Worms and Wellbeing: 15 Year Economics Impacts from Kenya[*]

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Abstract: Estimating the impact of child health investments on adult living standards faces several major methodological challenges, including the paucity of experimental interventions for which it is feasible to locate participants many years later, as well as difficulties in accurately measuring economic outcomes. This study exploits a randomized school health intervention that provided deworming treatment to Kenyan children. We estimate impacts on their living standards and wellbeing 15 years later, at which point the effective respondent tracking rate was 85%. In our main finding, we show that deworming beneficiaries experience a large and persistent 15% gain in total adult earnings. Treatment group individuals also have significantly higher total consumption expenditures, are more likely to live in urban areas, and are more likely to state that they are "very happy" in surveys. Given deworming's extremely low cost, a conservative estimate of deworming's annualized social internal rate of return is 42.5%.

(JEL codes: E21, I15, I25, J24, O15)

1. Introduction

The role that child health status plays in determining later life outcomes is a major topic of inquiry across research fields. Beyond the direct utility benefits that healthy children (and their families) experience, the belief that investing in child health and nutrition can generate improvements in these individuals' quality of life when they reach adulthood provides a rationale for many public initiatives around the world, including in low-income countries, from school lunch programs to subsidized access to health insurance and medical care for children.

Despite this interest, there remains a limited body of evidence establishing causal impacts of child health gains on adult living standards, due to the methodological challenges inherent in doing so. While there has been some recent progress in wealthy countries, often exploiting administrative data and the targeting or scale-up rules of large-scale public programs (as surveyed in Almond et al 2017), there are few studies in low-income countries that are able to exploit credibly exogenous variation in child health status, combined with long-term tracking of program participants, and the ability to carefully measure adult living standards. This is in part due to the lack of high-quality administrative data on most workers in low-income countries. Measurement of economic wellbeing is also typically more challenging in poor countries given widespread of informal sector activity and subsistence agricultural production. One notable exception is the remarkable 30-year follow-up of the four villages in the INCAP nutritional supplementation study in Guatemala (Martorell et al 2010).

This study exploits a randomized school health intervention that provided deworming treatment to Kenyan children starting in 1998, the Primary School Deworming Project (PSDP). The PSDP treatment group of 50 schools received up to 3 years of additional deworming treatment, relative to the control group (of 25 schools). We estimate impacts on their living standards and wellbeing roughly 15 years later, during 2011-2014, using data from the Kenya Life Panel Survey (KLPS). A noteworthy aspect of KLPS is its success at maintaining contact with the original sample: at the 15 year follow-up mark, the effective respondent tracking rate was still 85%, with rates balanced across treatment arms. This success is due to the project's decision to track migrants beyond the original study region, including to other parts of Kenya, East Africa, and beyond. The survey instrument, which we designed, also gathers rich information on adult earnings, labor productivity, occupation, and living standards, as well as subjective wellbeing. Taken together, these features allow this study to address many of the methodological challenges mentioned above.

In our main finding, we show that deworming beneficiaries experience a large and persistent 15% gain in total earnings. Treatment group individuals also have significantly higher total consumption expenditures (by 26%), are more likely to live in urban areas, and are more likely to state that they are "very happy" in surveys. Given these benefits and deworming's extremely low cost, a conservative estimate implies that deworming's annualized social internal rate of return is 42.5%, a very high return by any standard, and that deworming in Kenya is likely to generate more in future government tax revenue than it initially cost.

The health condition that we focus on, intestinal helminth infections, are extremely widespread, infecting one in five people worldwide (Pullan et al 2014). Worms infections are known to have a range of adverse health and nutritional consequences for children, including stunted growth, weakness, and anemia (for certain types of worms) (Stephenson et al. 1993, Stoltzfus et al. 1997, Guyatt et al 2001, Silva et al. 2003, Disease Control Priorities Project 2008). There is also increasing evidence that worm infections have broader immunological effects, making individuals more prone to other infections, including malaria (Kirwan et al 2010), and having adverse consequences for the gut microbiome including dysbiosis (Guernier et al 2017, Zaiss and Harris 2016); worm infections in pregnant mothers may also affect the birthweight of their children Larocque et al 2006).

It has long been hypothesized that this constellation of health effects could translate into deficits in cognitive development as well as worse living standards and life outcomes (Schapiro 1919, Weisbrod et al 1973). This has formed the basis for the long-standing World Health Organization recommendation to provide mass school-based treatment in endemic regions (World Health Organization 1992). Mass treatment is attractive because diagnosing infections (typically using stool samples analyzed by lab technicians) is very expensive relative to the cost of common deworming drugs, which typically cost less than US$0.60 per year per child, and given the safety of the drugs.

There has been an active recent debate regarding the appropriateness of this recommendation, especially in light of a recent survey article that claimed that population-wide

4

child nutritional gains from mass treatment are generally small (Taylor-Robinson et al. 2015).

However, more recent meta-analysis incorporating more studies and focusing on settings with

worm infection prevalence over 20% – the relevant range for mass treatment programs – find

larger, positive and statistically significant impacts of mass deworming on child weight, as well

as on height (Croke et al 2016). The low cost of deworming drugs mean that it is far more cost

effective than several other approaches to improving child nutritional status, such as school-

feeding programs. There is limited evidence regarding long-run impacts, with the exception of

Bleakley (2007), which finds that the expansion of mass deworming in the U.S. South in the

early 20th century led to significantly higher educational attainment and income gains when the

beneficiary children reached adulthood.

Several existing studies have exploited the experimental variation induced by the PSDP.

Miguel and Kremer (2004) find evidence of improvements in child school participation in the

treatment schools over the first two years of the deworming program, with absenteeism falling

by roughly one quarter. They also estimate sizeable deworming treatment externalities,

presumably as treatment kills off worms already in the body and thus reduces transmission to

others in the community. In particular, they document reductions in worm infection rates both

among untreated children attending treatment schools, as well as among children attending other

primary school located within 4 km of the treatment schools.[1] Further evidence on deworming

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[1] Aiken et al (2015), Davey et al (2015), Miguel and Kremer (2014), Clemens and Sandefur (2015), and Miguel, Kremer and Hamory Hicks (2015) present discussions of the school participation estimates and of the robustness of the cross-school externality results in Miguel and Kremer (2004), and in particular whether there are such effects beyond 4 km. The issues raised in those articles are not relevant to the current paper, which employs a different dataset than Miguel and Kremer (2004).

5

treatment externalities is provided in Ozier (2017), who shows that young children living in the deworming treatment communities – who were not yet school aged, and thus did not directly receive the drugs themselves – also experienced sizeable gains in school learning outcomes up to ten years later. These gains, which are equivalent to roughly 0.5 years of schooling on average, are twice as large among children with older siblings, suggesting that reducing infection transmission within the home may be particularly important.

The current study builds on previous work examining PSDP deworming impacts in the 10 year follow-up survey, called KLPS-2 (Baird et al 2016). That study also documented several long-run benefits of deworming treatment, including improvements in self-reported health, educational attainment (by roughly 0.3 years on average), improved test scores and higher secondary schooling attainment (concentrated among females), higher incomes among wage earners (20% gains), more meals eaten, longer hours worked and more manufacturing employment (concentrated among males).

The current study makes several novel contributions beyond those already documented in Baird et al (2016). First, the analysis estimates impacts 15 years after the start of the deworming project, when most respondents were between 23 to 30 years old, allowing us to estimate the extent to which impacts persist for an additional five years. The study sample in the 15 year follow-up round (KLPS-3) is now firmly out of adolescence and in their prime working years, which is informative. Second, the respondent tracking rates are nearly identical, and if anything slightly higher, in the KLPS-3 (15 year) round relative to KLPS-2; we attribute the continued

success with respondent tracking, in part, due to the rapid diffusion of mobile phones in the region, which has greatly facilitated locating respondents.

Most importantly, the measurement of earnings, economic productivity and living standards was improved between survey rounds. The KLPS-3 round used in the current analysis contains better measures of agricultural productivity, including in subsistence agricultural production, providing a more comprehensive measure of total earnings. The current analysis also incorporates (for a representative subsample) a detailed consumption expenditure module modeled on the World Bank Living Standards Measurement Survey, which is often considered the gold standard for measuring living standards in rural low income settings (Glewwe and Grosh 2000). It is reassuring that estimated deworming treatment effects on living standards are similar when measured either as earnings or in terms of consumption expenditures.

2. Data and Estimation Strategy

2.1 The Primary School Deworming Project and Kenya Life Panel Survey Dataset

The original Primary School Deworming Project (PSDP) study area is Busia District, a largely agrarian region located in western Kenya that is fairly typical for Kenya in terms of living standards, if not slightly poorer than average. Boys and girls both typically attend local primary schools, with dropout rates rising in grades 7 and 8 (the final two years of primary school). Primary school completion typically occurs when children are between 15 to 18 years of age,

after which slightly less than half of the individuals in our sample attended some 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. This segmentation makes it plausible that the impacts of human capital interventions could differ by gender, as hypothesized in Pitt, Rosenzweig and Hassan (2012).

In 1998 the non-governmental organization (NGO) International Child Support (ICS) launched the Primary School Deworming Program (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% in these areas. Using modified WHO infection thresholds, over one third of the sample had moderate-heavy infections with at least one helminth (Miguel et al. 2014), a high rate but not atypical in African settings (Brooker et al. 2000; Pullan et al. 2011, Pullan et al 2014).

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. Appendix Figure A.1 presents the project research design and describes the timing of data collection. The three treatment groups were well-balanced along baseline characteristics, shown in Appendix Table A.1 (also refer to Miguel and Kremer 2004).

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. These early beneficiaries are the treatment group in the analysis here (following Baird et al 2016). Drug take-up rates were approximately 75% in the treatment group and under 5% in the control group (Miguel and Kremer 2004).

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, from approximately 75% to 18% (Appendix Figure A.1). This implies that deworming drug take-up rates are quite similar in the cost-sharing schools and the control schools. In 2002-2003 the NGO again provided free deworming in all schools (Kremer and Miguel 2007).

The Kenya Life Panel Survey Round 1 (KLPS-1) was collected during 2003-2005, and tracked a representative sample of approximately 7,500 respondents who were enrolled in grades 2-7 in the PSDP schools at baseline. At that time, sample respondents were still mainly teenagers, and few were active labor market participants. Subsequent survey rounds were collected in 2007-2009 (KLPS-2), and in 2011-2014 in Round 3 (KLPS-3), and these are the focus of this study. Survey enumerators traveled throughout Kenya and Uganda to interview those who had moved out of local areas, and the growing ubiquity of mobile phones in East Africa during the study period greatly facilitated participant tracking.

9

The effective survey tracking rate has remained high in all KLPS survey rounds. The effective tracking rate is calculated as a fraction of those found, or not found but searched for during intensive tracking, with weights adjusted appropriately, in a manner analogous to the approach in the U.S. Moving To Opportunity study (Orr et al. 2003; Kling, Liebman and Katz 2007). In KLPS-2 the rate is 82.5%, and 84% among those still alive (see Appendix Table A.2, Panel A). The rates are slightly higher in KLPS-3, with 84.2% surveyed, rising to 86% among those still alive (Panel B). These are high tracking rates 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 (columns 4-6). Rates are slightly higher among males than females, and this may be because many women move out of their birth area upon marriage, as is traditional in this region. A representative subsample of respondents were surveyed for a second time (roughly a week or two later) during KLPS-3, for the detailed module capturing consumption expenditures and subjective wellbeing measures. Effective tracking rates are somewhat lower in this subsample (77% among those still alive, Panel C), possibly in part due to survey fatigue, though tracking rates remain balanced across treatment arms even in this case.

2.2 Estimation Strategy

The analytical approach exploits the PSDP's experimental research design, namely, that the program exogenously provided individuals in treatment schools (Groups 1 and 2) two to three

additional years of deworming. [2] We focus on intention-to-treat estimates, since compliance rates are high, and previous research showed that untreated individuals within treatment communities experienced gains (Miguel and Kremer 2004), complicating estimation of treatment effects on the treated within schools. While we focus on full sample results, we also present results separately for women and men. This follows the tradition in the labor economics literature of (Altonji and Blank 1999; Bertrand 2011), and is also sensible given the findings on treatment effect heterogeneity in Baird et al (2016), and the conceptual discussion in Pitt, Rosenzweig and Hassan (2012) regarding why the labor market effects of health investments could differ for males and females in low-income "brawn-based economies".

The dependent variable is an outcome Y_{ijt}, for individual i in school j, in survey round t (for KLPS-2 or KLPS-3):

$$Y_{ijt} = \alpha + \beta T_j + \lambda_1 C_j + \lambda_2 P_j + X'_{\{ij,0\}}\gamma + \varepsilon_{ijt} \tag{1}$$

The outcome is a function of the assigned deworming program treatment status of the individual's primary school, T_j.

The main coefficient of interest is β, which captures gains accruing to individuals in treatment schools relative to the 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

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[2] This study is registered on the American Economic Association RCT registry (#AEARCTR-0001191). We did not register a pre-analysis plan as they were uncommon in Economics when data collection for KLPS-3 began in 2011.

externalities. This is an attractive coefficient to focus on since it is a lower bound on the overall

effect of deworming, as shown in Baird et al (2016).[3]

There are two other sources of exogenous variation in exposure to deworming treatment,

namely, the 2001 cost-sharing school indicator (C_j), and the proportion of students in

neighboring schools within 6 km that received deworming treatment in PSDP (P_j). While not the

main focus of the analysis, below we also present evidence that these two sources of variation

had significant impacts on economic outcomes.

The λ_1 term captures the effect of the sharp reduction in deworming drug treatment

induced by the cost-sharing requirement, and this effect is predicted to have the opposite sign of

the β effect. The λ_2 term captures the spillover effects for nearby schools, following the

approach in Miguel and Kremer (2004), in which cross-school externalities are estimated by

taking advantage of variation in the local density of treatment schools induced by the

randomization. This effect is predicted to generally have the same sign of the β effect. As

explained further in that paper, since reinfection rates are high in the area, the magnitude of

externality effects may be either larger or smaller than the effect of own-school treatment.[4]

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[3] In the presence of within-school epidemiological externalities, we cannot separately identify the labor market impact of individual deworming status and of deworming status of others within the school. We can, however, identify the aggregate school-level effect of the deworming subsidy. We, therefore, classify all individuals in deworming subsidy schools as "treated" in the empirical analysis.

[4] Baird et al (2016) analyzed other specifications, including interactions between treatment and local saturation, and non-linearities in saturation, but cannot reject that T_j and P_j are additively separable and enter in linearly. Note that the bound proven in Baird et al (2016) will still be valid, albeit looser, if the geographic spread of epidemiological externalities over time means that even "pure control" (i.e., $T = 0$ and $P = 0$) schools are subject to some spillover from the program. Those whose infection intensity falls due to cross-school spillovers could themselves generate positive spillovers for other nearby schools, which would then lead to less local re-infection with worms, and so on.

We also include a vector $X_{\{ij,0\}}$ of baseline individual and school covariates; and a disturbance term ε_{ij}, which is clustered at the school level. The $X_{\{ij,0\}}$ terms include school geographic and demographic characteristics used in the PSDP "list randomization", the student gender and grade characteristics used for stratification in drawing the KLPS sample (Bruhn and McKenzie 2009), a pre-program average school test score to capture academic quality, the total number of primary school pupils within 6 km of the school, and survey month and wave controls. Estimates are weighted to make the results representative of the full PSDP sample originally in grades 2-7, taking into account the sampling for KLPS and the tracking strategy.

Another estimation issue is worth discussing. One issue with employing local treatment saturation rates as an explanatory variable in practice is that they are a function of the local treatment decisions of households in the relevant local area, leading to possible endogeneity concerns, for instance, if take-up is higher in areas where people have (unobservably) more positive attitudes towards child health. To address these concerns we construct the local saturation measure P_j as a function of the local coverage rate of treatment school pupils within 6 km of school j, which is exogenously determined by the experimental design, times the average drug take-up rate in the entire sample. This implies that variation in the local saturation variable is driven entirely by the experimental design, with the average take-up rate serving as a useful "rescaling" to allow for a more meaningful interpretation of the magnitude of estimated effects.

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hile, of course, these effects may fade over time, no school in our study area of roughly 15 km by 40 km can be considered a "pure control" in the presence of these externalities.

3. Results

This study focuses on estimating the impacts of deworming treatment on adult earnings, labor market outcomes, residential choice, and living standards, and we present those next. We also find some evidence of moderate positive impacts on adult health status and educational attainment (see appendix Tables A.3 and A.4), as Baird et al (2016) also documented, but they are not the focus of this study.

3.1 Impacts on Earnings

We being with the measure of total individual earnings in the KLPS-3 round, which includes the sum of earnings in wage employment (across all jobs), non-agricultural self-employment profit across all businesses, and farming profits, including in subsistence agriculture. This is our most comprehensive measure of individual labor productivity, including both formal and informal sector earnings. We first focus on earnings in the past month, analogous to the approach in Baird et al (2016), before bringing in additional data. We focus on measures that trim the top 1% of earnings observations throughout in order to limit the influence of outliers in the analysis. Those without any earnings in the last month are included in the analysis, with zero values.

Total earnings in the past year is significantly higher in the deworming treatment group than the control group, with a gain of 560.6 Kenya Shillings per month (Table 1, Panel A,

14

column 1 – s.e. 260.2, P-value<0.05), or roughly US$6.[5] This is a sizeable increase, corresponding to 15.4% of average earnings in the control group. The effects are driven both by moderate increases in earnings among those who are working (column 2, a 9 log point increase) as well as smaller increases in the proportion of the sample working at all (earnings greater than zero) in the last month (column 3), in total hours worked in the last month (column 4), and in earnings per hour worked (column 5); these latter effects are more pronounced when the KLPS-2 and KLPS-3 data is pooled below. There are modest shifts in employment sector into both non-agricultural work (column 6) and manufacturing employment (column 7), although neither of these effects is statistically significant in the most recent month reported in KLPS-3.

There is a large shift into residence in urban areas, with an increase of 7.0 percentage points on base urban residence of 40% (column 8 – s.e. 2.9, P-Value<0.05). The move into urban areas among treatment group individuals can likely explain at least part of the deworming earnings result: in related work, Hicks et al (2017) find a moderate positive wage premium for urban employment in Kenya, on the order of 15-20 log points.

As in Baird et al (2016), there are pronounced gender differences in the long-run effects of deworming. On average, treatment group males (shown in Table 1, Panel C) gain somewhat more than females (Panel B) in terms of total earnings (column 1), the various intensive and extensive margins of labor market participation and wages (columns 2-5), as well as in the shifts

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[5] Table 1 presents the coefficient estimates on the deworming treatment indicator, the main focus of this study. Appendix Table A.5 contains results from the exact same regressions, but also presents estimates from other explanatory variables, including the cost-sharing school indicator and the local deworming saturation terms, as well as stars indicating statistical significance. We discuss these additional results below.

out of agricultural work (column 6-7), although few of these differences are statistically

significant. In contrast, although the base rate of urban migration among females (36%) is lower

than among males (45%) in the control group, there is a larger shift into urban residence among

females: the treatment effects for females is 8.6 percentage points (Panel B, column 8 – s.e. 2.5,

P-value<0.01), and roughly half at 4.6 percentage points for males (Panel C, column 8).

We next turn to our preferred estimates of deworming impacts on adult earnings, which

pool data for both the KLPS-2 and KLPS-3 rounds, and can thus be interpreted as the average

effect on total earnings between approximately 10 to 15 years after the start of treatment. For

both rounds, we focus first on our most comprehensive measure of earnings across all sectors.

Here in the pooled analysis we utilize monthly earnings over the past 12 months, since this is the

timeframe over which detailed agricultural productivity data is captured in the survey; this

timeframe also lines up with the annual consumption expenditure measure discussed below. The

use of 12 months of data (rather than just the most recent month, as in Table 1) leads to more

statistically precise estimates.

Total earnings are higher in the treatment group, with an average gain of 291.5 Kenya

Shillings per month (Table 2, Panel A, column 1 – s.e. 123.7, P-value<0.05), or roughly

US$3.43. Mean earnings in the control group are somewhat lower in the pooled sample (since

earnings are lower in KLPS-2, as average earnings are rising over time in this young adult

population), but this is once again equivalent to a roughly 15% increase in earnings.

The overall gain can be decomposed into an increase in earnings among those with positive earnings (by 12 log point, column 2 – s.e., 5 log points, P-value<0.05), an increase in the proportion of individuals with any positive earnings (3 percentage points, column 3 – P-value<0.05), and an increase of 4.3 hours worked per month (column 4). Earnings per hour worked also increase in the treatment group (column 5 – P-value<0.05). There are once again suggestive shifts in the sector of employment, into non-agricultural employment (column 6) and manufacturing jobs (column 7), although neither is significant at traditional confidence levels.

Taking both the KLPS-2 and KLPS-3 rounds together, the proportion of urban residence is somewhat higher in the deworming treatment group, at 3.2 percentage points, although this effects is not statistically significant (Panel A, column 8). Once again this effect is larger and statistically significant among females, at 4.8 percentage points (Panel B, column 8 – s.e. 2.1, P-value<0.05).

The total earnings results over the previous 12 months for KLPS-2 and KLPS-3 are presented graphically in Figure 1, for the full sample (in the left panel), and then for females and males separately. The pooled effect for the full sample reproduces the estimate presented in Table 2, Panel A, column 1, and the female (male) results are from Panel B (Panel C).[6] It is evident that the average deworming treatment effect is rising over time between the 2007-2009 KLPS-2 round and the 2011-2014 KLPS-3 round, although the latter effects are somewhat less precisely estimated. It is noteworthy how the evolution of treatment effects differs by gender: in

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[6] A more complete presentation of the results in Table 2 are contained in Appendix Table A.6. The treatment effects estimates show in Figure 1 for the previous 12 months from the KLPS-3 round are presented in Appendix Table A.7.

absolute monetary terms, the deworming treatment effect is positive and nearly identical for females across the two survey rounds, while estimated effects appear to grow larger over time for males (although we cannot reject the hypothesis that impacts are stable over time).

The gender differences in treatment effects extend into the sector of employment. The most salient pattern is a larger shift into wage employment among males than among females, both in terms of earnings by sector (Appendix Table A.8) and hours worked by sector (Appendix Table A.9), while among females there is a more pronounced increase in self-employment. However, while suggestive, few of these cross-sectoral differences in treatment effects by gender are statistically significant at traditional confidence levels.

3.2 Impacts on Living Standards

A representative subset of roughly one sixth of the sample was administered an additional survey module in the KLPS-3 round, including a consumption expenditure module, as well as more detailed questions on subjective wellbeing. The consumption questions follow the standard LSMS format of detailed consumption recall questions (as shown in Appendix Figure A.2). In cases where a large share of household income comes from subsistence agriculture or informal sector employment, consumption may yield a more accurate measure of total household income.

Deworming treatment has a positive impact on total household consumption expenditures per capita, with an average gain of 30 log points (Table 3, Panel A, column 1 – s.e. 11 log points,

P-value<0.01). This corresponds to a gain of 26.1% relative to the control group mean. While

larger than the roughly 15% average gain in earnings in the treatment group, we cannot reject

that the magnitudes of these two effects are equal. The distribution of per capita consumption in

the treatment group is shifted clearly to the right relative to the control group, with particularly

large shifts in the right tail of the distribution (Figure 2, Panel A).

There is an approximately 15 log points increase in food consumption (column 2), and

suggestive evidence of an increase in meals eaten (column 3). The total consumption effects are

larger among males (Panel C) than females (Panel B), consistent with the larger earning gains

among males presented above, and this is reflected graphically (Figure 2, Panels B and C). [7]

There are also positive estimated effects of deworming on household assets but these are

generally small. We created a mean effect index of six improved home characteristics, including

improved housing materials, electricity connection, water and sanitation connections, and the

number of rooms. The average effect of deworming treatment on the home characteristics index

is 0.10 standard deviation units (column 4). [8] In terms of other assets, we create an index of

household ownership of up to 28 assets, and once again the estimated effects are positive but

small (column 5).

The same subset of respondents surveyed regarding household consumption were also

asked to assess their own wellbeing. Approximately 41% of individuals in the control group

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[7] The complete set of living standards results in Table 3 are presented in Appendix Table A.10. The distributions of per capita consumption (unlogged) are presented in Appendix Figure A.2. The distributions of log per capita food consumption are presented in Appendix Figure A.3.
[8] The results for the separate components of the home characteristics index are presented in Appendix Table A.11.

responded that they were "very happy", with the rest distributed between "somewhat happy" and "not happy". Subjective wellbeing questions have long been controversial among economists and other social scientists, in part because comparisons of rates of happiness across societies and cultures may be complicated by local social norms regarding the public expression of happiness; those specific concerns are not relevant in our Kenyan sample.

The proportion of respondents claiming to be "very happy" rises by 11 percentage points, to 52%, in the deworming treatment group (Table 3, Panel A, column 6 – s.e. 4 percentage points, P-value<0.05). Although base rates of happiness are higher among women respondents, the magnitude of these effects are nearly the same among females (Panel B) and males (Panel C).

3.3 Other deworming treatment effects: cost-sharing and local spillovers

We next assess the effects of the other two forms of exogenous variation in deworming treatment exposure in our sample, namely, the 2001 cost-sharing experiment carried out in the Group 1 and Group 2 schools, as well as the variation in local treatment saturation. All coefficient estimates on these terms are presented in the Appendix tables.

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. There is substantial evidence that the sharp reduction in deworming treatment due to the introduction of cost-sharing led to worse adult labor market and living

standards outcomes. For instance, out of the 37 unique outcome variables considered in both the main tables and the appendix tables, the coefficient estimate on the cost-sharing term is negative (as predicted) in 34 cases, an outcome that would be very unlikely to occur by chance in the absence of a treatment effects. In many cases (although not all), the coefficient estimate on cost-sharing also as a smaller absolute magnitude than the direct treatment, which is also sensible since the timeframe of the reduction in treatment was shorter than the average duration of treatment. In a seemingly unrelated regressions (SUR) specification across all of these outcomes, we reject the hypothesis that the coefficient estimate on the cost-sharing indicator equals zero at high levels of confidence (P-value<0.001).

There is similar, albeit somewhat weaker, evidence that higher levels of local treatment saturation improved adult outcomes. Under the null hypothesis of no epidemiological externalities, there should be no correlation with the direct treatment effect. The coefficient estimate on the saturation term is positive for 25 of the 37 outcome variables, an outcome that is somewhat unlikely to occur by chance. In a seemingly unrelated regressions (SUR) specification across all of these outcomes, we reject the hypothesis that the coefficient estimate on the local treatment saturation term equals zero at high levels of confidence (P-value<0.001). The existence of cross-school externalities, as well as impacts of being in a cost-sharing school, provides additional evidence on the robustness of the deworming impacts, and reassurance that estimated effects are not simply due to some form of reporting bias in the treatment schools.

The same SUR approach also allows us to test the hypothesis that the main deworming treatment effect is equals zero across all outcomes, which we reject (P-value<0.001). Similarly, we reject the hypothesis that the coefficient estimates on the main treatment term, the cost-sharing indicator, and the treatment saturation term are all jointly equal to zero at high levels of confidence (P-value<0.001). We conclude that exposure to deworming has a significant impact on long-run adult labor market and livings standards outcomes.

3.4 Cost-effectiveness, rate of return and fiscal impacts of deworming subsidies

The estimated impacts of deworming on labor market outcomes, combined with other data, allow us to estimate the internal financial rate of return and fiscal impacts of deworming subsidies.

We base our calculations on the observed differences in total earnings between the treatment and control groups in both the KLPS-2 and KLPS-3 survey rounds, and focus on the average treatment effect when pooling this data; this is likely to be somewhat conservative since the magnitude of average treatment effects is rising over time (Figure 1).

For projections about the future path of earnings and thus government revenues, we examine the following expression:

(2)

$$SQ(S) < \tau \sum_{t=10}^{t=50} \beta(1+g)^{t-9} \left(\frac{1}{1+r}\right)^t - K \sum_{t=0}^{t=9} \Delta \bar{E}_t(S) \left(\frac{1}{1+r}\right)^t$$

The left hand side is the fiscal cost to the government of implementing a deworming subsidy at level $S > 0$ (relative to the case of no subsidies), which in turn may affect deworming take-up Q; take-up is non-decreasing in the subsidy. We focus on the free treatment case, and use PSDP project data to compute this (Miguel and Kremer 2004, Kremer and Miguel 2007), together with current estimates of per pupil mass deworming treatment costs (provided by the NGO Deworm The World) of $0.59 per year. The total direct deworming cost then is the 2.41 years of average deworming in the treatment group times this figure, or $M = \$1.42$ per person treated and $1.07 per pupil in a deworming treatment school, given average take-up of 75%.

The right hand side captures the implications for government revenue of introducing the subsidy. The first term captures the increase in tax revenue generated by any increase β in earnings in the treatment group: τ is the prevailing tax rate; and r is the per period interest rate. These gains are captured over an individual's working life, which we take to be 50 years. We assume that recent Kenyan economic growth trends continue, increasing incomes proportionally at rate g in both the treatment and control groups. To be conservative regarding benefits, we ignore any gains from cross-school deworming treatment externalities, or in other populations (as documented in Ozier 2017).

The second term in the square brackets accounts for the fact that improved child health may lead the government to accrue additional educational expenditures, for instance, if secondary schooling rates increase, which we find for females in our sample. Let K capture the cost of an additional unit of schooling, and $\Delta \bar{E}_t(S)$ denote the average increase in schooling when the deworming subsidy is introduced.

To compute the right hand side of eqn. 2, we use a combination of estimates from this paper and other Kenyan data. The increase in earnings due to deworming subsidies is our preferred pooled KLPS-2 and KLPS-3 estimate from Table 2 (Panel A, column 1), namely, $3.43 per month. At the time KLPS-2 and KLPS-3 were being collected, the Government of Kenya paid 11.85% interest on its sovereign debt and inflation was approximately 2%, so we set the real cost of capital r to 9.85%.[9] We assume that the sample population begins working ten years after they first began receiving deworming and retires after 40 years of work.[10] From year 10 post-treatment onwards, they experience the average deworming earnings treatment effect (from Table 2), and we assume that per capita income growth continues at a rate of 1.52% per year (the average over the period according to World Development Indicators data). Kenyan taxes (mainly on consumption) absorb roughly 16.6% of GDP so we set the tax rate τ to 16.6%.[11]

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[9] See http://www.centralbank.go.ke/securities/bonds/manualresults.aspx and World Bank Development Indicators. This is a conservative assumption since other potential funders of deworming subsidies (e.g., international organizations, private donors) are likely to face lower interest rates.

[10] This 10 year gap roughly corresponds to the time elapsed from the start of PSDP until the KLPS-2 survey (2007-09). By ignoring the time before KLPS-2 data was collected, it underestimates gains due to greater work hours prior to the survey. Yet it misses any reduction in work hours due to substitution of school for work. However, existing estimates of child labor productivity suggest these foregone earnings are likely to be small (Udry 1996).

[11] From World Development Indicators, government expenditures are roughly 19.5% of GDP, and from http://blogs.worldbank.org/africacan/three-myths-about-aid-to-kenya about 15% of government expenditure is financed from donors, thus 0.195*0.85=0.166.

Following Baird et al (2016), we estimate deworming impacts on school enrollment by gender and year, and also gathered detailed information on current teacher salaries and class sizes from the Ministry of Education, allowing us to estimate per capita schooling costs K for both primary and secondary schooling. Because the PSDP program did not increase the number of teachers or classrooms in primary schools, and there is no reason to believe the Kenyan government adjusted these factors in response to the program (based on our observations as well as on discussions with local officials), any costs of increased classroom congestion at the primary level due to deworming would have been incurred by students in these schools and thus is already captured in the labor market outcomes in our data. We therefore focus on measuring the fiscal costs to the government of increased secondary school enrollment, since these costs would be incurred either by the government (by paying for additional teachers) or by secondary school students. Teacher salaries constitute the bulk of recurrent government education spending, at over 90% of secondary school spending (Otieno and Colclough 2009), and most other expenses are traditionally covered by tuition and parent fees. We factor in the costs that the government would need to incur to maintain the secondary school pupil-teacher ratio, using our estimated per student secondary school teacher cost of $116.85 per year.

In this base case, $\sum_{t=10}^{t=50} \beta (1+g)^{t-9} \left(\frac{1}{1+r}\right)^t = \$203.72$, implying that individuals gain an average of $203.72 in take-home pay and the NPV of government revenue increases by $33.77 per person. The additional public educational costs incurred are estimated to be approximately $10.71, so the net increase in government revenue is $23.06, far greater than the $1.07 subsidy.

A standard approach to assessing the desirability of a program is to calculate the social internal rate of return (IRR), which solves for the interest rate that equates the NPV of the full social cost and all earning gains, whether taxed or untaxed: $MQ(S) = \sum_{t=10}^{t=50} \beta(1 + g)^{t-9} \left(\frac{1}{1+r}\right)^t - K \sum_{t=0}^{t=9} \Delta \bar{E}_t(S) \left(\frac{1}{1+r}\right)^t$. The annualized social IRR is very high at 42.2%.

The main result that deworming is a very cost-effective investment holds across a range of alternative assumptions. First, we consider the case in which we assume that the average deworming treatment effect on earnings will remain constant for the remainder of these individuals' work lives, and will not grow at the same rate as the Kenyan economy (i.e., in the notation above, $g=0$). In this case, the NPV of future earnings is still large, at $176, the gain in government net revenue is $18, and the social IRR is nearly 42.0%.

A second even more conservative assumption is that deworming treatment effects on earnings do not persist after the KLPS-3 round, and instead fall down to zero for the reminder of individuals' working lives. Here we find that the earnings gains already experienced are sufficient to deliver a high rate of return on deworming: the NPV of gains in individual earnings is $99, the NPV of gains in net government revenue is $6 (again, even after subtracting off increased schooling costs), which is still far higher than the cost of subsidy (roughly $1), and social IRR falls to 41%.

Regarding the issue of whether deworming generates at least as much net government revenue than it costs, this holds (in the base case) as long as the government collects at least 5.7% of income in taxes, which seems likely to hold in most low income countries.

In fact, the upfront costs of deworming subsidies are so low that an average earnings gain of just 1% would deliver a social IRR of 10% (per annum), which roughly corresponds to real interest rates in Kenya. In other words, even miniscule earnings gains (or other welfare benefits) could justify deworming subsidies given their small cost.

4. Conclusion

This study estimates the long-run impacts of mass school-based deworming treatment on adult labor market outcomes, earnings, and living standards fifteen years later. Relative to the control group, deworming beneficiaries in Kenya experience substantial gains in later earnings (with an average increase of 15%), higher consumption expenditures, higher rates of urban residence, and improved levels of subjective wellbeing. The findings add to a growing body of evidence that the Primary School Deworming Project had meaningful positive effects on child education (Miguel and Kremer 2004), labor market outcomes over a ten year time horizon (Baird et al 2016), and generated positive treatment externalities both among primary school age children as well as among infants living in the study area at the time (Ozier 2017). Taken together, the social rate of return for this intervention appears to be large.

From a policy perspective, it is important to consider the external validity of the findings. Intestinal worm infections are widespread globally, with high infection rates in many parts of Africa, South Asia, and Latin America, and a possible (and unfortunate) recent resurgence in

poor rural pockets of the U.S. South (McKenna et al 2017). The ubiquity of the infections suggests that this study's findings have relevance for many other settings.

At the same time, the degree to which deworming treatment generates positive long-run labor market effects is plausibly linked to the extent of infections. The study setting was one with quite high baseline infection prevalence, at over 90%, and a fairly large share of children with moderate to heavy infections (roughly one third). The PSDP intervention also began in the midst of the 1997-1998 El Niño–Southern Oscillation (ENSO) event, one of the most powerful in recorded history. The 1997-1998 ENSO brought torrential rains to many parts of Kenya, including the study area, and led to a substantial deterioration of the disease environment, with outbreaks of cholera, malaria, and rift valley fever. The deterioration in hygiene and access to sanitation almost certainly contributed to elevated infection prevalence for both the soil-transmitted helminths and schistosomiasis. Deworming treatment impacts would plausibly have been somewhat smaller if worm infection levels had not been at these unusually high levels, although this is admittedly speculative.

There are several important questions for future research in this areas. First, it is unknown if the gains that we document will continue to persist in the future. To assess the durability of these gains, we plan to continue tracking these individuals over time and will periodically collect information on their economic and other life outcomes. Most individuals in the study sample have also already become parents themselves. Another direction for future research will be to assess the extent of any inter-generational impacts of deworming treatment on the children of

sample respondents. The sizeable labor market and living standards gains we document suggest

that these are at least plausible. The existence of any gains for the next generation would further

bolster the cost-effectiveness of the deworming child health intervention. Finally, and echoing

Almond et al.'s (2017) review, further research is needed to understand how institutional and

contextual factors interact with child health investments to change adult outcomes, in order to

better understand the cause of heterogeneous treatment impacts across settings, as well as the

mechanisms driving these effects.

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Table 1. Earnings Measures: KLPS-3 Cross Section

Panel A: Full Sample

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	560.6	.09	.02	2.56	1.67	.013	.008	.070
	(260.2)	(.07)	(.02)	(4.48)	(1.74)	(.021)	(.008)	(.029)
Control Mean	3631.6	8.08	.56	118.08	22.02	.46	.03	.40
Treatment Effect (%)	15.4	8.93	4.32	2.16	7.57	2.89	25.70	17.32
Number Observations	4549	2603	4595	4577	4549	4595	4595	4590

Panel B: Females

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	214.3	.05	.01	-2.13	1.11	.006	-.000	.086
	(220.2)	(.11)	(.03)	(7.65)	(1.95)	(.031)	(.008)	(.025)
Control Mean	2047.4	7.55	.47	93.81	13.49	.40	.02	.36
Treatment Effect (%)	10.5	4.52	3.00	-2.27	8.20	1.46	-2.84	23.78
Number Observations	2254	1044	2261	2258	2247	2261	2261	2258

Panel C: Males

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	853.0	.07	.03	5.84	1.62	.017	.018	.046
	(505.4)	(.10)	(.03)	(6.34)	(2.51)	(.029)	(.014)	(.037)
Control Mean	5116.9	8.43	.65	140.58	29.94	.52	.04	.45
Treatment Effect (%)	16.7	6.91	4.97	4.15	5.40	3.29	42.27	10.36
Number Observations	2295	1559	2334	2319	2302	2334	2334	2332

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is previous month total earnings (Ksh) and is trimmed from the top at the 1% level. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% of earners), full sample. The dependent variable in column (2) is the log of total earnings (restricting the sample to non-zero earners) and is trimmed from the top at the 1% level. The dependent variable in column (3) is an indicator variable for non-zero earnings and is untrimmed. The dependent variable in column (4) is previous month total hours worked in agriculture, a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (5) is previous month total wage earnings per hour worked in a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (6) is an indicator for main employment in non-agricultural work, denoted as the individual reporting more work hours in non-agricultural than agricultural work, across all wage employment, self-employment, and subsistence farming. The dependent variable in column (7) is an indicator for main employment in manufacturing, coded as "1" if an individual's main wage job is in the manufacturing industry. An individual's main wage job is the job in which they reported the most hours. The dependent variable in column (8) is an indicator for having an urban residence. Urban includes any non-rural areas, such as cities or towns. Covariates follow Baird et al 2016, including 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 a cost-sharing school indicator; see also Appendix Table A.4. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level.

Table 2. Earnings Measures: KLPS-2 and KLPS-3

Panel A: Full Sample

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	291.5	.12	.03	4.35	1.81	.021	.007	.032
	(123.7)	(.05)	(.01)	(3.05)	(.76)	(.014)	(.005)	(.025)
Control Mean	1886.7	8.06	.34	69.12	10.57	.28	.02	.42
Treatment Effect (%)	15.4	11.40	9.41	6.29	17.09	7.54	34.23	7.67
Number Observations	115329	42057	116597	115299	115475	116597	116597	116568
Number Individuals	5364	3390	5391	5377	5368	5391	5391	5391

Panel B: Females

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	238.6	.09	.03	4.01	1.25	.032	.003	.048
	(123.4)	(.09)	(.02)	(4.37)	(.84)	(.019)	(.006)	(.021)
Control Mean	1116.7	7.71	.26	52.72	6.70	.22	.01	.39
Treatment Effect (%)	21.4	8.25	10.54	7.60	18.61	14.37	30.53	12.16
Number Observations	56509	15012	56706	56328	56473	56706	56706	56703
Number Individuals	2629	1387	2631	2629	2627	2631	2631	2631

Panel C: Males

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	369.0	.10	.04	5.02	2.38	.010	.012	.015
	(197.5)	(.07)	(.02)	(3.59)	(1.06)	(.016)	(.008)	(.033)
Control Mean	2585.9	8.26	.42	83.92	14.07	.33	.03	.44
Treatment Effect (%)	14.3	9.46	9.44	5.98	16.94	3.09	43.58	3.52
Number Observations	58820	27045	59891	58971	59002	59891	59891	59865
Number Individuals	2735	2003	2760	2748	2741	2760	2760	2760

Notes: Analysis pools the last 12 month of retrospective data from KLPS-2 and KLPS-3. Observations are at the individual-month level, up to 12 months prior to the interview date for each of the two follow up surveys. The dependent variable in column (1) is previous month total earnings (Ksh) and is trimmed from the top at the 1% level. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% level). The dependent variable in column (2) is the log of total earnings (restricting the sample to non-zero earners) and is trimmed from the top at the 1% level. The dependent variable in column (3) is an indicator variable for non-zero earnings and is untrimmed. The dependent variable in column (4) is previous month total hours worked in agriculture, a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (5) is previous month total wage earnings per hour worked in a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (6) is an indicator for main employment in non-agricultural work, denoted as the individual reporting more work hours in non-agricultural than agricultural work, across all wage employment, self-employment, and subsistence farming. The dependent variable in column (7) is an indicator for main employment in manufacturing, coded as "1" if an individual's main wage job is in the manufacturing industry. An individual's main wage job is the job in which they reported the most hours. The dependent variable in column (8) is an indicator for having an urban residence. Urban includes any non-rural areas, such as cities or towns. Covariates follow Baird et al 2016; see also Appendix Table A.5. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level.

Table 3. Living Standards Measures: KLPS-3 Cross Section

	(1) Log Consumption	(2) Log Food Consumption	(3) Meals Eaten Yesterday	(4) Improved Home Characteristics Index	(5) Asset Index Share Owned	(6) "Very Happy" Index
Panel A: Full Sample						
Treatment	.30	.15	.04	.10	.33	.11
	(.11)	(.10)	(.03)	(.07)	(.48)	(.04)
Control Mean	8.38	7.60	2.17	.00	36.94	.41
Treatment Effect (%)	26.10	13.68	1.70	–	.91	10.43
Number Observations	717	716	4582	4404	4582	724
Panel B: Females						
Treatment	.01	-.01	.07	.18	.48	.11
	(.10)	(.10)	(.04)	(.07)	(.81)	(.07)
Control Mean	8.31	7.52	2.23	-.07	36.14	.49
Treatment Effect (%)	1.08	-.54	3.12	–	1.33	10.09
Number Observations	372	368	2255	2184	2255	372
Panel C: Males						
Treatment	.42	.17	.01	.01	.05	.09
	(.19)	(.15)	(.03)	(.09)	(.78)	(.06)
Control Mean	8.44	7.67	2.13	.07	35.83	.34
Treatment Effect (%)	35.02	15.90	.33	–	.13	8.97
Number Observations	345	348	2327	2220	2327	352

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is the log of total per capita consumption (trimmed from the top at the 1% level), which is measured for a subsample of KLPS-3 individuals. The dependent variable in column (2) is the log of per capita food consumption (trimmed from the top at the 1% level), which is measured for a subsample of KLPS-3 individuals. The dependent variable in column (3) is number of meals eaten yesterday (untrimmed). The dependent variable in column (4) is an index comprising of seven home characteristics, including an indicator for having an improved floor, an indicator for having an improved roof, an indicator for having an electric connection, an indicator for having a toilet at home, number of rooms, and an indicator for having access to clean water, in which we demean and standardize each outcome, sum them together, and then demean and standardize the sum. See Appendix Table A.10 for a full breakdown of this index. The dependent variable in column (5) is an asset index (0 to 100), constructed by taking the fraction of household assets owned and multiplying by 100 (untrimmed). We measure 28 assets in KLPS-3. The dependent variable in column (6) is an indicator variable for feeling "very happy" overall (untrimmed), given alternatives of "somewhat happy" and "not happy". Covariates follow Baird et al 2016; see also Appendix Table A.9. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level.

Figure 1. Total Earnings, KLPS-2 (2007-2009), KLPS-3 (2011-2014), and Pooled
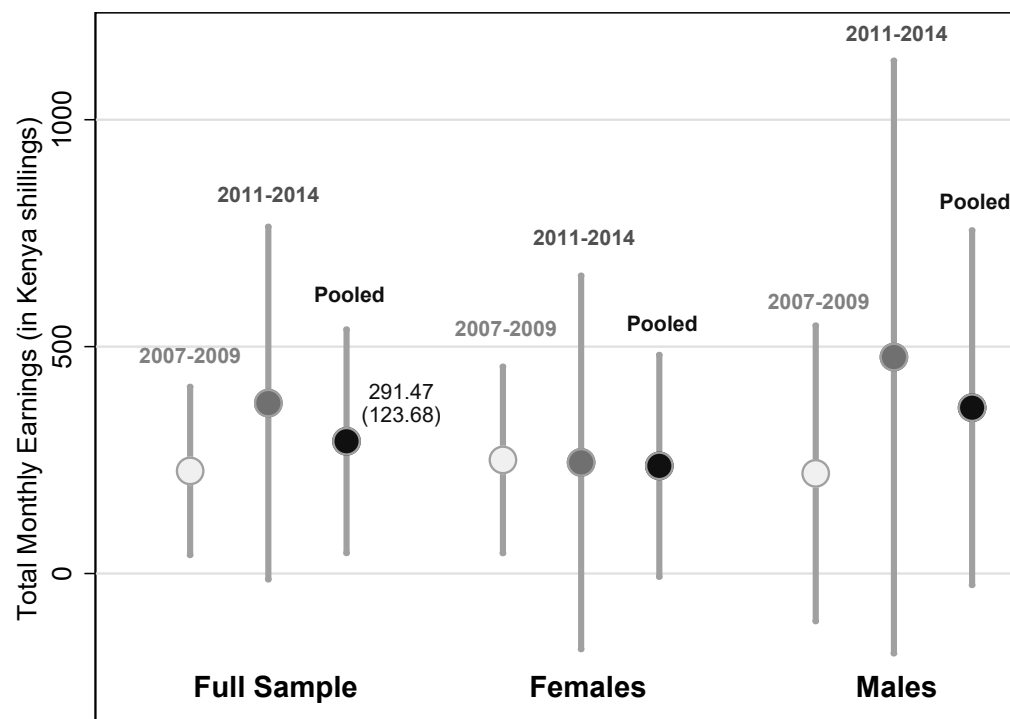
Notes: Each circle denotes an estimate from a separate regression of the outcome on the treatment indicator and the standard set of regression controls from the specified survey round. For 2007-2009, see Baird et al 2016. For 2011-2014, see Appendix Table A.5, Column 1. For pooled results, see Table 1, Column 1. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% of earners), full sample. The vertical lines denote the 95% confidence interval.

Figure 2. Log Per Capita Total Consumption (KLPS-3, Kenya Shillings)

A: Full Sample

Control

Treatment

B: Females

C: Males
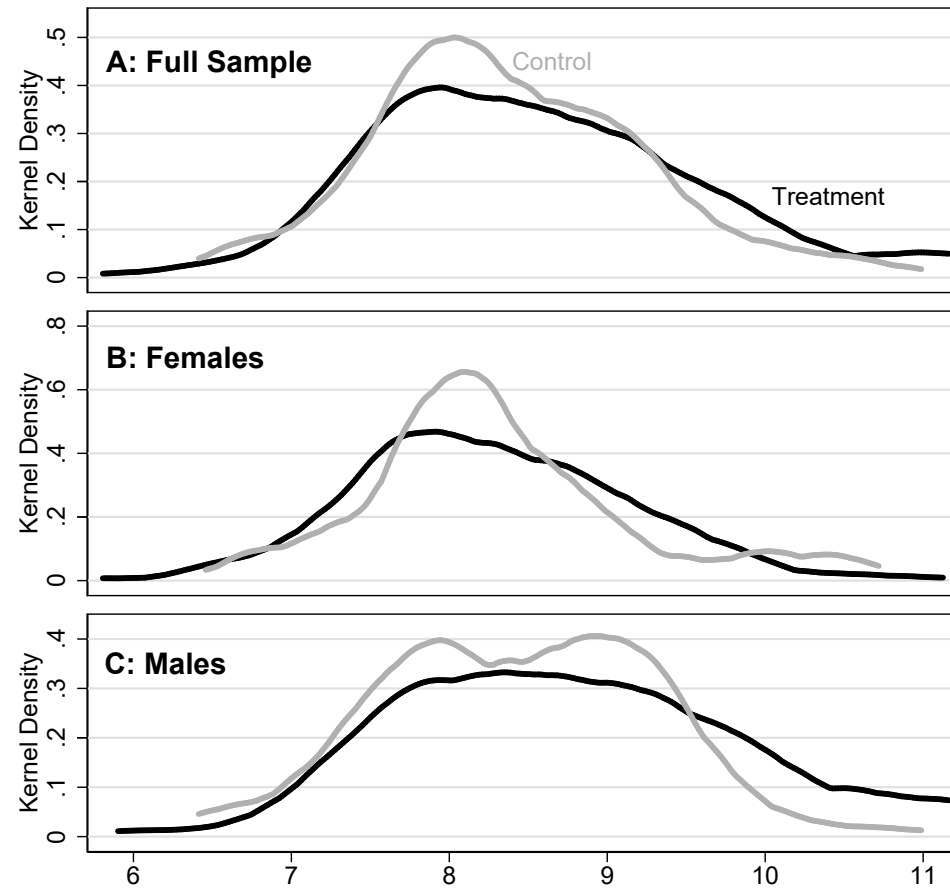
Note: The sample is trimmed at the 1% level. Light line is control. Dark line is treatment.

Appendix Table A.1: 1998 Average Pupil and School Characteristics, Pre-Treatment: KLPS Sub-Sample

		Panel A: Pre-school to Grade 8						
		Treatment			Control		Treatment - Control	
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Coeff.	T-stat.
Male	48	0.49	0.08	25	0.50	0.02	73	-0.01	(-0.68)
Proportion girls < 13, and all boys	48	0.83	0.03	25	0.82	0.03	73	0.01	(1.34)
Grade progression (=Grade - (Age - 6))	48	-2.15	0.36	25	-2.12	0.36	73	-0.02	(-0.23)
Year of birth	48	1985.29	0.34	25	1985.21	0.39	73	0.08	(0.86)

		Panel B: Grades 3 to 8						
		Treatment			Control		Treatment - Control	
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Coeff.	T-stat.
Attendance recorded in school registers	48	0.97	0.02	25	0.97	0.01	73	-0.00	(-0.33)
Access to latrine at home	48	0.83	0.10	25	0.80	0.15	73	0.03	(0.73)
Have livestock (cows, goats, pigs, sheep) at home	48	0.68	0.11	25	0.68	0.10	73	-0.01	(-0.58)
Weight-for-age Z-score (low scores denote undernutrition)	48	-1.44	0.17	25	-1.46	0.20	73	0.03	(0.51)
Blood in stool (self-reported)	48	0.25	0.12	25	0.21	0.14	73	0.03	(0.99)
Sick often (self-reported)	48	0.10	0.05	25	0.08	0.04	73	0.02	(1.56)
Malaria/fever in past week (self-reported)	48	0.39	0.10	25	0.41	0.13	73	-0.02	(-0.57)
Clean (observed by field workers)	48	0.62	0.14	25	0.65	0.14	73	-0.03	(-0.74)

		Panel C: School Characteristics						
		Treatment			Control		Treatment - Control	
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Coeff.	T-stat.
District exam score 1996, grades 5-8	50	-0.01	0.45	25	0.01	0.41	75	-0.02	(-0.16)
Distance to Lake Victoria	49	9.98	6.80	25	9.46	6.40	74	0.52	(0.33)
Pupil population	50	398.26	222.52	25	375.88	153.53	75	22.38	(0.51)
School latrines per pupil	46	0.01	0.00	24	0.01	0.00	70	0.00	(0.29)
Proportion moderate-heavy infections in zone	50	0.37	0.10	25	0.36	0.11	75	0.01	(0.30)
Total primary school pupils within 3	50	1320.90	760.07	25	1151.87	670.29	75	169.03	(0.98)
Total primary school pupils within 3-6km	50	3345.52	1174.96	25	3502.10	1489.97	75	-156.58	(-0.46)

Appendix Table A.2: Effective Survey Tracking Rates in the Kenya Life Panel Survey, Rounds 2 and 3

Panel A: KLPS-2

	Control Mean			Treatment − Control (se)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Female	Male	All	Female	Male
Found indicator	0.867	0.854	0.878	-0.007	-0.021	0.007
				(0.017)	(0.025)	(0.022)
Surveyed indicator	0.827	0.820	0.834	-0.003	-0.023	0.016
				(0.018)	(0.025)	(0.023)
Not surveyed, deceased indicator	0.014	0.012	0.016	0.004	0.006	0.003
				(0.004)	(0.005)	(0.005)

Panel B: KLPS-3 I Module

	Control Mean			Treatment − Control (se)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Female	Male	All	Female	Male
Found indicator	0.875	0.863	0.887	-0.005	-0.014	0.004
				(0.021)	(0.026)	(0.023)
Surveyed indicator	0.842	0.827	0.856	-0.017	-0.017	-0.015
				(0.022)	(0.026)	(0.024)
Not surveyed, deceased indicator	0.022	0.022	0.022	0.005	-0.000	0.009
				(0.004)	(0.006)	(0.006)

Panel C: KLPS-3 E Module

	Control Mean			Treatment − Control (se)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Female	Male	All	Female	Male
Found indicator	0.853	0.816	0.887	0.030	0.033	0.030
				(0.044)	(0.066)	(0.049)
Surveyed indicator	0.739	0.706	0.769	0.009	0.019	0.001
				(0.046)	(0.064)	(0.052)
Not surveyed, deceased indicator	0.028	0.034	0.023	-0.003	-0.023	0.016
				(0.011)	(0.018)	(0.016)

Notes: Attrition data comes from a regression of indicators for respondent found, surveyed, or deceased on an indicator for PSDP treatment. Sample includes all PSDP individuals found in initial tracking or placed under intensive tracking, and only includes individuals in the PSDP sample not treated in a separate vocational training intervention or small grant intervention (see Hicks et al 2018). Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. Tracking for KLPS-2 took place from 2007 - 2009. Tracking for KLPS-3 took place from 2011 to 2014.

Appendix Table A.3: Health Measures

Panel A: Full Sample

	(1) "Very Good" Health (Self-Reported)	(2) BMI (kg/m^2)	(3) Hand Strength (PSI)	(4) Hb (g/dL)
Treatment	.03	-.00	-.05	-.04
	(.02)	(.13)	(.11)	(.07)
Cost Sharing School (2001)	-.05**	-.14	-.02	-.10
	(.02)	(.15)	(.11)	(.07)
Saturation	-.06	.04	.14	-.16
	(.05)	(.26)	(.28)	(.15)
Control Mean	.56	22.14	13.61	13.56
Control SD	.50	2.77	3.54	2.09
Treatment Effect (%)	5.16	-.01	-.35	-.30
Number Observations	4587	4347	4302	4050

Panel B: Females

	(1) "Very Good" Health (Self-Reported)	(2) BMI (kg/m^2)	(3) Hand Strength (PSI)	(4) Hb (g/dL)
Treatment	.04	-.12	.19	-.05
	(.04)	(.20)	(.13)	(.12)
Cost Sharing School (2001)	-.05	-.21	-.09	-.04
	(.04)	(.24)	(.13)	(.14)
Saturation	-.08	.47	.41	-.35
	(.10)	(.40)	(.30)	(.23)
Control Mean	.50	22.84	11.05	12.31
Control SD	.50	3.22	2.37	1.80
Treatment Effect (%)	8.62	-.53	1.69	-.38
Number Observations	2261	2137	2144	2016

Panel C: Males

	(1) "Very Good" Health (Self-Reported)	(2) BMI (kg/m^2)	(3) Hand Strength (PSI)	(4) Hb (g/dL)
Treatment	.01	.12	-.27	-.06
	(.02)	(.14)	(.18)	(.11)
Cost Sharing School (2001)	-.05*	-.10	.08	-.13
	(.03)	(.12)	(.18)	(.12)
Saturation	-.02	-.36	-.19	-.01
	(.06)	(.24)	(.37)	(.27)
Control Mean	.61	21.54	15.91	14.66
Control SD	.49	2.14	2.75	1.67
Treatment Effect (%)	1.32	.57	-1.72	-.41
Number Observations	2326	2210	2158	2034

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is an indicator for reporting own general health as "very good," given alternatives of "somewhat good" and "not good" (untrimmed). The dependent variable in column (2) is the body mass index in kilograms per square meter (trimmed at top and bottom). The dependent variable in column (3) is hand strength in pounds per square inch, measured with a Pneumatic Grip Strength Dynamometer (trimmed at top and bottom). The dependent variable in column (4) is the amount of hemoglobin in the blood measured in grams per deciliter, taken by a finger prick (trimmed at top and bottom). All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. * p < 0.10, ** p < 0.05, *** p < 0.01

Appendix Table A.4: Educational Attainment

	(1) Raven's Score	(2) Educational Attainment	(3) Some Secondary School	(4) Completed Secondary School	(5) Some University Education
Panel A: Full Sample					
Treatment	.00	.30*	.04	.02	.01
	(.04)	(.17)	(.03)	(.03)	(.01)
Cost Sharing School (2001)	-.06	-.26	-.03	-.04	-.01
	(.04)	(.16)	(.02)	(.03)	(.01)
Saturation	-.01	-.67	-.15**	-.16**	-.04
	(.09)	(.43)	(.06)	(.07)	(.03)
Control Mean	.01	9.35	.47	.37	.03
Control SD	1.02	2.94	.50	.48	.16
Treatment Effect (%)	24.36	3.20	8.46	6.14	44.50
Number Observations	4575	4589	4596	4596	4596
Number Individuals	4575	4589	4596	4596	4596
Panel B: Females					
Treatment	.05	.36	.06*	.04	.00
	(.06)	(.22)	(.04)	(.03)	(.01)
Cost Sharing School (2001)	-.07	-.20	-.03	-.04	.00
	(.06)	(.22)	(.04)	(.03)	(.01)
Saturation	.10	-.14	-.10	-.08	-.03
	(.13)	(.63)	(.08)	(.08)	(.05)
Control Mean	-.26	8.80	.37	.27	.01
Control SD	.98	2.75	.48	.45	.12
Treatment Effect (%)	-19.42	4.08	15.81	15.22	28.10
Number Observations	2254	2258	2263	2263	2263
Number Individuals	2254	2258	2263	2263	2263
Panel C: Males					
Treatment	-.04	.20	.02	-.01	.02
	(.06)	(.21)	(.04)	(.04)	(.01)
Cost Sharing School (2001)	-.05	-.23	-.02	-.02	-.02
	(.06)	(.22)	(.03)	(.04)	(.01)
Saturation	-.06	-1.05**	-.19***	-.20**	-.03
	(.11)	(.44)	(.07)	(.08)	(.02)
Control Mean	.24	9.84	.56	.46	.04
Control SD	1.00	3.02	.50	.50	.19
Treatment Effect (%)	-16.55	2.02	2.89	-1.21	47.73
Number Observations	2321	2331	2333	2333	2333
Number Individuals	2321	2331	2333	2333	2333

Appendix Table A.5: Earnings Measures: KLPS-3 Cross-Section

Panel A: Full Sample

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	560.6**	.09	.02	2.56	1.67	.013	.008	.070**
	(260.2)	(.07)	(.02)	(4.48)	(1.74)	(.021)	(.008)	(.029)
Cost Sharing	-423.7	-.08	-.02	-7.09*	-1.73	-.030	-.002	-.027
	(284.8)	(.08)	(.02)	(4.23)	(1.86)	(.024)	(.008)	(.028)
Saturation	-546.4	-.26*	-.03	-5.22	-5.34	.027	.044**	.126*
	(488.6)	(.14)	(.06)	(9.72)	(4.39)	(.063)	(.020)	(.065)
Control Mean	3631.6	8.08	.56	118.08	22.02	.46	.03	.40
Control SD	6505.6	1.41	.50	115.83	47.57	.50	.17	.49
Treatment Effect (%)	15.4	1.16	4.32	2.16	7.57	2.89	25.70	17.32
Number Observations	4549	2603	4595	4577	4549	4595	4595	4590

Panel B: Females

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	214.3	.05	.01	-2.13	1.11	.006	-.000	.086***
	(220.2)	(.11)	(.03)	(7.65)	(1.95)	(.031)	(.008)	(.025)
Cost Sharing	-472.7*	-.11	-.05*	-8.74	-5.10***	-.033	.001	-.041
	(250.9)	(.15)	(.03)	(6.81)	(1.82)	(.029)	(.008)	(.030)
Saturation	-281.7	-.36	-.04	-10.39	-1.11	.009	-.003	.118*
	(505.0)	(.27)	(.07)	(15.16)	(3.54)	(.067)	(.016)	(.069)
Control Mean	2047.4	7.55	.47	93.81	13.49	.40	.02	.36
Control SD	4953.3	1.41	.50	104.61	39.56	.49	.13	.48
Treatment Effect (%)	10.5	4.52	3.00	-2.27	8.20	1.46	-2.84	23.78
Number Observations	2254	1044	2261	2258	2247	2261	2261	2258

Panel C: Males

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	853.0*	.07	.03	5.84	1.62	.017	.018	.046
	(505.4)	(.10)	(.03)	(6.34)	(2.51)	(.029)	(.014)	(.037)
Cost Sharing	-304.5	-.01	.01	-5.20	1.92	-.020	-.005	-.006
	(496.1)	(.10)	(.03)	(5.96)	(2.92)	(.032)	(.014)	(.036)
Saturation	-496.7	-.11	-.02	4.58	-7.76	.064	.082**	.155**
	(830.8)	(.17)	(.07)	(16.37)	(6.91)	(.087)	(.036)	(.070)
Control Mean	5116.9	8.43	.65	140.58	29.94	.52	.04	.45
Control SD	7381.6	1.30	.48	121.13	52.76	.50	.20	.50
Treatment Effect (%)	16.7	6.91	4.97	4.15	5.40	3.29	42.27	10.36
Number Observations	2295	1559	2334	2319	2302	2334	2334	2332

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is previous month total earnings (Ksh) and is trimmed from the top at the 1% level. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% of earners), full sample. The dependent variable in column (2) is the log of total earnings (restricting the sample to non-zero earners) and is trimmed from the top at the 1% level. The dependent variable in column (3) is an indicator variable for non-zero earnings and is untrimmed. The dependent variable in column (4) is previous month total hours worked in agriculture, a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (5) is previous month total wage earnings per hour worked in a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (6) is an indicator for main employment in non-agricultural work, denoted as the individual reporting more work hours in non-agricultural than agricultural work, across all wage employment, self-employment, and subsistence farming. The dependent variable in column (7) is an indicator for main employment in manufacturing, coded as "1" if an individual's main wage job is in the manufacturing industry. An individual's main wage job is the job in which they reported the most hours. The dependent variable in column (8) is an indicator for having an urban residence. Urban includes any non-rural areas, such as cities or towns. All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. FDR-adjusted "sharpened" q values in square brackets. * p < 0.10, ** p < 0.05, *** p < 0.01

Appendix Table A.6: Earnings Measures: KLPS-2 and KLPS-3

Panel A: Full Sample

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	291.5**	.12**	.03**	4.35	1.81**	.021	.007	.032
	(123.7)	(.05)	(.01)	(3.05)	(.76)	(.014)	(.005)	(.025)
Cost Sharing	-85.2	-.12**	-.00	-2.38	-.88	-.013	-.005	-.012
	(133.5)	(.05)	(.01)	(2.73)	(.76)	(.014)	(.004)	(.026)
Saturation	303.3	-.07	.00	7.09	.61	.059	.030**	.093
	(375.3)	(.11)	(.05)	(7.66)	(2.35)	(.048)	(.014)	(.064)
Control Mean	1886.7	8.06	.34	69.12	10.57	.28	.02	.42
Control SD	4416.4	1.27	.47	105.72	27.49	.45	.14	.49
Treatment Effect (%)	15.4	1.50	9.41	6.29	17.09	7.54	34.23	7.67
Number Observations	115329	42057	116597	115299	115475	116597	116597	116568
Number Individuals	5364	3390	5391	5377	5368	5391	5391	5391

Panel B: Females

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	238.6*	.09	.03	4.01	1.25	.032	.003	.048**
	(123.4)	(.09)	(.02)	(4.37)	(.84)	(.019)	(.006)	(.021)
Cost Sharing	-414.1***	-.21*	-.04**	-9.42***	-2.56***	-.046***	-.002	-.037
	(101.0)	(.12)	(.02)	(3.41)	(.74)	(.016)	(.006)	(.024)
Saturation	474.8	.08	.02	15.69	.93	.056	.009	.124*
	(430.0)	(.22)	(.05)	(11.11)	(2.09)	(.047)	(.009)	(.074)
Control Mean	1116.7	7.71	.26	52.72	6.70	.22	.01	.39
Control SD	3413.8	1.27	.44	92.19	22.99	.42	.10	.49
Treatment Effect (%)	21.4	1.11	10.54	7.60	18.61	14.37	30.53	12.16
Number Observations	56509	15012	56706	56328	56473	56706	56706	56703
Number Individuals	2629	1387	2631	2629	2627	2631	2631	2631

Panel C: Males

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	369.0*	.10	.04**	5.02	2.38**	.010	.012	.015
	(197.5)	(.07)	(.02)	(3.59)	(1.06)	(.016)	(.008)	(.033)
Cost Sharing	155.3	-.04	.03	2.82	.37	.017	-.009	.012
	(214.5)	(.07)	(.02)	(4.19)	(1.10)	(.017)	(.007)	(.036)
Saturation	107.4	-.12	-.02	-.03	.03	.067	.044*	.069
	(689.5)	(.13)	(.08)	(14.05)	(4.33)	(.070)	(.026)	(.078)
Control Mean	2585.9	8.26	.42	83.92	14.07	.33	.03	.44
Control SD	5060.4	1.23	.49	114.61	30.59	.47	.17	.50
Treatment Effect (%)	14.3	1.20	9.44	5.98	16.94	3.09	43.58	3.52
Number Observations	58820	27045	59891	58971	59002	59891	59891	59865
Number Individuals	2735	2003	2760	2748	2741	2760	2760	2760

Notes: Analysis pools the last 12 month of retrospective data from KLPS-2 and KLPS-3. Observations are at the individual-month level, up to 12 months prior to the interview date for each of the two follow up surveys. The dependent variable in column (1) is previous month total earnings (Ksh) and is trimmed from the top at the 1% level. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% of earners), full sample. The dependent variable in column (2) is the log of total earnings (restricting the sample to non-zero earners) and is trimmed from the top at the 1% level. The dependent variable in column (3) is an indicator variable for non-zero earnings and is untrimmed. The dependent variable in column (4) is previous month total hours worked in agriculture, a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (5) is previous month total wage earnings per hour worked in a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (6) is an indicator for main employment in non-agricultural work, denoted as the individual having more work hours in non-agricultural than agricultural work, across all wage employment, self-employment, and subsistence farming. The dependent variable in column (7) is an indicator for main employment in manufacturing, coded as "1" if an individual's main wage job is in the manufacturing industry. An individual's main wage job is the job in which they reported the most hours. The dependent variable in column (8) is an indicator for having an urban residence. Urban includes any non-rural areas, such as cities or towns. All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. FDR-adjusted "sharpened" q values in square brackets. * p < 0.10, ** p < 0.05, *** p < 0.01

Appendix Table A.7: Earnings (KLPS-3 Panel)

Panel A: Full Sample

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	375.6*	.09	.04**	5.80	2.15*	.024	.007	.066**
	(195.0)	(.06)	(.02)	(3.86)	(1.22)	(.02)	(.01)	(.03)
Cost Sharing	-223.2	-.09	-.02	-5.41	-1.24	-.026	-.006	-.029
	(218.3)	(.07)	(.02)	(3.69)	(1.24)	(.02)	(.01)	(.03)
Saturation	77.3	-.16	-.00	2.11	.44	.062	.033*	.141**
	(412.9)	(.11)	(.05)	(7.17)	(2.67)	(.05)	(.02)	(.06)
Control Mean	1886.7	8.06	.34	69.12	10.57	.28	.02	.42
Control SD	4416.4	1.27	.47	105.72	27.49	.45	.14	.49
Treatment Effect (%)	19.9	8.31	12.69	8.39	20.31	8.64	36.75	15.74
Number Observations	58508	30005	59735	58743	58709	59735	59735	59706
Number Individuals	4515	2938	4595	4560	4535	4595	4595	4594

Panel B: Females

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	246.9	.04	.03	5.04	.66	.025	.001	.087***
	(207.7)	(.09)	(.03)	(5.99)	(1.42)	(.02)	(.01)	(.02)
Cost Sharing	-596.4***	-.15	-.05**	-12.34**	-3.22**	-.044*	-.002	-.030
	(193.9)	(.14)	(.02)	(5.27)	(1.28)	(.02)	(.01)	(.03)
Saturation	648.5	.03	.01	8.22	1.70	.046	.005	.162**
	(518.3)	(.23)	(.05)	(12.60)	(2.47)	(.05)	(.01)	(.07)
Control Mean	1116.7	7.71	.26	52.72	6.70	.22	.01	.39
Control SD	3413.8	1.27	.44	92.19	22.99	.42	.10	.49
Treatment Effect (%)	22.1	3.75	11.60	9.55	9.88	11.35	7.56	22.35
Number Observations	29196	11593	29393	29139	29174	29393	29393	29390
Number Individuals	2249	1222	2261	2254	2250	2261	2261	2261

Panel C: Males

	(1) Total Earnings	(2) Log Earnings	(3) Indicator Earnings > 0	(4) Hours Worked	(5) Wage & Self-Emp. Earnings/Hour	(6) Non-Ag. Employment	(7) Manufacturing Employment	(8) Urban Locality
Treatment	478.7	.08	.06**	6.02	3.38*	.021	.015	.040
	(328.6)	(.09)	(.02)	(5.40)	(1.91)	(.02)	(.01)	(.04)
Cost Sharing	97.6	-.02	.01	-.27	.37	-.010	-.011	-.022
	(351.7)	(.09)	(.02)	(5.75)	(2.02)	(.03)	(.01)	(.03)
Saturation	-177.8	-.21*	-.02	-1.59	.43	.089	.052*	.136*
	(737.3)	(.12)	(.07)	(15.35)	(5.00)	(.07)	(.03)	(.07)
Control Mean	2585.9	8.26	.42	83.92	14.07	.33	.03	.44
Control SD	5060.4	1.23	.49	114.61	30.59	.47	.17	.50
Treatment Effect (%)	18.5	7.82	13.50	7.17	24.01	6.49	53.70	9.19
Number Observations	29312	18412	30342	29604	29535	30342	30342	30316
Number Individuals	2266	1716	2334	2306	2285	2334	2334	2333

Notes: Analysis uses the KLPS-3 cross-section plus 12 months of retrospective data. Observations are at the individual-month level, up to 12 months prior to the interview date for each of the two follow up surveys. The dependent variable in column (1) is previous month total earnings (Ksh) and is trimmed from the top at the 1% level. Total earnings is the sum of wage employment across all jobs, non-agricultural self-employment profit across all businesses, and farming profit (dropping the top 1% of earners), full sample. The dependent variable in column (2) is the log of total earnings (restricting the sample to non-zero earners) and is trimmed from the top at the 1% level. The dependent variable in column (3) is an indicator variable for non-zero earnings and is untrimmed. The dependent variable in column (4) is previous month total hours worked in agriculture, a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (5) is previous month total wage earnings per hour worked in a wage-earning activity and self-employment, full sample. It is trimmed from the top at the 1% level. The dependent variable in column (6) is an indicator for main employment in non-agricultural work, denoted as the individual reporting more work hours in non-agricultural than agricultural work, across all wage employment, self-employment, and subsistence farming. The dependent variable in column (7) is an indicator for main employment in manufacturing, coded as "1" if an individual's main wage job is in the manufacturing industry. An individual's main wage job is the job in which they report the most hours. The dependent variable in column (8) is an indicator for having an urban residence. Urban includes any non-rural areas, such as cities or towns. All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A.8: Earnings By Sector (KLPS-3 Cross Section)

	Panel A: Full Sample		
	(1) Wage Earnings	(2) Self-Employment Earnings	(3) Agricultural Earnings
Treatment	356.5* (212.1)	-17.4 (94.5)	-6.8 (4.4)
Cost Sharing	-452.9* (249.9)	220.1* (111.0)	-1.7 (3.6)
Saturation	396.6 (389.1)	-345.5 (255.4)	17.8 (11.5)
Control Mean	2767.5	637.9	18.9
Control SD	5714.3	2405.3	108.1
Treatment Effect (%)	12.9	-2.7	-35.9
Number Observations	4549	4548	4549

	Panel B: Females		
	(1) Wage Earnings	(2) Self-Employment Earnings	(3) Agricultural Earnings
Treatment	-25.5 (234.1)	172.2 (118.2)	-5.9 (5.6)
Cost Sharing	-307.0 (233.3)	-134.1 (99.7)	-3.5 (5.3)
Saturation	57.6 (427.8)	-101.8 (163.7)	12.1 (12.9)
Control Mean	1493.2	384.2	23.5
Control SD	4273.8	1636.1	119.4
Treatment Effect (%)	-1.7	44.8	-24.9
Number Observations	2255	2249	2229

	Panel C: Males		

	(1) Wage Earnings	(2) Self-Employment Earnings	(3) Agricultural Earnings
Treatment	662.8	-211.0	-6.6
	(427.2)	(133.2)	(6.3)
Cost Sharing	-469.8	530.5***	-1.7
	(446.0)	(162.9)	(5.1)
Saturation	946.3	-510.9	20.6
	(679.6)	(441.4)	(14.5)
Control Mean	3965.8	875.0	14.6
Control SD	6576.9	2929.7	96.4
Treatment Effect (%)	16.7	-24.1	-45.3
Number Observations	2294	2299	2320

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is previous month wage employment compensation across all positions. Each observation is for an individual in the last month. The dependent variable in column (2) is previous month self-employment profits across all businesses. The dependent variable in column (3) is agricultural profits, measured as the sum of all crop-specific production (valued in cash) minus input costs, for farming activities for which the respondent provided all reported household labor hours and was the main decision-maker. All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A.9: KLPS-3 Hours By Sector (KLPS-3 Cross Section)

	Panel A: Full Sample		
	(1)	(2)	(3)
	Wage	Self-Employment	Agricultural
	Hours Worked	Hours Worked	Hours Worked
Treatment	3.99	1.17	-1.03
	(4.39)	(3.48)	(1.33)
Cost Sharing	-7.74*	3.81	-.39
	(4.31)	(3.50)	(1.34)
Saturation	-9.13	-2.60	6.35
	(10.92)	(6.35)	(4.29)
Control Mean	67.96	25.29	16.02
Control SD	107.17	67.29	33.47
Treatment Effect (%)	5.88	4.63	-6.41
Number Observations	4546	4549	4541

	Panel B: Females		
	(1)	(2)	(3)
	Wage	Self-Employment	Agricultural
	Hours Worked	Hours Worked	Hours Worked
Treatment	-4.31	8.78*	-3.40**
	(7.65)	(4.97)	(1.66)
Cost Sharing	-6.54	-3.26	.92
	(8.05)	(4.06)	(1.71)
Saturation	-11.64	4.47	-3.93
	(17.76)	(8.25)	(4.76)
Control Mean	47.28	20.46	18.93
Control SD	92.84	57.65	34.89
Treatment Effect (%)	-9.12	42.92	-17.95
Number Observations	2251	2241	2242

	Panel C: Males		

	(1) Wage Hours Worked	(2) Self-Employment Hours Worked	(3) Agricultural Hours Worked
Treatment	10.77 (6.63)	-5.90 (4.63)	1.70 (1.76)
Cost Sharing	-7.02 (6.67)	9.10* (4.70)	-2.06 (1.76)
Saturation	-.79 (16.30)	-9.88 (8.76)	14.20*** (4.86)
Control Mean	87.33	29.79	13.36
Control SD	115.79	74.92	31.91
Treatment Effect (%)	12.33	-19.81	12.73
Number Observations	2295	2308	2299

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is previous month hours worked in wage employment across all positions. Each observation is for an individual in the last month. The dependent variable in column (2) is previous month hours worked in self-employment across all businesses. The dependent variable in column (3) is hours worked in agriculture for farming activities for which the respondent provided all reported household labor hours. All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. * p < 0.10, ** p < 0.05, *** p < 0.01

Appendix Table A.10: Living Standards (KLPS-3 Cross-Section)

Panel A: Full Sample

	(1) Log Consumption	(2) Log Food Consumption	(3) Meals Eaten Yesterday	(4) Improved Home Characteristics Index	(5) Asset Index Share Owned	(6) "Very Happy" Index
Treatment	.30***	.15	.04	.10	.33	.11**
	(.11)	(.10)	(.03)	(.07)	(.48)	(.04)
Cost Sharing	-.10	-.06	.02	-.06	.15	-.15***
	(.13)	(.13)	(.03)	(.07)	(.51)	(.05)
Saturation	.20	.09	-.06	.34**	-.14	-.02
	(.28)	(.27)	(.06)	(.17)	(.99)	(.11)
Control Mean	8.38	7.60	2.17	.00	36.94	.41
Control SD	.86	.72	.67	1.00	12.41	.49
Treatment Effect (%)	3.56	1.93	1.70	–	.91	10.43
Number Observations	717	716	4582	4404	4582	724

Panel B: Females

	(1) Log Consumption	(2) Log Food Consumption	(3) Meals Eaten Yesterday	(4) Improved Home Characteristics Index	(5) Asset Index Share Owned	(6) "Very Happy" Index
Treatment	.01	-.01	.07	.18**	.48	.11
	(.10)	(.10)	(.04)	(.07)	(.81)	(.07)
Cost Sharing	-.08	-.08	-.02	-.07	-.42	-.20**
	(.12)	(.12)	(.04)	(.08)	(.72)	(.09)
Saturation	.02	.19	.12	.32*	1.61	.01
	(.25)	(.23)	(.09)	(.17)	(1.43)	(.17)
Control Mean	8.31	7.52	2.23	-.07	36.14	.49
Control SD	.86	.73	.72	1.04	12.19	.50
Treatment Effect (%)	1.08	-.54	3.12	–	1.33	10.09
Number Observations	372	368	2255	2184	2255	372

Panel C: Males

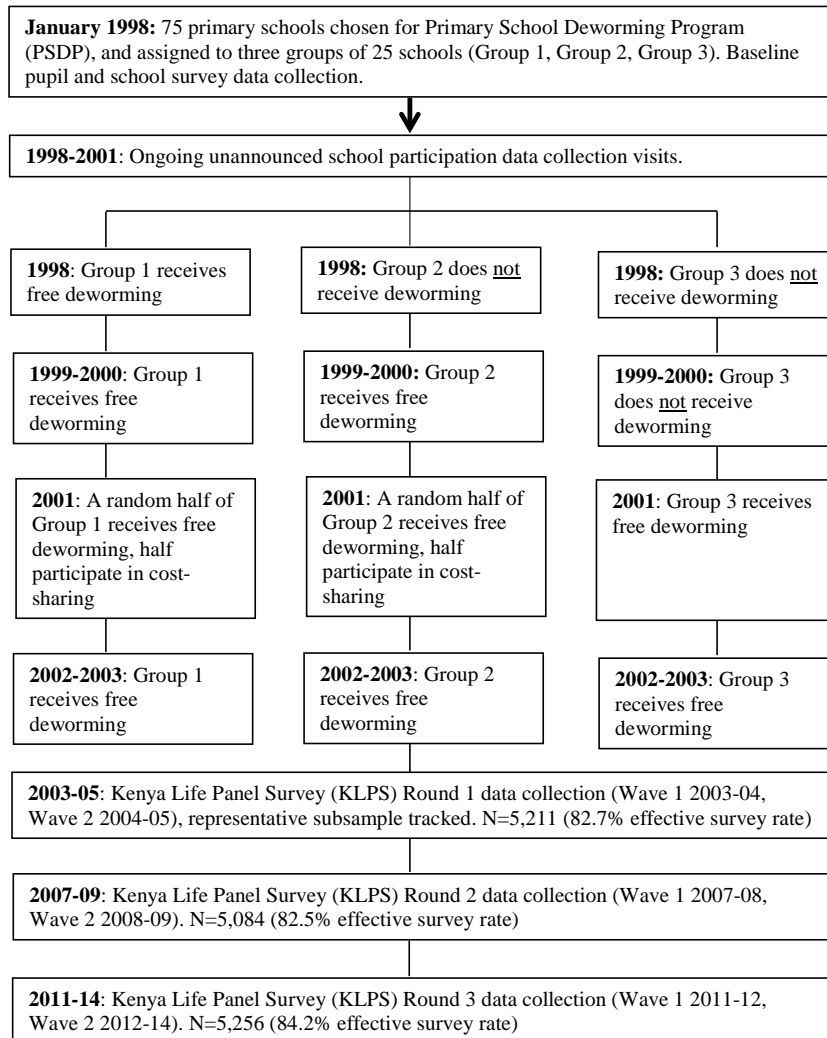|	(1) Log Consumption	(2) Log Food Consumption	(3) Meals Eaten Yesterday	(4) Improved Home Characteristics Index	(5) Asset Index Share Owned	(6) "Very Happy" Index
Treatment	.42**	.17	.01	.01	.05	.09
	(.19)	(.15)	(.03)	(.09)	(.78)	(.06)
Cost Sharing	-.00	.04	.05	-.03	.74	-.15**
	(.20)	(.16)	(.04)	(.09)	(.71)	(.06)
Saturation	.01	-.28	-.14	.37*	-1.13	-.01
	(.34)	(.37)	(.10)	(.21)	(1.60)	(.12)
Control Mean	8.44	7.67	2.13	.07	35.83	.34
Control SD	.86	.72	.69	.96	12.62	.48
Treatment Effect (%)	35.02	15.90	.33	–	.13	8.97
Number Observations	345	348	2327	2220	2327	352

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is the log of total per capita consumption (trimmed from the top at the 1% level), which is measured for a subsample of KLPS-3 individuals. The dependent variable in column (2) is the log of per capita food consumption (trimmed from the top at the 1% level), which is measured for a subsample of KLPS-3 individuals. The dependent variable in column (3) is number of meals eaten yesterday (untrimmed). The dependent variable in column (4) is an index comprising of seven home characteristics, including an indicator for having an improved floor, an indicator for having an improved roof, an indicator for having an electric connection, an indicator for having a toilet at home, number of rooms, and an indicator for having access to clean water, in which we demean and standardize each outcome, sum them together, and then demean and standardize the sum. See Appendix Table A.10 for a full breakdown of this index. The dependent variable in column (5) is an asset index (0 to 100), constructed by taking the fraction of household assets owned and multiplying by 100 (untrimmed). We measure 28 assets in KLPS-3. The dependent variable in column (6) is an indicator variable for feeling "very happy" overall, given alternatives of "somewhat happy" and "not happy" (untrimmed). All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. Untrimmed estimate for the treatment effect on log of total per capita consumption treatment is .24 (standard error .12, p-value .04). FDR-adjusted "sharpened" q values in square brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A.11: Home Characteristics

Panel A: Full Sample

	(1) Improved Home Characteristics Index	(2) Improved Floor	(3) Improved Roof	(4) Electric Connection	(5) Toilet at Home	(6) Number of Rooms	(7) Improved Water	(8) Grid Connection
Treatment	.10	.06**	.03	.04*	.01	-.10*	.03	.08***
	(.07)	(.03)	(.03)	(.02)	(.01)	(.05)	(.03)	(.03)
Cost Sharing School (2001)	-.06	-.03	.00	-.01	-.02	.04	-.03	-.05
	(.07)	(.03)	(.03)	(.03)	(.01)	(.07)	(.03)	(.03)
Saturation	.34**	.09	.03	.11*	.05**	-.52***	.27***	.16**
	(.17)	(.08)	(.08)	(.05)	(.02)	(.16)	(.06)	(.06)
Control Mean	.00	.50	.70	.35	.96	2.74	.82	.35
Control SD	1.00	.50	.46	.48	.18	1.54	.39	.48
Treatment Effect (%)	–	11.16	4.45	10.63	1.40	-3.82	3.54	22.22
Number Observations	4404	4404	4404	4404	4404	4404	4404	2244

Panel B: Females

	(1) Improved Home Characteristics Index	(2) Improved Floor	(3) Improved Roof	(4) Electric Connection	(5) Toilet at Home	(6) Number of Rooms	(7) Improved Water	(8) Grid Connection
Treatment	.18**	.11***	.05*	.06**	.02*	-.09	.03	.09**
	(.07)	(.03)	(.03)	(.03)	(.01)	(.08)	(.04)	(.03)
Cost Sharing School (2001)	-.07	-.05	.01	-.02	-.01	.02	-.03	-.02
	(.08)	(.04)	(.03)	(.03)	(.01)	(.08)	(.04)	(.04)
Saturation	.32*	.18**	.02	.11	.05**	-.44***	.19**	.17
	(.17)	(.08)	(.08)	(.08)	(.02)	(.15)	(.07)	(.10)
Control Mean	-.07	.45	.69	.31	.96	2.78	.81	.30
Control SD	1.04	.50	.46	.46	.21	1.45	.40	.46
Treatment Effect (%)	–	23.52	7.71	20.67	2.42	-3.28	3.64	28.79
Number Observations	2184	2184	2184	2184	2184	2184	2184	1097

Panel C: Males

	(1) Improved Home Characteristics Index	(2) Improved Floor	(3) Improved Roof	(4) Electric Connection	(5) Toilet at Home	(6) Number of Rooms	(7) Improved Water	(8) Grid Connection
Treatment	.01	.00	.00	.01	.00	-.11	.02	.06
	(.09)	(.04)	(.03)	(.03)	(.01)	(.08)	(.04)	(.04)
Cost Sharing School (2001)	-.03	-.00	.00	.01	-.02	.05	-.03	-.07
	(.09)	(.04)	(.03)	(.03)	(.02)	(.09)	(.03)	(.05)
Saturation	.37*	.01	.04	.11*	.06	-.56**	.37***	.16
	(.21)	(.09)	(.08)	(.06)	(.04)	(.23)	(.07)	(.10)
Control Mean	.07	.54	.72	.38	.97	2.70	.82	.39
Control SD	.96	.50	.45	.49	.16	1.63	.38	.49
Treatment Effect (%)	–	.44	.15	1.77	.29	-4.18	2.93	16.36
Number Observations	2220	2220	2220	2220	2220	2220	2220	1147

Notes: Analysis uses the KLPS-3 cross-sectional data. Each observation is for an individual in the last month from the interview date. The dependent variable in column (1) is an index comprising the dependent variables in columns (2) through (7), in which we demean and standardize each outcome, sum them together, and then demean and standardize the sum. The dependent variable in column (2) is an indicator for the respondent's home possessing an improved floor, including those made out of cement and tile, and not including floors made of mud (untrimmed). The dependent variable in column (3) is an indicator for the respondent's home possessing an improved roof, including those made out of iron, tin, cement, and tiles, and not including roofs made out of grass, mud, branches, or leaves (untrimmed). The dependent variable in column (4) is an indicator for having electricity (untrimmed). The dependent variable in column (5) is an indicator for a household having a toilet or latrine (untrimmed). The dependent variable in column (6) is the number of separate rooms in a household, including those separated by sheets (untrimmed). The dependent variable in column (7) is an indicator for access to clean water, including water from a pipe, well, protected spring, or borehole, and not including water from an unprotected spring, lake, river, or rainwater (untrimmed). The dependent variable in column (8) is an indicator for having a gridded source of electricity (Wave 2 sample only, untrimmed). All regressions 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 a cost-sharing school indicator. Estimates are weighted to make the results representative of the full PSDP sample, taking into account the sampling for KLPS and the tracking strategy. Standard errors are clustered at the 1998 school level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

January 1998: 75 primary schools chosen for Primary School Deworming Program (PSDP), and assigned to three groups of 25 schools (Group 1, Group 2, Group 3). Baseline pupil and school survey data collection.

1998-2001: Ongoing unannounced school participation data collection visits.

| **1998**: Group 1 receives free deworming | **1998:** Group 2 does not receive deworming | **1998:** Group 3 does not receive deworming |

| **1999-2000**: Group 1 receives free deworming | **1999-2000:** Group 2 receives free deworming | **1999-2000:** Group 3 does not receive deworming |

| **2001**: A random half of Group 1 receives free deworming, half participate in cost-sharing | **2001**: A random half of Group 2 receives free deworming, half participate in cost-sharing | **2001**: Group 3 receives free deworming |

| **2002-2003**: Group 1 receives free deworming | **2002-2003**: Group 2 receives free deworming | **2002-2003**: Group 3 receives free deworming |

2003-05: Kenya Life Panel Survey (KLPS) Round 1 data collection (Wave 1 2003-04, Wave 2 2004-05), representative subsample tracked. N=5,211 (82.7% effective survey rate)

2007-09: Kenya Life Panel Survey (KLPS) Round 2 data collection (Wave 1 2007-08, Wave 2 2008-09). N=5,084 (82.5% effective survey rate)

2011-14: Kenya Life Panel Survey (KLPS) Round 3 data collection (Wave 1 2011-12, Wave 2 2012-14). N=5,256 (84.2% effective survey rate)

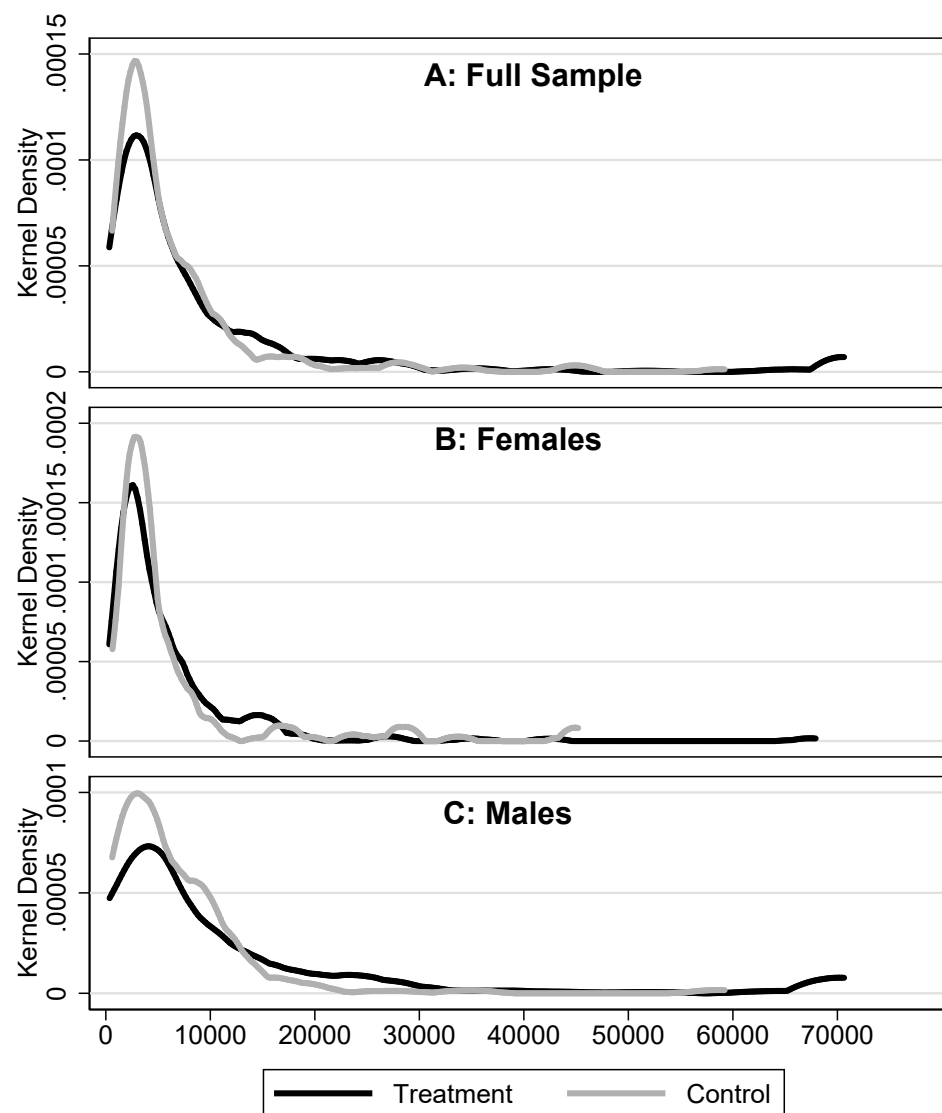## Appendix Figure A.2: Sample Consumption and Expenditure Survey Module

Read: In the following questions, I want to ask about all purchases made for your household, regardless of which person made them. Please exclude from your answer any food purchased for processing, livestock consumption or resale in a household enterprise. First I will ask you about staples that you eat at home. Include grains used for food or alcohol. Do not double count grain that is made into flour.

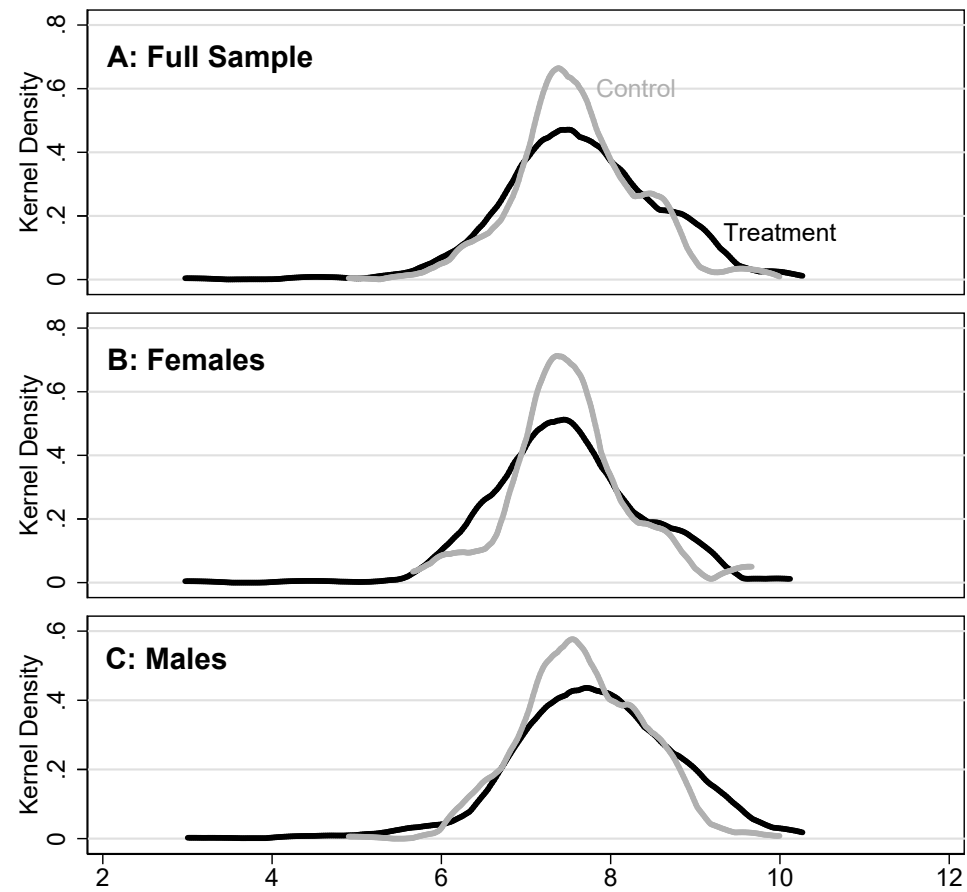|		Q1. Has your household consumed [FOOD] during the past 12 months?	Q2. Has your household grown or produced [FOOD] during the past 12 months? IF Q1 = 2 SKIP TO NEXT ITEM	PURCHASES IN LAST 7 DAYS Q3. How much [FOOD] have the members of your household purchased in the last 7 days? PROMPT FOR SHILLINGS IF Q2 = 2 → Q6.		HOME PRODUCTION Q4. During the last 12 months how many months was your household consuming [FOOD] that your household grew or produced? If "0" → Q6	Q5. During these months that your household grew or produced [FOOD], how much did your household consume **in a typical week**? PROMPT FOR SHILLINGS		MARKET PURCHASES Q6. How many months in the past 12 months did your household purchase [FOOD]? If "0" → Q8	Q7. How much does your household usually spend on [FOOD] **in a typical week** of the months that your household purchases [FOOD]? PROMPT FOR SHILLINGS		GIFTS Q8. What is the total amount of the [FOOD] consumed that your household received as a gift in the past 12 months?		UNIT CODES 1=KENYAN SHILLINGS 2=KILO 3=GRAM 4=GOROGORO-2KG 5=DEBE-20KG 6=GUNIA-90KG 7=LITRE 8=300ML 9= 500ML 10=700ML 11=KASUKU-1KG 12=KASUKU-2KG 13=JERRY CAN/DUMU-20L 14=NUMBER 15=PACK/PACKET 16=BUNDLE 17=OTHER (DESCRIBE) 18=UGANDAN SHILLINGS
	[FOOD]	1=YES 2=NO	1=YES 2=NO	UNIT	AMT	MONTHS	UNIT	AMT	MONTHS	UNIT	AMT	UNIT	AMT	
1	Maize			1										
2	Millet			2										
3	Sorghum			3										
4	Rice			4										
5	Sweet potato			5										
6	Cassava			6										
7	Irish potato			7										
8	Maize flour			8										
9	Wheat flour			9										
10	Plantains			10										
11	Other grains (specify):			11										

Note: The sample is trimmed at the 1% level.

Appendix Figure A.3: Per Capita Total Consumption (KLPS-3, Kenya Shillings)

Appendix Figure A.4: Log Per Capita Food Consumption (KLPS-3, Kenya Shillings)