults 19 to 26 years of age.

Data and Methods

The Primary School Deworming Project (PSDP)

The PSDP took place in Busia district, a densely-settled farming region in western Kenya adjacent to Lake Victoria that is somewhat poorer than the national average. Outside labor market opportunities for children are meager, and boys and girls both typically attend primary school, with dropout rates rising in grades 7 and 8 (the final two years of primary school). Primary school completion, when children in the study area are typically between 15 to 18 years of age, is a key time of labor market transition. Secondary education in Kenya, like tertiary education in the U.S., depends on exam performance, requires a substantial financial outlay, and often involves moving away from home. In our data, just over half of control group males and just under one third of females continue to secondary school. Occupational and family roles differ markedly by gender, with certain occupations, such as fishing, driving bicycle taxis, and manufacturing, overwhelmingly male, and others, such as small-scale market trading and domestic service, largely female. The model in (3) suggests that labor market opportunities will affect the gender-specific educational and labor market response to health investments.

In 1998 the non-governmental organization (NGO) International Child Support (ICS) launched the PSDP in two divisions of the district, in 75 primary schools with a total of 32,565 pupils. Parasitological surveys indicated that baseline helminth infection rates were over 90%. Using modified WHO infection thresholds, over one third of the sample had moderate to heavy infections with at least one helminth (24), a high but not atypical rate in African settings (25, 26).

The schools were experimentally divided into three groups (Groups 1, 2, and 3) of 25 schools each: the schools were first stratified by administrative sub-unit (zone), zones were listed

alphabetically within each geographic division, and schools were then listed in order of pupil enrollment within each zone, with every third school assigned to a given program group. Due to the NGO's administrative and financial constraints, the schools were phased into deworming treatment during 1998-2001: Group 1 schools began receiving free deworming and health education in 1998, Group 2 schools in 1999, and Group 3 in 2001. Children in Group 1 and 2 schools were thus assigned 2.41 more years of deworming than Group 3 children on average (Table S2), and these early beneficiaries are the treatment group in the analysis. Take-up rates were approximately 75% in the treatment group and 5% in the control group (20). In 2001, the NGO required cost-sharing contributions from parents in a randomly selected half of the Group 1 and Group 2 schools, substantially reducing take-up, and in 2002-2003 it provided free deworming in all schools (27). Section A of the Supplement contains a detailed description of the experimental design, provides further information on the sample (Figure S1), and shows that the three groups were well-balanced along baseline characteristics (Table S1).

Kenya Life Panel Survey (KLPS) Data

The Kenyan Life Panel Survey (KLPS-2) was collected during 2007-2009, and tracked a representative sample of approximately 7,500 respondents who were enrolled in grades 2-7 in the PSDP schools at baseline. Survey enumerators traveled throughout Kenya and Uganda to interview those who had moved out of local areas. The effective survey tracking rate in KLPS-2 is 82.7% (Table S2), and 84% among those still alive (see Supplement Sections A.1 and C.1 for detail on survey methodology, tracking rates, and attrition). These are high for any age group over a decade, and especially for a mobile group of adolescents and young adults. Tracking rates are nearly identical and not significantly different in the treatment and control groups.

Methods

The econometric approach relies on the PSDP's prospective experimental design, namely, that the program exogenously provided individuals in treatment (Group 1 and 2) schools two to three additional years of deworming treatment. We focus on intention-to-treat estimates, since compliance rates are high, and previous research showed that untreated individuals within treatment communities experienced gains (20), complicating estimation of treatment effects on the treated within schools. The dependent variable is an outcome Y_{ij} , for individual i from school j , as measured in the KLPS-2 survey:

$$Y_{ij} = \alpha + \lambda_1 T_j + \lambda_2 P_j + X'_{ij,0} \beta + \varepsilon_{ij} \quad (1)$$

The outcome is a function of the assigned deworming program treatment status of the individual's primary school (T_j); the treatment saturation proportion among neighboring schools during the original treatment phase of the PSDP (P_j); a vector $X_{ij,0}$ of baseline individual and school controls (described in Supplement Section A); and a disturbance term ε_{ij} , which is clustered at the school level. Estimates are weighted to make the results representative of the full PSDP sample, taking into account both the sampling for KLPS and the tracking strategy.

The first coefficient of interest is λ_1 , which captures gains accruing to individuals in treatment schools relative to control; since deworming was assigned by school rather than at the individual level, some of the gains in treatment schools are likely due to within-school externalities. The second coefficient of interest is λ_2 , which captures the spillover effects of treatment saturation for nearby schools, following (20). As explained further in that paper, since reinfection rates are very high in the area, the magnitude of externality effects may be either larger or smaller than the effect of own-school treatment. We analyzed other specifications,

including interactions between treatment and local saturation, and non-linearities in saturation (Supplement Section B), but cannot reject that T_j and P_j are additively separable.

Results

After briefly discussing long-run health effects, we present impacts on education, labor outcomes and living standards, by gender. Results are broadly consistent with the PRH (3) model.

Long-run health impacts

While treatment dramatically reduced moderate-heavy infections in the short-run (Table 1, row 1), adult helminth lifespans are typically between one and four years (28), so the direct effects of treatment will no longer be present a decade later in the data used in this analysis. Any long-run effects would instead be due to effects on other diseases through an immunological channel, or to the effects of changes in schooling or labor outcomes. There are no long-term effects on physical growth or body mass index. However, there is some evidence of persistent health gains in terms of self-reported health and reduced miscarriage. Respondent reports that their health was “very good” rose by 4.0 percentage points (SE 1.8, $P < 0.05$), on a base of 67.3% in the control group. We cannot reject equal effects for both genders, but gains are slightly larger for women. Deworming reduced miscarriage rates among treatment group females by 2.8 percentage points (SE 1.3, $P < 0.05$) on a base of 3.9 percent in a probit analysis (where each pregnancy is the unit of observation). The lack of miscarriage impact among the partners of men in the treatment group suggests a health, rather than a living standards, channel for these impacts.

Education impacts

The medium-run follow up (20) found increased primary school participation among both boys and girls, consistent with the idea that health investment increased the endowment of healthy time (1), and that for children, this increased time went into greater schooling rather than more time working. The long-run follow up data show that treatment continued to boost boys' primary school enrollment, but that average academic performance did not improve, with high rates of grade repetition and no significant differences between the treatment and control groups in rates of passing the secondary school exam or enrolling in secondary school (Table 2). (We do not have data on whether increased primary-school enrollment improved non-cognitive skills, a possible channel for labor market impacts (29)). Recall that in the models in (2) and (3), deworming would not increase secondary schooling if attractive work opportunities emerged around the time of primary school completion (roughly ages 15 to 18) and if health investments raised the marginal return to work as much as the discounted return to secondary schooling.

In contrast, deworming leads to marked academic gains for girls, increasing the rate at which girls passed the secondary school entrance exam by 9.6 percentage points ($P < 0.05$) on a base of 41%. This increase of roughly 25% reduces the existing gender gap in exam performance by half. Consistent with the model in (3), in which positive health shocks disproportionately induce women to allocate increased time to human capital acquisition, treatment also halved the gender gap in secondary school entry, increasing girls' secondary school enrollment by 0.325 years, or over one third (Table S3), and increasing overall years of school enrollment for women by 0.354 years (SE 0.179, $P < 0.05$) (Table 2).

Impact on labor hours and occupation

Average weekly hours worked in the control group are quite low, at 20.3 for men and 16.3 for women (although many women in our sample are engaged in home production or child-rearing activities, and time spent on these activities was not systematically collected in KLPS-2). Among men, deworming increased time spent working by 17%, or 3.49 hours per week (SE 1.42, $P < 0.05$, Table 3, Panel A). In contrast, estimated effects on non-household work hours among women are small. It is worth noting that three quarters of both the treatment and control groups are no longer in school by the time of the survey (Table 2). In this subpopulation, treated women worked 2.14 more hours per week, and although we cannot reject the hypothesis of no effect for women, we also cannot reject the hypothesis of equal treatment effects by gender.

Deworming changes how work hours are allocated across sectors and occupations, with important distinctions by gender (Table 3, Panel B). Taking the genders together, hours in non-agricultural self-employment increase by 45% ($P < 0.01$), with no statistically significant changes in hours worked in agriculture or wage employment.

Breaking results down by gender, women increase time in non-agricultural self-employment (“entrepreneurship”) by 1.86 hours (SE 0.81, $P < 0.05$) on a base of 2.7 hours, nearly 70%, and reduce hours worked in agriculture by 1.27 hours (SE 0.56, $P < 0.05$). This shift from agricultural work to entrepreneurship could potentially be interpreted as consistent with PRH (3), although the evidence on this issue is not dispositive. 77% of self-employed women work in retail, which seems less physically-intensive than agriculture, and there is evidence that retail profits are tied to math skills (30). However, there is no significant difference in education levels between women in agricultural employment and those in entrepreneurship in our data.

Point estimates suggest that deworming leads men to increase total work hours (Table 3, Panel B), and we cannot reject the hypothesis of equal percentage increases across sectors.

Deworming treatment also leads to shifts in occupational choice (Table 3, Panel C). Treatment respondents are three times more likely to work in manufacturing (coefficient 0.0110, $P < 0.05$) from a low base of 0.0049. On the flip side, casual labor – which typically does not require regular work hours – falls significantly ($P < 0.05$). Manufacturing jobs require more hours per week than other occupations: they average 53 hours per week, compared to 42 hours for all wage earning jobs, 34 hours for self-employment and 11 hours for agriculture. Workers in manufacturing tend to miss relatively few work days due to poor health, at just 1.1 days in the last month (in the control group), compared to 1.5 days among all wage earners. Manufacturing jobs are highly paid, with average earnings almost double those in casual labor (Table S17).

Deworming led to an increase in cash crop cultivation for the sample as a whole (Table 3, Panel C), with a gain of 1.04 percentage points ($P < 0.05$) on a low base of 0.45 percent.

Estimates of occupational effects by gender are less precise, but there are significant increases in manufacturing among men and in growing cash crops among women. The particularly large effect of deworming on physically-demanding and well-paid manufacturing employment among men is consistent with the PRH model. There is suggestive evidence of a shift into high work hour occupations for men but not women (see Supplement Section C.4).

The increase in secondary education, entrepreneurship, and cash crop cultivation among women may reflect a desire to engage in higher productivity activities within existing family and social constraints, which may complicate moves into manufacturing or other lucrative male-dominated jobs. More speculatively, these may pay off in the form of higher future earnings, even if not yet apparent in our data.

Impact on living standards

Living standards can be assessed using data on either consumption or earnings. We do not have data on overall consumption, but do have data on the number of meals consumed. Treatment respondents eat 0.095 more meals per day (SE 0.029, $P < 0.01$, Table 4, Panel A). The increase in meals eaten is larger for men, at 0.125 meals/day ($P < 0.01$) than for women (0.051 meals), implying that treatment males miss just under one fewer meal each week than control males.

Total earnings are the sum of earnings in wage labor, in non-agricultural self-employment, and in agriculture, each weighted by the proportions working in each sector. In principle, the proportions in each sector could differ by treatment group, but there are no significant differences by treatment status (see Supplement Table S5, odd numbered columns). We consider each source of income below.

Those working in wage employment likely have the best measured data. The distribution of log wage earnings is shifted to right for both men (Figure 1, Panel C) and women (Panel D) in the treatment group relative to control. Log earnings (Table 4, Panel B) are 26.9 log points (SE 8.5, $P < 0.01$) greater. The estimated differences in earnings are larger than those of hours, consistent with the hypotheses that treatment leads men to shift into jobs that require more work hours and that pay better. Log wages computed as earnings per hour worked (among those who work at least 10 hours per week) are 19.7 log points (SE 10.2, $P < 0.10$) greater in the treatment group. Wage earnings differences between treatment and control are also positive among the larger number of respondents who had ever earned wages since 2007, with an average difference of 22.5 log points ($P < 0.01$) during the most recent earnings period.

The data on self-employment profits are likely measured with more noise. In the full sample, monthly profits are 22% larger in the treatment group, but the difference is not significant (Table 4, Panel C), in part due to large standard errors created by a few male outliers

reporting extremely high profits. In a version of the profit data that trims the top 5% of observations, the difference is 28% ($P < 0.10$).

With no changes in the proportion of respondents in different sectors, estimated increases in earnings of more than 20% among wage earners, and similar (if less precisely estimated) increases in profits among the non-agriculturally self-employed, treatment will have increased overall earnings unless agricultural earnings declined. Unfortunately, we lack sufficient data on agricultural earnings to perform a direct test. However, several patterns suggest that it is unlikely agricultural earnings declined, and highly unlikely that they declined sufficiently to outweigh the gains observed in other sectors. Recall that cash crop cultivation increased, and that hours worked in agriculture did not change. Most importantly, if agricultural productivity had declined, one might expect that food consumption among those working in agriculture would decline, but there is in fact an increase of 0.065 meals (SE 0.033) in this group. There is no evidence that the quality of agricultural labor was lower in the treatment group (Supplement Section C.5).

In general, while weighted earnings by sector can always be summed to generate total earnings, the treatment versus control differences within particular sectors reflect a combination of treatment and selection effects. There are significantly different patterns of selection into wage employment and non-agricultural self-employment by treatment status (Table S5). However, the similar rates at which treatment and control individuals work as wage laborers and the similar selection patterns along observable dimensions (Tables S5, S14-S15) suggest that the wage differences might plausibly be interpreted as primarily due to treatment effects.

While statistical power is limited, we do not find strong evidence of heterogeneous treatment effects on education, labor market or living standards outcomes by baseline school

grade, local treatment saturation, or the presence of schistosomiasis (as proxied for by distance to Lake Victoria, see Supplement Section C.4 and Tables S6-S13).

Accounting for multiple inference

To assess robustness, we next account for multiple inference, and then examine two additional sources of variation in exposure to deworming. Supplementary Tables S18-S21 present the false discovery rate adjusted q-values (analogues to the standard P-value) that limit the expected proportion of rejections within a set of hypotheses that are Type I errors (31, 32). Key results are robust to this adjustment: taking both genders together, the deworming impact on meals eaten and labor earnings is statistically significant at the 1% level (q-value < 0.01), on total hours worked in non-agricultural self-employment, trimmed self-employed profits, and manufacturing employment is significant at the 5% level, and the reduction in casual labor jobs and the increase in cash crops are significant at the 10% level. There is less power with the smaller gender subsamples but key results continue to hold at the 10% level (Supplement Section C.5).

Variation in cost-sharing

Because the temporary 2001 deworming treatment cost-sharing program substantially reduced take-up, it provides an additional, orthogonal source of variation in treatment, albeit with less statistical power. Reassuringly, the estimated effect of cost-sharing has the opposite sign of the main deworming treatment effect for 24 of the 28 outcomes presented in Tables 1-4 (excluding the first outcome in Table 1, which was measured before cost-sharing was introduced), and this pattern is extremely unlikely to occur by chance ($P < 0.001$). In addition, stacking the data and

using seemingly unrelated regression (SUR) estimation across outcomes, we reject the hypothesis that the cost-sharing coefficients are zero ($P < 0.001$); see Supplement Section C.4.

Cross-school treatment externalities

Cross-school externalities provide a third source of exogenous variation in exposure to deworming. Several of the externality effect estimates in Tables 1-4 are significant and large in magnitude, including for miscarriage, manufacturing employment, and meals eaten ($P < 0.05$). Under the null hypothesis of no epidemiological externalities, there should be no correlation with the direct treatment effect. In 24 of the 29 specifications in Tables 1-4, the sign of the treatment effect and the cross-school externality effect are the same, which is extremely unlikely to occur by chance; an alternative test estimates a correlation of 0.655 between the t-statistics for the direct effect and the externality effect across outcomes (P -value < 0.002); and using SUR, we reject the hypothesis that the cross-school externality effects are zero ($P < 0.001$); see Supplement Section B. The existence of cross-school externalities provides additional reassurance that estimated deworming impacts are not simply due to reporting effects in treatment schools.

Conclusion

Previous work (20) found that a primary-school deworming program increased school participation. This paper shows that education and labor market outcomes improve one decade after receiving deworming. These gains could have major welfare impacts for households living near subsistence, like many in our Kenyan sample. One can estimate the financial internal rate of return (IRR) by solving for the interest rate that equates the net present value of the full cost of the deworming program to all future earnings gains. This approach neglects any future earnings

gains due to women's higher levels of education in the treatment group, as well as any intrinsic value of better health and education, and is thus conservative. As discussed in Supplement Section C, the estimated annualized IRR is extremely high at 32.2%. Including the estimated gains due to cross-school externalities raises this to 51.6%.

The high rate of return to deworming in the Kenyan context is consistent with findings in the 20th century U.S. South (2, 21). Of course, there is uncertainty around these estimates and returns could differ in other environments, but even given some uncertainty, or substantial weight on priors that the returns to deworming are smaller, the expected financial rate of return would likely exceed conventional hurdles for public health investment. In other work, we are exploring a welfare analysis that estimates the fiscal externalities created by increased labor supply. The present study lacks data on the full household response, and we hope to examine impacts on children and spouses in future research. Future survey rounds will also allow us to assess labor outcomes at a later point when nearly the entire sample is out of school.

Many studies argue that early childhood health gains *in utero* or before age three have the largest impacts (33) and some have argued that interventions outside a narrow window of child development will not have major effects. Our evidence suggests that health interventions among school-aged children, which are too late in life to affect cognition or height, can have long-run impacts on labor outcomes by affecting the amount of time people spend in school or work.

While there is a literature on differences in work hours across wealthy countries (34), the determinants of labor hours in developing countries have been less studied. Work hours are quite low in some low income settings (35), including among the control group in our data. The findings here suggest that poor child health may be one factor behind this low adult labor supply.

Table 1: Deworming impacts on health

	Coefficient estimate (s.e.) on deworming treatment indicator			Coeff. est. (s.e.) externality term	Control group mean (s.d.); Number of Observations		
	All	Male	Female	All	All	Male	Female
Moderate-heavy worm infections in 2001	-0.166*** (0.026)	-0.191*** (0.028)	-0.144*** (0.032)	-0.074 (0.223)	0.327 (0.469) 2,297	0.319 (0.466) 1,216	0.337 (0.473) 1,081
Self-reported health "very good" indicator at KLPS-2	0.040** (0.018)	0.023 (0.025)	0.051** (0.025)	0.128 (0.115)	0.673 (0.469) 5,070	0.713 (0.452) 2,585	0.629 (0.483) 2,485
Height at KLPS-2	-0.109 (0.271)	0.072 (0.382)	-0.301 (0.387)	-1.891 (1.667)	167.3 (8.0) 5,072	171.7 (6.5) 2,585	162.3 (6.5) 2,487
Body mass index (BMI) at KLPS-2	0.022 (0.045)	-0.012 (0.060)	0.058 (0.066)	0.317 (0.269)	27.22 (1.31) 5,072	26.50 (1.02) 2,585	28.03 (1.11) 2,497
Miscarriage indicator (obs. at pregnancy level) at KLPS-2 (for females – themselves; for males – their partners)	-0.015* (0.008)	0.000 (0.004)	-0.028** (0.013)	-0.078** (0.037)	0.030 (0.171) 5,022	0.015 (0.123) 1,622	0.039 (0.194) 3,238

Notes: The sample includes all individuals surveyed in KLPS-2 (2007-2009), except for the moderate-heavy worm infection data, which is from the 2001 PSDP parasitological survey. Each entry is from a separate OLS regression except the miscarriage outcome, which are marginal probit specifications in which each observation is a pregnancy. All observations are weighted to maintain initial population proportions, except for the 2001 moderate-heavy worm infection results. Standard errors are clustered by school. Significant at 90% (*), 95% (**), 99% (***) confidence. The coefficient on the deworming treatment indicator term is λ_1 in equation 1. The cross-school externality term is the "saturation rate" – the number of treatment group (Group 1,2) pupils within 6 km divided by the total number of primary school pupils within 6 km, multiplied by the average deworming take-up rate in the sample – demeaned, and the coefficient on the externality term is λ_2 in equation 1. All regressions except for the first include controls for baseline 1998 primary school population, geographic zone of the school, survey wave and month of interview, a female indicator variable, baseline 1998 school grade fixed effects, the average school test score on the 1996 Busia District mock exams, total primary school pupils within 6 km, and the cost-sharing school indicator. The first row includes controls for baseline 1998 primary school population, geographic zone of the school, a female indicator variable, baseline 1998 school grade fixed effects, the average school test score on the 1996 Busia District mock exams, and total primary school pupils within 6 km. Self-reported health "very good" takes on a value of one if the answer to the question "Would you describe your general health as somewhat good, very good, or not good?" is "very good", and zero otherwise.

Table 2: Deworming impacts on education

	Coefficient estimate (s.e.) on deworming treatment indicator			Coeff. est. (s.e.) externality term	Control group mean (s.d.); <i>Number of Observations</i>		
	All	Male	Female		All	Male	Female
Total years enrolled in school, 1998-2007	0.294** (0.145)	0.150 (0.166)	0.354** (0.179)	1.015 (0.839)	6.69 (2.97) 5,037	7.05 (2.93) 2,567	6.29 (2.96) 2,470
Total years enrolled in primary school, 1998-2007	0.155** (0.075)	0.238** (0.102)	0.026 (0.098)	0.784 (0.485)	4.38 (2.48) 5,037	4.43 (2.42) 2,567	4.32 (2.55) 2,470
Repetition of at least one grade (1998-2007) indicator	0.063*** (0.018)	0.072*** (0.025)	0.053* (0.030)	0.099 (0.123)	0.672 (0.470) 5,084	0.669 (0.471) 2,595	0.676 (0.468) 2,489
Grades of schooling attained by 2007	0.150 (0.143)	-0.030 (0.148)	0.261 (0.171)	0.323 (0.842)	8.72 (2.21) 5,084	9.06 (2.28) 2,595	8.34 (2.07) 2,489
Attended secondary school indicator	0.030 (0.035)	-0.035 (0.038)	0.090** (0.038)	-0.032 (0.217)	0.421 (0.494) 5,084	0.504 (0.500) 2,595	0.329 (0.470) 2,489
Passed secondary school entrance exam during 1998-2007 indicator	0.050 (0.031)	0.004 (0.030)	0.096** (0.040)	0.220 (0.161)	0.505 (0.500) 4,974	0.590 (0.492) 2,541	0.409 (0.492) 2,433
Out-of-school (at 2007-09 survey) indicator	-0.006 (0.022)	0.022 (0.030)	-0.029 (0.026)	0.185 (0.142)	0.75 (0.43) 5,058	0.70 (0.46) 2,582	0.80 (0.40) 2,476

Notes: For details on the regressions, see the notes for Table 1. Each entry is from a separate OLS regression.

Table 3: Deworming impacts on labor hours and occupational choice

	Coefficient estimate (s.e.) on deworming treatment indicator			Coeff. est. (s.e.) externality term	Control group mean (s.d.); <i>Number of Observations</i>		
	All	Male	Female		All	Male	Female
Panel A: Hours worked							
Hours worked in all sectors in last week, full sample	1.58 (1.04)	3.49** (1.42)	0.32 (1.36)	10.20 (7.80)	18.4 (23.1) <i>5,084</i>	20.3 (24.6) <i>2,595</i>	16.3 (21.1) <i>2,489</i>
Hours worked in all sectors in last week, out-of-school sample	2.93** (1.29)	4.55** (1.95)	2.14 (1.49)	14.61 (9.16)	22.0 (24.8) <i>3,873</i>	25.9 (26.5) <i>1,869</i>	18.3 (22.4) <i>2,004</i>
Panel B: Sectoral time allocation							
Hours worked in non-agricultural self-employment in last week, full sample	1.51*** (0.55)	1.35* (0.73)	1.86** (0.81)	6.00* (3.23)	3.3 (12.8) <i>5,084</i>	3.8 (13.7) <i>2,595</i>	2.7 (11.7) <i>2,489</i>
Hours worked in agriculture in last week, full sample	-0.07 (0.42)	1.03* (0.55)	-1.27** (0.56)	-0.55 (3.41)	8.3 (11.4) <i>5,084</i>	7.8 (11.6) <i>2,595</i>	8.8 (11.2) <i>2,489</i>
Hours worked in wage earning in last week, full sample	0.14 (0.84)	1.11 (1.32)	-0.27 (1.08)	4.74 (5.07)	6.9 (18.5) <i>5,084</i>	8.8 (20.0) <i>2,595</i>	4.8 (16.5) <i>2,489</i>
Panel C: Occupational choice (full sample)							
Manufacturing job indicator	0.0110*** (0.0040)	0.0192** (0.0077)	0.0050 (0.0035)	0.0531** (0.0250)	0.0049 (0.0698) <i>5,084</i>	0.0068 (0.0824) <i>2,595</i>	0.0027 (0.0522) <i>2,489</i>
Construction/casual labor job indicator	-0.0053** (0.0026)	-0.0031 (0.0030)	-0.0073 (0.0045)	-0.0196 (0.0154)	0.0048 (0.0691) <i>5,084</i>	0.0040 (0.0628) <i>2,595</i>	0.0057 (0.0756) <i>2,489</i>
Domestic service job indicator	-0.0050 (0.0061)	0.0016 (0.0038)	-0.0134 (0.0129)	-0.0097 (0.0322)	0.0192 (0.1372) <i>5,084</i>	0.0067 (0.0813) <i>2,595</i>	0.0331 (0.1791) <i>2,489</i>
Grows cash crop indicator	0.0104** (0.0051)	0.0032 (0.0044)	0.0187** (0.0090)	-0.0171 (0.0228)	0.0045 (0.0671) <i>5,018</i>	0.0048 (0.0692) <i>2,565</i>	0.0042 (0.0648) <i>2,453</i>

Notes: For details on the regressions, see the notes for Table 1. Each entry is from a separate OLS regression. Agricultural work in Panel A includes both farming and pastoral activities.

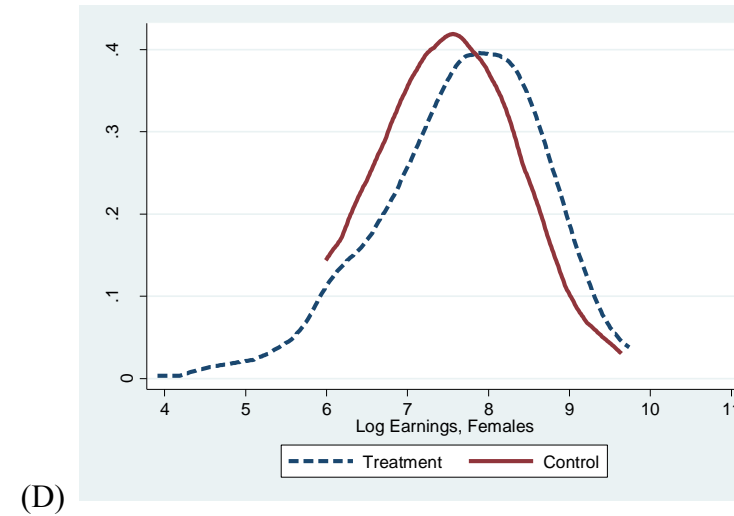
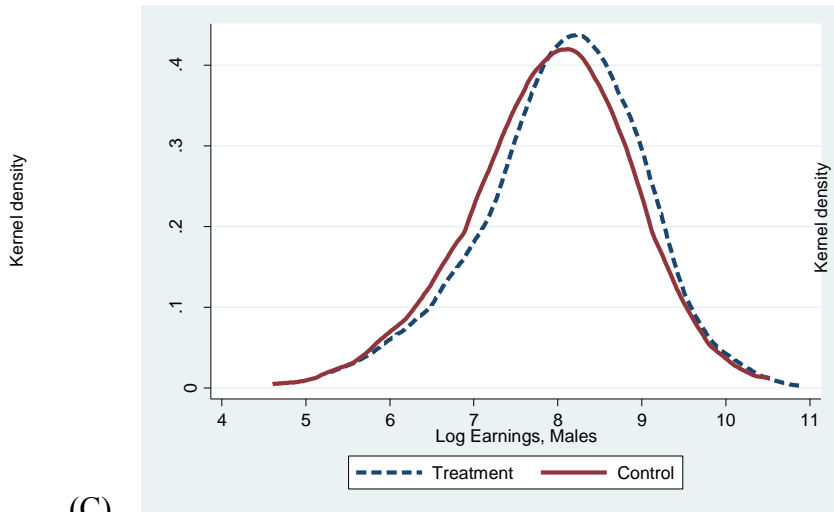
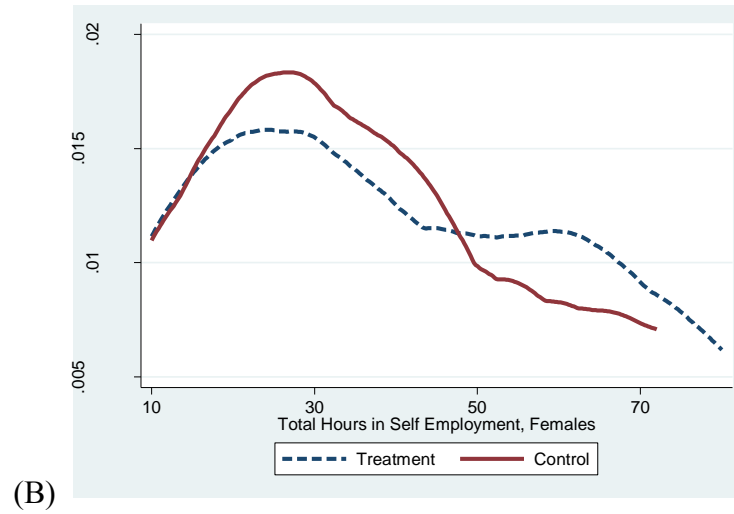
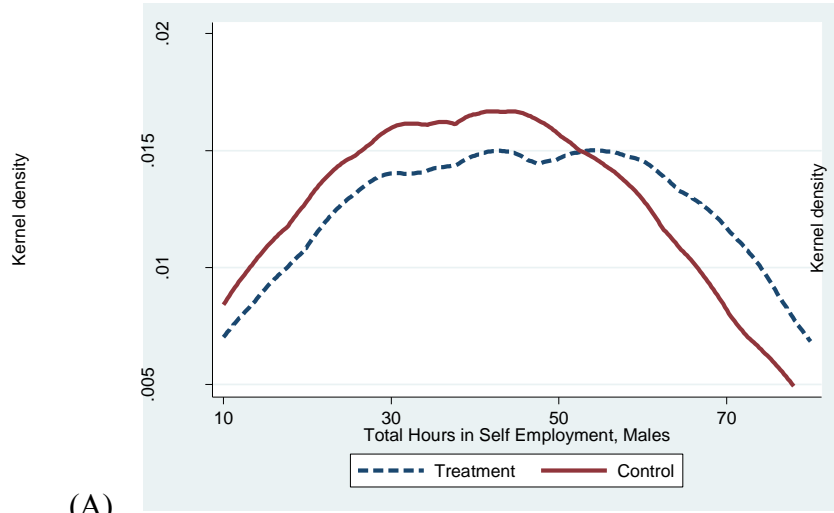
Table 4: Deworming impacts on living standards and labor earnings

	Coefficient estimate (s.e.) on deworming treatment indicator			Coeff. est. (s.e.) externality term	Control group mean (s.d.); <i>Number of Observations</i>		
	All	Male	Female		All	Male	Female
Panel A: Consumption							
Number of meals eaten yesterday, full sample	0.095*** (0.029)	0.125*** (0.041)	0.051 (0.043)	0.415*** (0.124)	2.16 (0.64) 5,083	2.10 (0.65) 2,595	2.23 (0.62) 2,488
Number of meals eaten yesterday, out-of-school sample	0.102*** (0.029)	0.158*** (0.046)	0.037 (0.044)	0.542*** (0.168)	2.16 (0.64) 3,872	2.08 (0.66) 1,869	2.25 (0.62) 2,003
Panel B: Wage earnings (among wage earners)							
Ln(Total labor earnings), past month	0.269*** (0.085)	0.244** (0.109)	0.165 (0.175)	1.141 (0.869)	7.79 (0.88) 710	7.92 (0.87) 542	7.46 (0.81) 168
Ln(Wage = Total labor earnings / hours), past month, if ≥ 10 hours per week of work	0.197* (0.102)	0.181 (0.128)	0.225 (0.194)	0.378 (0.898)	2.68 (0.91) 601	2.88 (0.89) 448	2.21 (0.81) 153
Ln(Total labor earnings), most recent month worked since 2007	0.225*** (0.070)	0.221** (0.097)	0.178* (0.104)	0.941 (0.597)	7.83 (0.91) 1,175	7.97 (0.89) 819	7.54 (0.89) 356
Panel C: Non-agricultural self-employment outcomes (among non-agricultural self-employed)							
Total self-employed profits (self-reported) past month	384 (308)	111 (465)	250 (265)	-77 (1,646)	1,766 (2,619) 585	2,135 (3,235) 313	1,265 (1,261) 272
Total self-employed profits past month, top 5% trimmed	341* (177)	259 (309)	80 (219)	440 (1,256)	1,221 (1,151) 553	1,184 (1,056) 284	1,265 (1,261) 269
Total employees hired (excluding self)	0.416 (0.361)	0.245 (0.403)	0.603 (1.275)	-0.886 (2.547)	0.188 (0.624) 633	0.253 (0.614) 343	0.097 (0.630) 290

Notes: For details on the regressions, see the notes for Table 1. Each entry is from a separate OLS regression, except for “total employees hired” in Panel C, which utilizes a negative binomial regression. Real earnings measures account for the higher prices found in the urban areas of Nairobi and Mombasa. We collected price surveys in both rural western Kenya and in urban Nairobi during KLPS-2, and base the urban price deflator on these data; results are unchanged without this price adjustment. The wage, earnings and profits results in panels B and C are among those who reported wage employment or non-agricultural self-employment, respectively. When computing wages, we exclude those with fewer than 10 hours per week to address division bias from noise in estimation of number of hours worked. “Total employees hired” is among those who are self-employed.

Figure 1: Hours worked in self-employment (if working 10 to 80 hours in sector) and earnings, treatment versus control

Panel A: Hours worked in self-employment in last week, males; Panel B: Hours worked in self-employment in last week, females; Panel C: Log earnings in wage employment in past month, males; Panel D: Log earnings in wage employment in past month, females.



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Author contributions

All authors contributed equally to the manuscript. The author order is alphabetical by surname.