The Educational Impact of De-Worming in Kenya

Ted Miguel*
Harvard University

Michael Kremer*
Harvard University

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Abstract

We examine the effect of a school-based deworming program on primary education outcomes in seventy-five primary schools in rural western Kenya. The intervention consists of medical treatment for hookworm, roundworm, whipworm, and schistosomiasis, parasites that infect 92 percent of school-aged children in western Kenya. The selection of schools for assistance was randomized. After one year of treatment, the program is associated with significantly higher pupil participation in school (pupils are considered non-participants if they are absent or have dropped out). However, treatment is not significantly associated with academic test score performance or promotion rates. Translating average school participation treatment effects into wage gains using existing estimates of the return to education in Kenya suggests that the benefits of school-based deworming program may exceed the costs by more than ten times.

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* SUMMARY OF WORK-IN-PROGRESS: PLEASE DO NOT CITE. Correspondence: Department of Economics, Harvard University, Cambridge, MA 02138, USA; miguel @fas.harvard.edu. The authors thank ICS Africa, Simon Brooker, Donald Bundy, and Paul Glewwe for their cooperation in all stages of the project, and would especially like to thank Sylvie Moulin, without whom the project would not have been possible. Gratitude is also extended to the teachers and school children of Busia, Kenya for participating in the study. The study has received funding from the World Bank and the Partnership for Child Development. Tim Besley, Caroline Hoxby, and Lawrence Katz have provided valuable comments. All errors are our own.

1 Introduction

Educational policies are an important mechanism through which governments promote human capital investment and economic growth. Investments in the health of school children may be especially important for educational outcomes if healthy children study more effectively, attend school more frequently, and drop out less often.

Treatment for intestinal helminth infections is a particularly promising health intervention for school children in poor countries. Intestinal helminth infections - hookworm (*Necator americanus, Ancylostoma duodenale*), roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichura*) and schistosomiasis - are widespread in less developed countries.[1] Recent studies estimate that 1.3 billion people worldwide are infected with roundworm, 1.3 billion with hookworm, 900 million with whipworm, and 200 million with schistosomiasis, and the disease burden is especially high in Sub-Saharan Africa (Bundy, et al. [1998]; WHO [1993]). School-aged children typically exhibit the greatest prevalence of infection and the highest infection intensity, as well as the highest disease burden (since disease is related to infection intensity), due to a combination of exposure and immunological factors (Bundy [1988]). The geohelminths - hookworm, roundworm, and whipworm - are transmitted by poor sanitation and hygiene, and schistosomiasis is acquired by bathing in infected fresh water, such as streams and lakes.

The adverse health and nutritional impact of worm infections on children is well documented (Adams, et. al. [1994]; Stephenson, et. al. [1989]; Corbett, et. al. [1992]; Hotez and Pritchard [1995]). Intestinal helminth infections and schistosomiasis often lead to listlessness, abdominal pain, iron deficiency anemia, protein energy malnutrition, stunting and wasting[2]. They may also have serious

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[1] Bundy et al [1998] contains a further discussion of helminthic infections.

[2] Stunting is a measure of chronic undernutrition, and is defined as a standard normal height-for-age Z-score<-2. The Z-score takes on a value of zero for children of “average” nutrition, where the distribution uses international standards for child growth. Wasting is a measure of acute undernutrition, defined as a standardized normal weight-for-height Z-score<-2.

medical consequences: roundworm infection sometimes leads to fatal intestinal obstruction, hookworm infection can cause severe anemia, and whipworm is associated with chronic dysentery (Bundy, 1994).

However, existing research has not conclusively identified the impact of helminth infections on educational outcomes. The few existing randomized studies that investigate educational treatment effects focus principally on outcomes on cognitive exams rather than outcomes of more direct interest to policymakers, such as pupil participation in school, pupil attendance, drop-out and repetition rates, and academic examination scores. Moreover, wide adoption of school-based programs will likely require the active participation of Ministries of Education in developing countries, and this may require evidence on the effect of helminth control programs on educational outcomes. There is increasing interest in implementing school-based deworming projects in less developed countries as witnessed by ongoing World Bank projects in Uganda and India, Partnership for Child Development (PCD) projects in Ghana, Tanzania, and Vietnam, and government programs in Egypt and Kenya.

Intestinal helminths and schistosomiasis can be treated using low-cost, single dose oral therapy appropriate for delivery at infrequent intervals of six months to a year (Bundy and Guyatt, 1996). The broad-spectrum antihelminthic albendazole is used to treat intestinal helminths, and praziquantel is used to treat schistosomiasis. These drugs have been endorsed by scientific committees of the World Health Organization (WHO, 1992). Moreover, medical treatment for intestinal worms is inexpensive and has virtually no side effects. A single yearly treatment of albendazole costs less than 50 cents per student per year, and praziquantel costs roughly one dollar for a student of average weight (PCD, 1998). School-based deworming programs that use the existing school infrastructure to deliver anthelmintics and health education to a large number of children have been identified as an especially cost-effective public health intervention in high prevalence areas (Bundy et al. [1990]; Warren, et al 1993; World Bank 1993), as mass treatment eliminates the need for costly individual parasitological screening.

2 The Primary School Deworming Project

The Primary School Deworming Project (PSDP) offers a unique opportunity to evaluate the impact of a school-based helminth control program on primary education outcomes. The non-governmental organization Internationaal Christelijk Steunfonds Africa (ICS) is carrying out the project in Kenya's Busia district, a poor and densely-settled farming region in western Kenya. The seventy-five schools participating in the program consist of all rural primary schools in Budalangi division and Funyula division in southern Busia District, which are adjacent to Lake Victoria and contain roughly 30,000 pupils. Parasitological surveys by both the Kenyan Ministry of Health and ICS indicate that Budalangi and Funyula divisions have the highest rates of helminthic infections in Busia.

In January 1998, the seventy-five PSDP schools were randomly divided into three groups of twenty-five schools – Group 1, Group 2, and Group 3. Due to administrative constraints of the NGO, the health intervention is being phased in to these schools over several years. Table 1 presents the order of treatment across groups. The randomized phase in of treatment creates treatment and comparison groups which allow differences in educational outcomes to be attributed to the health intervention. Treatment is not randomized among students within schools, because the NGO believes that this would meet resistance from parents. Group 3 schools will receive assistance from the NGO in 2001.[3]

Table 1: ICS Deworming Project Schedule

Year	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)
1998	Treatment	Comparison	Comparison
1999	Treatment	Treatment	Comparison
2000	Treatment	Treatment	Comparison

In 1998, the ICS field staff measured the pupils' school attendance, drop-out rates, grade progression, and academic test score performance, and administered questionnaires to collect detailed information on school and pupil characteristics, including family possessions and sanitation facilities at home, the quality of student's clothing, personal hygiene, and certain symptoms associated with worm

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[3] In 2001, we will assess parental willingness to participate in an NGO cost-sharing program. The financial sustainability in developing countries of school-based health programs may require parental cost-sharing.

infection, such as blood in stool. Collecting pupil and school baseline characteristics allows us to control for pre-treatment differences across treatment and comparison schools, and permits us to estimate the treatment effects among pupils with different characteristics. School participation information is collected during unannounced NGO visits to each school, made five times per year. A pupil actually in school on the day of an unannounced visit is counted as a participant. Pupils listed in the official school register who are either absent or have dropped out on the day of a visit are counted as non-participants.

Tables 2a and 2b present summary statistics on pupil and school characteristics collected in the 1998 questionnaires. Table 2a indicates that pupils in the 25 treatment and 50 comparison schools have similar demographic and socioeconomic characteristics. Table 2b indicates that there are no statistically significant differences among treatment and comparison schools in terms of pupil population, school sanitation facilities, and parent involvement in school affairs. Treatment schools have 40 percent lower local school funding than comparison schools on average, although this difference is not statistically significant at traditional confidence levels. In rural Kenya, local school funds are principally used to purchase textbooks, desks, chalk, and classroom construction.

Treatment schools had substantially lower scores on Kenya government primary school academic examinations in 1996 on average, although the difference was not significantly different than zero at traditional confidence levels.[4] Among the twenty-seven sample schools for which there is detailed pre-treatment school participation data from early 1998, the comparison schools slightly outperform treatment schools in terms of school participation, although the difference is not significantly different than zero.

Medical aspects

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[4] 1996 test scores are available averaged by standard for each school. Scores were normalized to a *N(0,1)* for each standard. The test score magnitudes presented in Table 2a are thus not directly comparable to the 1998 test scores, which were normalized at the individual level.

In January and February 1998, a randomly chosen sample of 90 standard 3 to 8 pupils in each of the 25 Group 1 schools participated in a parasitological survey conducted by the Kenya Ministry of Health Division of Vector Borne Diseases. Table 3 presents the results of the survey. Nearly 92 percent of pupils had at least one helminthic infection, and nearly 37 percent had at least one moderate or heavy infection using modified WHO standards of infection intensity (Brooker, et al [1999a]). These helminthic infection rates are high by international standards (Bundy [1994]).

Following WHO guidelines (WHO [1992]), all schools with geohelminth (hookworm, roundworm, and whipworm) prevalence over 50 percent were mass treated with albendazole[5], and all schools with schistosomiasis prevalence over 30 percent were mass treated with praziquantel. All treatment (Group 1) schools met the geohelminth cut-off in 1998 and were mass treated. Six schools met the schistosomiasis cut-off and were mass treated. In addition to the deworming medical treatment, the program intervention in 1998 consisted of a series of lectures on worm prevention methods, and health education materials focusing on hygiene and sanitation for to treatment schools.

On the recommendation of the Kenya Ministry of Health, each child was required to produce written parental consent in order to receive medical treatment. Some pupils in treatment schools did not receive medical treatment due to a failure to produce parental consent. Other pupils in treatment schools were not treated due to absence on the day of drug administration. (Detailed data on which pupils received parental consent, and which pupils received medical treatment is currently being entered and will be included in future versions.)

Girls thirteen years of age and older did not receive medical treatment because albendazole may be embryotoxic (WHO [1992]) and determination of pregnancy status is problematic during mass treatment. Current practice is to exclude all females of reproductive age during mass deworming treatment with both albendazole and praziquantel (Bundy and Guyatt [1996]), since pregnancy test

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[5] In 1998, pupils received 600 mg doses during each round of medical treatment. In 1999 and 2000, pupils are treated with 400 mg albendazole (WHO [1992]). Praziquantel was provided at the standard 40mg/kg (WHO[1992]).

reagent strips require trained staff to administer and are not practical during mass treatment. Personal interviews (i.e., asking girls when they had their most recent menstrual period) may not be effective because pregnant girls might conceal such information from the interviewer, fearing that the information might not be held in confidence. In Kenya, pregnant girls are often expelled from primary school.

Availability and compliance

A survey of the availability of anthelmintic drugs in Budalangi and Funyula divisions was conducted by ICS during May to July 1999.[6] All hospitals, health clinics, dispensaries, and pharmacies, as well as many local shops (*dukas*) in all towns and markets in the area were surveyed, for a total of 89 health facilities and shops. The results of the survey are presented in Table 4. None of the 64 local shops - where most residents regularly shop - surveyed had the recommended (WHO [1992]) broad-spectrum treatments for geohelminths (albendazole and mebendazole) and schistosomiasis (praziquantel) in stock. A minority of local shops carried cheaper but less effective anthelminthic medicines (levamisole hydrochloride and piperazine). Praziquantel is rarely found even in government clinics, and where it is stocked in clinics and pharmacies it is prohibitively expensive for most residents of the area. The results of the drug availability survey confirm the impressions of public health workers and NGO fieldworkers suggesting that few children in Busia have been properly treated for intestinal helminthic infections.[7]

Table 5 presents the prevalence of moderate to heavy helminthic infections among Group 1 and Group 2 schools in early 1999, a year after the first round of medical treatment. Comparing infection rates across treated (Group 1) and untreated (Group 2) schools suggests that the prevalence of hookworm, roundworm, and schistosomiasis were significantly lower as a result of the intervention, but that the program may have been less effective against serious whipworm infections. The weak whipworm results

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[6] The survey also contained information on the availability of anti-malarial drugs in the area.
[7] A detailed survey of pupils' deworming treatment history is currently being conducted in these schools.

may be the result of high whipworm resistance to single dose albendazole treatments (Renganathan et al. [1994]). Widespread flooding associated with the El Nino weather system may have contributed to the rise in schistosomiasis prevalence between 1998 and 1999, as the schistosomiasis parasite is water-borne.

Table 5 also presents evidence that levels of anemia are low in Busia: less then 4 percent of pupils in comparison (Group 2) schools fell below the Kenya Ministry of Health anemia threshold of 100 g/L in early 1999, and the rate was even lower among pupils in schools that received treatment in 1998. These rates of anemia are similar to those recently found in nearby Kisumu, Kenya (Olsen et al. [1998]), though they are low by East African standards (Stoltzfus et al. [1997]). The near absence of anemia in western Kenya eliminates the most frequently hypothesized link mechanism linking helminthic infections and cognitive performance (Nokes et al [1998]).

3 Related literature

William Watkins and Ernesto Pollitt [1997] comprehensively review studies examining the impact of intestinal worms on mental performance. Most retrospective and quasi-experimental studies have associated worm infections with reduced mental performance and school achievement. However, few of these early studies convincingly control for other factors – such as socioeconomic status – that are correlated with worm infections (Simeon, et. al. [1994]; Callender, et. al. [1993]). These results are potentially flawed because it is difficult to identify and measure all personal characteristics that determine school performance. Omitting relevant explanatory variables leads to spurious correlations if unmeasured characteristics that lead to better school performance are associated with a lower risk of helminth infection.

Randomized selection into treatment and comparison groups addresses some of the issues that make retrospective studies difficult to interpret. If the randomization is conducted properly, students in the treatment and comparison groups should be similar in both measured and unmeasured characteristics.

Five recent randomized studies have examined the impact of worm infections on cognitive performance among primary school children. These studies suffer from small sample sizes, limited outcome measures, and short time periods of study, shortcomings addressed by the ICS Primary School Deworming Project, which measures the impact of a school-based helminth control program on school outcomes over three years with a sample size of roughly 30,000 students.

Participation and promotion rates

Only two of the existing randomized studies examine 1the treatment effect on school attendance, reaching opposing conclusions. Simeon, Grantham-McGregor, Callender and Wong [1995] show that stunted children with heavy whipworm loads showed significant gains in attendance over the course of six months. However, Watkins et al. [1996a, 1996b] find no attendance gain among Guatemalan school children with moderate to heavy roundworm infections after six months. None of the existing studies has estimated deworming treatment effects on promotion rates, due to their limited durations. The longest existing study examines outcomes for less than one school year.

Test scores

Although there is some evidence from the existing studies that heavily infected children show improved performance on memory tests after treatment, the evidence on academic test outcomes is inconclusive (Pollitt, et al. [1991]; Nokes, et al. [1992]; Simeon, Grantham-McGregor, and Wong [1995]; Simeon, Grantham-McGregor, Callender, and Wong [1995]; Watkins et al. [1996a, 1996b]). An estimate of the long-term impact of deworming treatment on school learning may have more relevance than an estimate of improvement on memory tests or other psychological tests, especially given Knight and Sabot's evidence linking cognitive achievement and wages in Kenya (Knight and Sabot [1990]).

Schistosomiasis

Although it is thought that schistosomiasis may adversely affect school performance because of its negative nutritional and health consequences, and a number of cross-sectional studies have investigated the impact of schistosomiasis on school learning, there has been no well-designed randomized study (Kvalsig [1981]; Pollitt [1990]; Savioli et al [1998]; Stephenson et al. [1985]). The current study compares treatment effects across areas of high and low schistosomiasis prevalence to estimate the educational benefits of treating schistosomiasis.

Cost-benefit analysis

The existing randomized evaluations of deworming treatment effects were conducted in few schools over short time periods, making it difficult to assess how closely their project costs match the costs of implementing a large-scale school-based helminth control program. The advantage of the current study lies in examining an actual NGO intervention taking place over multiple years in seventy-five schools, providing cost information more relevant to policymakers.

4 Estimation Strategy

The most important feature of the identification strategy is the project's randomized design. Since treatment status is randomly assigned, program participation is not correlated with observed or unobserved individual characteristics, or with infection status in expectation.

Estimator 1

The following simplified linear equation, Equation 1, illustrates the basic estimation strategy. Linear regression is employed to estimate test score treatment effects and probit estimation is used for participation and promotion effects. *Y* is the school average of the educational outcome measure, *T* is school's assigned treatment status, and *u* is the school random effect, where *i* refers to the school.[8] If the randomized assignment to treatment is carried out properly, the coefficient estimate on *b* is an unbiased estimate of the true deworming treatment effect.

$$Y_i = a + b\,(T_i) + u_i \qquad (1)$$

Estimator 2

The exclusion of older girls from medical treatment creates treatment assignment heterogeneity within Group 1 schools. This increases the precision of the treatment effect estimates, as the outcomes of untreated older girls can be compared across treatment and comparison schools to partially control for school random effects. School effects may be related to headmaster competence, teacher motivation or parental involvement in school affairs.

Untreated older girls in treatment schools may benefit from being in treatment schools in several ways. Their health may improve as a result of lower environmental exposure to helminths (as their classmates are treated), the impact of the project's health education component, or an improved learning environment in treatment schools. Some older girls may also have received deworming drugs despite the eligibility rule. (Detailed compliance information is currently being processed and will be incorporated into future versions.) Such positive externalities tend to overstate the school random effect in treatment schools, leading to a downward bias in the estimated deworming treatment effect that strengthens the empirical results.

Equation 2 illustrates Estimator 2. *Y* is the individual educational outcome measure, *X* are school characteristics, *T* is assigned treatment status, *E* is an indicator variable for eligibility (which takes on a

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[8] Weighted least squares is used since pupil population size varies across schools.

value of one for boys and for girls under 13 years of age), *u* is the school random effect, and *e* is individual effect, where *i* refers to the school and *j* refers to the student. Including *X* controls for pre-treatment differences across treatment and comparison schools, and increases the precision of the coefficient estimates.

$$Y_{ij} = a + b\,(T_i) + c\,(E_{ij}) + d\,(T_i * E_{ij}) + f'\,(X_i) + u_i + e_{ij} \tag{2}$$

The treatment effect coefficients are *b* and *d*. *b* captures the difference in the performance between treatment and comparison schools of older girls ineligible for medical treatment, which may result from the externalities mentioned above. The treatment effect for pupils eligible for medical treatment is (*b* + *d*). The joint significance of *b* and *d* is assessed using an F-test of the hypothesis that both coefficients are equal to zero.

Estimator 3

Existing studies indicate that children with mild helminthic infections may not show significant improvement in mental performance after deworming treatment (Simeon, Grantham-McGregor, Callender, and Wong [1995]; Watkins et. al. [1996b]; Simeon, Grantham-McGregor, and Wong [1995]). Since only a minority of children are moderately or heavily infected in Busia, despite high worm infection prevalence (Table 3), the estimated average treatment effect over the entire sample may be small despite a large treatment effect among heavily infected students. In this case, identifying students likely to be moderately or heavily infected is important for the evaluation.

Given the evidence that helminth infections are associated with serious health and nutritional deficits, standard ethical guidelines for health research require that all children found to be infected in the parasitological survey receive treatment. For this reason, parasitological surveys were only conducted in treatment (Group 1) schools in 1998. Pupil characteristics collected during pupil questionnaire administration are used to identify pupils likely to have serious infections, rather than parasitological survey results.

Table 6 presents probit estimates of the relationship between pupil characteristics and worm infections. The dependent variables is an indicator variable for having a moderate or heavy helminthic infection in January 1998, using the modified WHO infection intensity criteria (Brooker et al [1999a]). Age, gender, grade progression (years ahead of the ideal grade progression), access to a latrine at home, weight-for-age z-score, and self-reported blood in stool are all significant predictors of moderate and heavy infections with the expected signs. The importance of access to a latrine is consistent with the fact that intestinal helminths are transmitted through poor hygiene and sanitation; latrine ownership is also related to higher socioeconomic status, which may be negatively associated with infections. Poor nutritional status, as measured by weight-for-age Z-score[9], and blood in stool are often the result of helminthic infections. The negative association between grade progression and serious infections may result from a negative impact of worms on academic performance or omitted variables.

Estimator 3 includes pupil characteristics associated with worm infections as explanatory variables, as well as all eligibility and treatment interactions. If heavily infected pupils have the largest improvement in health status after deworming, pupils with these characteristics may also show the largest treatment effects on educational outcomes. Allowing *P* to be a vector of personal characteristics related to moderate to heavy helminthic infections, the estimation equation becomes:

$$\begin{aligned} Y_{ij} = a + b\,(T_i) + c\,(E_{ij}) + d\,(T_i * E_{ij}) + f\text{¢}\,(X_i) \\ + g\text{¢}\,(P_{ij}) + h\text{¢}\,(E_{ij}*P_{ij}) + k\text{¢}\,(T_i *E_{ij}*P_{ij}) + u_i + e_{ij} \end{aligned} \tag{3}$$

The treatment effect coefficients are *b*, *d*, and the vector *k*. *P* is likely to be correlated with individual disturbance terms due to omitted variables. However, once the effect of *P* on outcomes is controlled for with the *P* and *E*P* terms, the coefficient estimates on the interaction terms $k\text{¢}\,(T_i *E_{ij}*P_{ij})$

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[9] Weight-for-age is used as a measure of nutritional status in 1998 rather than height-for-age due to inconsistent height measurements made during part of the 1998 school year.

are unbiased due to the random assignment of treatment.[10] The joint significance of estimates of *b*, *d*, and *k¢* is assessed with an F-test that all coefficients equal zero.

The predicted likelihood of having a moderate to heavy helminthic infection (using modified WHO standards) is included as an explanatory variable to assess if more heavily infected pupils gain more from treatment.[11] The child's weight-for-age Z-score, a measure of nutritional status, is also included. Previous studies have shown that pupils with poor nutritional status may benefit more from deworming treatment than other pupils (Simeon, Grantham-MacGregor, Calender, and Wong [1995]). An indicator variable for being in standards 6, 7, or 8 is included to assess if the treatment effect differs across lower and upper standard pupils. Upper standard pupils tend to be more dedicated to their studies, as many low achieving students drop out before reaching the upper standards.

Proximity to Lake Victoria is strongly associated with the prevalence of schistosomiasis infections in this region (Brooker, et al [1999b]). Four of the six project schools that met the WHO schistosomiasis mass treatment threshold of 30 percent prevalence in 1998 were located within three kilometers of Lake Victoria, and all four Group 1 schools within three kilometers of Lake Victoria met the WHO criterion. In all, 23 of the 75 sample schools are within three kilometers of Lake Victoria. The $E*T$ interaction term on distance to Lake Victoria can be interpreted as the benefit to schistosomiasis, treatment in addition to any benefit from treating geohelminths.

Compliance

The indicator variable T in the above expression corresponds to assignment to deworming treatment, which can be treated as an instrumental variable for actual treatment status. However, assignment to treatment is not perfectly correlated with actual treatment due to non-compliance. For example, some students in treatment schools did not receive parental consent or were absent on the day of administration,

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[10] The conditional covariance $Cov(T_i * E_{ij} * P_{ij}, e_{ij}) \mid E_{ij}*P_{ij} = (E_{ij}*P_{ij})Cov(T_i, e_{ij}) = 0.$

[11] Technically, when the predicted likelihood of moderate to heavy infections is included as an explanatory variable, standard errors should be adjusted to reflect the two-stage estimation procedure. In practice, small changes in standard errors do not change the interpretation of the results presented in Table 11.

and as a result did not receive treatment, while some students in comparison schools may have received treatment in a health clinic. The intention-to-treat design allows the estimation of both the overall program effect including non-compliance - the estimates presented in Tables 7 to 13 - as well as the treatment effect on compliers using a two-stage instrumental variable procedure (Angrist et al. [1996]).[12]

School controls

The average school result on the 1996 Kenya Government District Mock exams for Standards 5 to 8 is included as an explanatory variable in the test score regressions to capture aspects of school academic quality. Average school scores from 1996 - two years before the first year of the project - were used since no district mock exam was offered in 1997 due to a teacher strike in Kenya. Standard averages are used because individual exam results are not available for 1996.

Indicators for school participation in other ICS assistance programs are included as explanatory variables in all regression specifications.

5 Empirical Results

Participation in school

Participation in school is an important outcome measure. Pupils who are absent or have dropped out on the day of an unannounced NGO school visit are considered non-participants. Participation is measured during five unannounced NGO visits to the school during the school year, and by participation in the ICS academic exam administered in October 1998. Considering participation as an outcome measure may be more appealing than considering drop-out rates and attendance separately, since the distinction between an absent pupil and a drop-out is often difficult to make. Moreover, measuring pupil attendance conditioning on not dropping out is unattractive, since dropping out is itself endogenous.

All pupils in the school register during first term 1998 are included in the participation analysis. Pupils who dropped out in First Term 1998 (January to March), before the first NGO visit and before

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[12] Drug compliance data is currently being processed. Intention-to-treat estimates will be included in future work.

medical treatment began in March 1998 are included in the analysis. Since many pupils recorded as dropped out in early 1998 enrolled in school at some point during the 1998 school year, it is desirable to consider them in the sample.[13]

Some pupils are missing age information because of absence on the day of pupil questionnaire administration or the day of ICS exam administration. Although boys with missing age information are all assigned to be eligible for treatment, certain assumptions need to be made regarding the assignment of eligibility status to girls with missing ages. Girls in pre-school and standards 1, 2, and 3 are assigned to be eligible, and girls in standards 7 and 8 are assigned to be ineligible, since all but a tiny fraction of girls in these standards meet the respective eligibility criterion. Girls in standards 4, 5, and 6 with missing ages are assigned missing eligibility status. This eliminates 281 girls from the sample.

Average participation rates in treatment and comparison schools from March 1998 to January 1999 are presented in Table 7. The participation rate in treatment schools, including pupils with missing eligibility data, is 5.6 percent higher than participation in comparison schools, and this difference is significantly different than zero at 99 percent confidence. If the sample is restricted to pupils with non-missing eligibility data, this difference falls slightly to 5.2 percent, and remains significant at 95 percent confidence. The treatment effect is larger for pupils eligible for treatment (5.5 percent) than among ineligible pupils (3.7 percent). The treatment effect is also larger among lower standard pupils (6.1 percent) than upper standard pupils (0.9 percent).

Surveys are currently being conducted to determine which health symptoms associated with helminthic infections - including stomach ache, listlessness, stunted growth, and febrile episodes - differ across treatment and comparison schools, in an attempt to identify the health mechanisms through which deworming affects school participation. (This survey data will be included in future versions.)

Estimates of the program impact on participation using probit estimation are presented in Table 8.[14] The program impact on pupil participation in school is positive and significantly different than zero

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[13] Many of these drop-outs were not assigned a standard by the NGO field staff, complicating the analysis of participation rates by standard.

at 99 percent confidence in regressions 1 (no random effects) and 2 (school random effects), and the estimated participation treatment effect among pupils eligible for medical treatment is approximately 4.5 percent. Regression 3 includes an indicator variable for being in Standards 6, 7 or Standard 8, the proportion of heavy infections among pupils in the surrounding geographic zone, and an indicator for being within 3 kilometers of Lake Victoria as explanatory variables, as well as all eligibility and treatment interactions.[15] The results suggest that lake schools gain significantly more from treatment than other schools, that upper standard pupils gain less from treatment, and, unexpectedly, that pupils in more heavily infected areas gain less from treatment than other pupils. Pupils with the highest likelihood of infection may gain less from treatment if it takes more time for the most ill pupils to recover after deworming treatment, or because they are burdened with other problems that make academic improvements less likely. Moreover, compliance with treatment assignment may be lower among pupils more likely to be heavily infected. (Compliance data will be incorporated in future versions.) The average treatment effect among lake schools is high (0.078).

Figures 1 and 2 present the participation rates observed during six unannounced NGO school visits from March 1998 to March 1999 and participation on the October 1998 ICS examination, for eligible and ineligible pupils, respectively. While the participation rates are similar for eligible pupils in treatment and comparison schools before and immediately after the first round of medical treatment in March 1998 - suggesting that pre-treatment differences between treatment and comparison schools are not driving the results - they diverge sharply during the course of the program (Figure 1). Ineligible pupils show less dramatic, though still positive, gains during the course of the 1998 school year (Figure 2).

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[14] Not all schools were visited the planned five times in 1998, leading to variation in the number of participation observations across schools.

[15] Including pupil characteristics from the 1998 pupil questionnaire - such as the predicted likelihood of infection - as explanatory variables in Table 8 would imply a major loss of sample size, since pupils in pre-primary programs and Standards 1 and 2 were not administered pupil questionnaires, and these pupils make up nearly half of the sample.

Test scores

Two types of examinations were administered to treatment and comparison school pupils in 1998: the ICS exams in English, Maths, and Science-Agriculture – which are modelled on Kenyan Ministry of Education exams – and the Busia District exams in English, Maths, Science-Agriculture, Kiswahili, Geography-History, Home Science, and Arts-Crafts. The average score over all subjects for each collection of tests is employed as the principal test score outcome measure.

The empirical analysis focuses on the ICS exams for several reasons. First, while pupils taking the District Mocks needed to pay an exam fee, the ICS exam was free. As a result, exam participation was far higher on the ICS exam than on the District Mocks: while 86 percent of enrolled pupils took the ICS exam, the corresponding rate for Mocks was only 66 percent. Higher exam participation on the ICS exam provides treatment effect estimates for more of the exam distribution. Moreover, the treatment schools showed far higher participation on the District Mocks than comparison schools, complicating the interpretation of the test score results due to potential selection biases. Second, treatment effect estimates for the District Mock exams are similar to those found with the ICS exam. Finally, the ICS exams were administered to pupils in Standards 3 to 8, rather than Standards 4 to 8 for the District Mocks, providing information on more pupils.

Table 9 presents average performance on the ICS exam. Treatment school pupils do significantly worse than comparison school pupils on the exams (at 10 percent confidence), performing an average of 0.19 test score standard deviations worse on the exam.[16] Moreover, pupils eligible for treatment show even worse performance in treatment schools than the ineligible pupils, with a difference of 0.20 test score standard deviations between treatment and comparison schools.

Two possible explanations for the negative treatment effects are investigated: pre-treatment differences in exam performance in the treatment and comparison schools, and biases due to differences

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[16] Tests are often normalized to *N(0,1)* distributions and test scores expressed in units of standard deviations in the education literature, to facilitate comparison of results across studies.

in exam participation across treatment and comparison schools. Table 2a suggests that there were large differences in average exam performance in treatment and comparison schools in 1996, despite the randomized assignment to treatment. The 1996 average school scores on District Mocks are included in the regression analysis to control for these initial differences. Table 10 indicates that participation in the ICS exams was also somewhat higher in the treatment schools: 88.5 percent of eligible pupils in treatment schools sat for the District exams, compared to only 85.4 percent of eligible pupils in comparison schools. If pupils unlikely to participate in the ICS exam are poorer academic performers than average, this will result in selection bias.

Regressions 1 (without school random effects) and 2 (with school random effects) in Table 11 suggest that there is a large and negative treatment effect. The inclusion of the school random effect reduces the size of the estimated treatment effect - which becomes statistically insignificant - but the effect remains large (-0.16 standard deviations). Indicators for school participation in other ICS assistance programs are included in all specifications.

In Regression 3 the 1996 average school District Mock score is included as an explanatory variable to control for pre-treatment differences in school quality. The coefficient estimate on the 1996 score is positive and statistically significant at 99 percent confidence, and inclusion of the 199 school average test score eliminates nearly two-thirds of the variance of the school random effect. The estimated treatment effect in this specification is negative but small (-0.030 standard deviations), and insignificant at traditional confidence levels.

Regression 4 includes pupil characteristics - including predicted likelihood of moderate to heavy helminthic infection, an indicator for being in standards 3, 4, or 5, an indicator for location within three kilometers of Lake Victoria, and weight-for-age Z-score - as well as all interactions with eligibility and treatment status to determine which groups of pupils gain from treatment. Inclusion of these covariates restricts the sample to pupils who were administered the 1998 pupil questionnaire, eliminating much of the potential exam participation bias. Table 10 indicates that the difference in exam participation among pupils administered the 1998 questionnaire was only 1.1 percent, and insignificantly different between treatment and comparison schools.

The estimated exam score treatment effect in Regression 4 is positive but small (0.015 standard deviations). The (*likelihood of infection)*E*T* interaction term is unexpectedly negative - pupils more likely to be infected gain less from treatment - but is statistically insignificant. The relationship between likelihood of infection and test scores is investigated further in regression 5. The quadratic (*likelihood of infection)*^{2} term and interactions are included to determine if the relationship is non-linear. The results indicate that pupils with moderate (*likelihood of infection)* scores gain the most from deworming treatment; both the pupils least likely to be uninfected and those most likely to be infected gain less. Pupils with low propensity scores are expected to show little gain from deworming, since the treatment is unlikely to cause an improvement in their health status. Pupils with highest propensity scores may not significantly gain from treatment if it takes more than a few months for the most ill pupils to recover academically, because they are burdened with other medical or financial problems that make academic improvements less likely, or if they were less likely to attend school on the days of drug administration and remained untreated.[17]

Regression 6 performs an extreme correction for the potential selection bias due to differences in exam participation between treatment and comparison schools by truncating the lower left tail of the ICS exam score distribution among eligible pupils in treatment schools. 1.2 percent of eligible pupils in treatment schools were dropped from the sample. This extreme correction is equivalent to assuming that the additional exam participants in treatment schools were the worst exam performers, and the resulting estimate can be understood an upper bound on true treatment effect on exam scores. The estimated treatment effect in the restricted Regression 6 is slightly larger but small (0.04 standard deviations). [18]

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[17] The test score treatment effect increases with likelihood of infection for (*predicted likelihood of infection) Î [0,0.36*). The median of (*predicted likelihood of infection)* is 0.38. The sum of the (*predicted likelihood of infection)*E*T* and (*predicted likelihood of infection)*^{2}**E*T* terms is positive for (*predicted likelihood of infection) Î [0,0.72*). 0.72 is the 97th percentile of the (*predicted likelihood of infection)* distribution.

[18] By contrast, a recent study of the impact of class size on Israeli primary school outcomes finds test score treatment effects of roughly 0.2 standard deviations (Angrist and Lavy [1999]).

Promotion rate

Average promotion rates in treatment and comparison schools are presented in Table 12. Promotion rates are not conditional on continued school enrolment in 1999. In other words, pupils who dropped out by the start of the 1999 school year are counted as not promoted. The promotion rate is 0.7 percent lower in treatment schools, although this difference is not statistically significant at traditional levels of confidence. Eligible pupils in treatment schools have 0.1 percent lower promotion rates than eligible pupils in comparison schools, while among ineligible pupils treatment schools have 2.6 percent lower promotion rates. The corresponding promotion rate treatment effects for Pre-school to Standard 5 and Standard 6 to Standard 8 are 0 percent and -2.5 percent, respectively. Unfortunately, there is no baseline data on promotion rates in previous years that would allow us to control for pre-existing differences in promotion patterns across treatment and comparison schools. One explanation for these promotion rate treatment effects is selection bias: higher participation rates may mean that more low-achieving pupils with low promotion rates remain in treatment schools.

The probit estimation results presented in Table 13 suggest that there is an insignificant statistical association between deworming and the promotion rate. Zonal infection rates, distance to Lake Victoria, and standards are not significantly related to promotion treatment effects.

Cost-benefit analysis

The following estimate of the costs and benefits of this deworming program suggests that the benefits of deworming far outweigh the costs even under the following conservative assumptions. Attention is restricted to the labor market benefits of increased school participation after one year of treatment, assuming that there are school participation gains only during the year of medical treatment; in fact, the participation gains of deworming may extend beyond one year. The benefit-cost estimate also excludes the potential health and nutritional benefits of deworming, which are difficult to measure despite the development of the DALY concept (Murray and Lopez [1997]). Finally, deworming spillover benefits in terms of lower helminth morbidity for other members of the community - including untreated older girls, younger children not yet enrolled in school, and adults - are excluded in the calculation of benefits. The participation results presented in Table 7 suggest that these externalities may be large.

Detailed program costs from 1999 are used. The 1998 costs are slightly lower since cheaper generic albendazole and praziquantel were used. The costs of parasitological examination are not included in the cost estimate, since parasitological screening is not recommended in areas with high infection prevalence (WHO [1988]), including most of sub-Saharan Africa.

Table 14 presents the costs of treating the 15,500 school children in the fifty Group 1 and Group 2 schools in 1999. The total deworming cost per pupil treated is 1.46 USD. More than half of this cost is the expense of purchasing albendazole and praziquantel and shipping them to western Kenya. It is possible that the per unit cost of drug purchase and shipping would be lower in a larger program. Food is purchased to limit gastrointestinal discomfort among pupils immediately after medical treatment.

Table 14: 1999 ICS Primary School Deworming Program Costs

Expenditure type	Cost (USD)	Cost (USD) per child	Proportion of total cost
Medical treatment (total)	13,000	0.84	0.573
Deworming drugs (purchase, shipping)	11,300	0.73	0.498
Food	1,700	0.11	0.075
Delivery (total)	7,700	0.63	0.427
Salaries and administrative costs	6,900	0.45	0.304
Vehicle transportation	2,800	0.18	0.123
Total cost	22,700	1.46	1

Armitage and Sabot’s [1987] estimates of the returns to education in Kenya are used to assess the wage benefits of increased school participation. Armitage and Sabot find that the wage return to an addition year of schooling is 0.085. We assume that this gain is log-linear, such that an additional fraction x of a year of schooling at any level of schooling increases wages $x(0.085)$. Tables 7 and 8 indicate that the average increase in participation among primary school children in treatment schools after one year of treatment in 1998 was approximately 0.05. Income per worker in Kenya is 570 USD (World Bank

[1997]). Assuming that wage gains from increased school participation are earned over forty years in the workforce, and that future wages are discounted at 10 percent, the average wage benefit from one year of deworming treatment is 26.06 USD, or nearly twenty times the estimated cost of one year of deworming treatment per child.[19] This is in some sense a conservative estimate of deworming benefits, as direct health benefits and externalities are not considered.

However, it is unclear how generalizable the program costs are to other settings since governments and other NGO might not function as efficiently as ICS. Moreover, these calculations assume that Armitage and Sabot's estimate reflects a true relationship between participation in school and wages, rather than a relationship between cognitive skill and wages. If the Armitage and Sabot estimates suffer from upward omitted variable bias from unobserved cognitive skills, the estimate of program benefits would be reduced, given the insignificant relationship between deworming and test scores after one year of treatment.

6 Discussion

The results suggest that the school-based deworming program conducted by a Kenyan NGO had a significant positive impact on school participation among lower standard pupils after one year of treatment. The gains in participation among these pupils - aged 6 to 14 years old - were approximately 6 percent. Treatment effects were also particularly large for pupils residing near Lake Victoria, suggesting that treatment of schistosomiasis is associated with additional participation gains. However, there were small and generally insignificant deworming treatment effects in both test scores and promotion rates among pupils of all ages, even after controlling for possible selection biases.

The near lack of anemia in western Kenya eliminates the most frequently cited mechanism linking helminth infections and education. The strong participation treatment effects found after one year

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[19] This estimate of program costs does not include the opportunity cost of alternative uses of children's time other than schooling. For example, children not participating in school may work on their parents' farm, or learn vocational skills. However, this opportunity cost is likely to be small for children in the lower standards of primary school who show the largest gains in school participation.

of the program suggest that deworming may have an important educational impact in the absence of anemia. The insignificant treatment effects on test scores may leaves open the possibility that anemia is an important mechanism linking deworming and cognition.

The cost of deworming medicine is very low, less than one dollar per year for a pupil of average weight. The cost-benefit analysis suggests that the benefits of a school-based deworming program may far outweigh the costs, making the intervention potentially attractive to policymakers and NGOs.

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8 Data Appendix

Table 2a: 1998 Pre-treatment Average Pupil Characteristics[*]

	Treatment (25 schools)	Comparison (50 schools)	Treatment – Comparison
Standards 1-8			
Age	12.4	12.1	0.313 (0.208)
Male	0.534	0.517	0.017 (0.017)
Eligible for treatment	0.848	0.851	-0.003 (0.007)
Grade progression gap (standard - (age-6))	-1.49	-1.36	-0.129 (0.101)
School participation in March 1998, among all pupils on school register	0.720	0.742	-0.023 (0.032)
Standards 3-8			
Access to latrine at home	0.822	0.813	0.009 (0.029)
Textbook at home	0.378	0.378	-0.001 (0.029)
Cement floor at home	0.207	0.227	-0.020 (0.030)
Wears shoes to school	0.150	0.187	-0.037 (0.034)
Standards 5-8			
District mock exam score (1996), normalized grade average scores	-0.197	0.098	-0.295 (0.202)

Table 2b: 1998 Pre-treatment Average School Characteristics

	Treatment (25 schools)	Comparison (50 schools)	Treatment – Comparison
Local school expenditures per pupil, in Kenya shillings (1997)	95.8	160.0	-64.7 (56.4)
Pupil population	395.9	392.5	3.40 (49.9)
School latrines per pupil	0.0074	0.0064	0.001 (0.001)
PTA enrollment per pupil	0.316	0.360	-0.044 (0.092)

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[*] Standard errors are in parentheses. Data from the 1998 ICS Pupil Namelist, and 1998 Pupil Questionnaire and School Questionnaire. Pupil participation data is only for 7 treatment and 20 comparison schools taking part in the ICS School Assistance Program which have participation data for March 1998. Local primary school expenditures are raised through parent school fees and community fundraisers, and are typically used to purchase textbooks, desks, and classroom construction.

Table 3: January 1998 Helminthic Infections,
Treatment (Group 1) schools[*]

Infection	Prevalence	Moderate or heavy infections (%), WHO standard	Moderate or heavy infections (%), modified WHO standard
Hookworm	0.773	0.023	0.154
Roundworm	0.424	0.157	0.157
Whipworm	0.552	0.039	0.098
Schistosomiasis	0.218	0.071	0.071
At least one infection	0.916	0.246	0.366
At least two infections	0.308	0.043	0.103
At least three infections	0.279	0.001	0.012

Table 4: 1999 Drug availability questionnaire[*]

	Local shops (*dukas*)	Government health institutions	Private pharmacies
Albendazole, mebendazole (hookworm, roundworm, whipworm)			
Proportion with drug in stock	0	0.778	0.857
Average cost (Kenyan shillings)	-	124.9	109.7
Praziquantel (schistosomiasis)			
Proportion with drug in stock	0	0.167	0.571
Average cost (Kenyan shillings)	-	706.7	1057.5
Other WHO-endorsed drugs for hookworm, roundworm, whipworm			
Proportion with drug in stock	0.344	0.556	0.714
Average cost (Kenyan shillings)	17.4	16.2	28.0
Number of units surveyed	64	18	7

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[*] Notes: Refer to Brooker, et al (1999a) for a discussion of the modified WHO infection cut-offs. The data were collected in January to March 1998 by the Kenya Ministry of Health, Division of Vector Borne Diseases (DVBD). All cases of schistosomiasis were *S. mansoni*; *S. hemotobium* is rare in Busia.

[*] Government health centers include hospitals, clinics, and dispensaries. Other WHO endorsed drugs for the geohelminths include levamisole hydrochloride, piperazine citrate, and piperazine phosphate. The exchange rate in July 1999 was approximately 70 Kenya Shillings = 1 USD.

Table 5: January 1999 Proportion moderate or heavy helminthic infections (modified WHO standards), and proportion of anemic children, Treatment (Group 1) and Comparison (Group 2) schools [**]

Moderate or heavy infection (modified WHO standard)	Treatment (Group 1)	Comparison (Group 2)	Treatment - Comparison
Hookworm	0.059	0.216	-0.157*** (0.015)
Roundworm	0.094	0.243	-0.149*** (0.016)
Whipworm	0.068	0.075	-0.007 (0.011)
Schistosomiasis	0.084	0.180	-0.096*** (0.015)
Any moderate or heavy infection	0.269	0.522	-0.253*** (0.020)
Number of pupils	*877*	*1490*	
Proportion anemic (Hb < 100g/L)	0.020	0.038	-0.022 (0.016)
Number of pupils	*298*	*501*	

[**] Notes: Refer to Brooker, et al (1999a) for the modified WHO infection cut-offs. The Kenya Ministry of Health definition of anemia (Hb < 100g/L) is used. Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence.

Table 6: Correlates of helminthic infection status
among Treatment (Group 1) schools in January 1998 (probit estimation)[*]

	Dependent variable: 1998 moderate-heavy infection, modified WHO standard	
Age	-0.166***	-0.124***
	(0.022)	(0.023)
Male	0.255***	0.235**
	(0.098)	(0.099)
Eligible for treatment	-0.259**	-0.248**
	(0.114)	(0.116)
Grade progression measure	-0.102***	-0.110***
(=Standard - (Age - 6))	(0.029)	(0.030)
Access to latrine at home	-0.255***	-0.190**
	(0.082)	(0.084)
Wears shoes to school	0.123	0.028
	(0.090)	(0.093)
Cement floor at home	-0.099	-0.157*
	(0.080)	(0.082)
Have cows at home	-0.099	-0.098
	(0.064)	(0.065)
Weight-for-age (Z-score)	-0.100**	-0.106**
	(0.042)	(0.042)
Blood in stool	0.175**	0.070
	(0.072)	(0.075)
Clean (observed by field worker)	-0.088	-0.004
	(0.066)	(0.067)
Proportion of moderate or heavy infections		2.179***
(modified WHO) in surrounding geographic zone		(0.325)
<3 km from Lake Victoria		0.391***
		(0.095)
Number of pupils	1742	1742
Mean of dependent variable	0.366	0.366
Fit of regression	0.131	0.218

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[*] Data from 1998 PSDP Pupil questionnaire and 1998 parasitological surveys. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The fit of the regression is defined as: ((Proportion of moderately-heavily infected pupils in upper 0.366 of propensity score distribution) - 0.366)/(1 - 0.366), where 0.366 id the proportion of pupils that actually are moderately-heavily infected. Fit takes on a value of one if all pupils with moderate to heavy infections are in the upper 0.366 of the predicted distribution, and zero if the propensity score does no better than a random process of selection.

Table 7: 1998 Participation rate in Busia, Kenya primary schools[*]

	Treated (25 schools)	Comparison (50 schools)	Treated – Comparison
Pre-school to Standard 8			
All students	0.751	0.695	0.056** (0.021)
Pre-school to Standard 8, complete eligibility data			
All students	0.760	0.708	0.052** (0.020)
Eligible for treatment	0.751	0.697	0.055** (0.021)
Ineligible for treatment	0.807	0.770	0.037 (0.027)
Pre-school to Standard 5, complete eligibility data[**]			
All students	0.730	0.669	0.061** (0.024)
Standards 6 to 8, complete eligibility data			
All students	0.843	0.833	0.009 (0.015)

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[*] Notes: Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The participation rate is computed among pupils enrolled in the school during the 1998 school year. Pupils who are absent or dropped out are counted as not participating. The results are from School Visit 1 in 1998 (which occurred while the first round of treatment was being administered) to School Visit 1 in 1999. Pupils had up to seven participation observations (5 visits in 1998, participation in the 1998 ICS exam, and 1 visit in 1999). Pupils eligible for treatment include all boys, and girls under age 13.

[**] The pre-school to Standard 5 data includes pupils with missing standard data, due to having dropped out in early 1998.

Table 8: Probit estimation with random effects:
Dependent variable: 1998 Participation observation[**]

	(1)	(2)	(3)
Treatment school (T)	0.076**	0.046	-0.112**
	(0.020)	(0.049)	(0.052)
Eligible for treatment (E)	-0.244***	-0.200***	-0.239**
	(0.012)	(0.033)	(0.122)
E*T	0.060***	0.093*	1.002***
	(0.022)	(0.052)	(0.138)
Standards 6-8			0.428***
			(0.049)
Zonal moderate-heavy infection rate			-1.177***
			(0.364)
< 3km from Lake Victoria			0.033
			(0.107)
E*(Standards 6-8)			-0.243
			(0.062)
E*(Zonal moderate-heavy infection rate)			0.830**
			(0.393)
E*(< 3km from Lake Victoria)			-0.216*
			(0.116)
T*E*(Standards 6-8)			-0.191***
			(0.057)
T*E*(Zonal moderate-heavy infection rate)			-2.741***
			(0.423)
T*E*(< 3km from Lake Victoria)			0.415***
			(0.140)
School random effects	No	Yes	Yes
Number of schools	75	75	75
Number of individuals	26029	26029	26029
Number of participation observations	139520	139520	139520
F-test, p-value	<0.001	<0.001	<0.001
Estimated treatment effect for eligible pupil, at mean pupil characteristics	0.045	0.045	-0.019
Same, (< 3km from Lake Victoria)=1			0.078

[**] Notes: Robust standard errors in parentheses. The F-test tests the hypothesis that coefficients on the T and E*T terms equal zero. Indicator variables for school participation in the ICS School Assistance Program are included in all regressions (coefficients not shown). The participation rate is computed among pupils enrolled in the school during the 1998 school year. Pupils who are absent or dropped out are counted as not participating. The results are from School Visit 1 in 1998 (the first visit post-treatment) to School Visit 1 in 1999. Pupils had up to seven participation observations (5 visits in 1998, participation in the 1998 ICS exam, and 1 visit in 1999). Pupils eligible for treatment include all boys, and girls under age 13. Inclusion of individual level random effects does not significantly alter the results in Regression (1).

Figure 1: Participation rate from March 1998 to January 1999, pupils eligible for medical treatment[*]

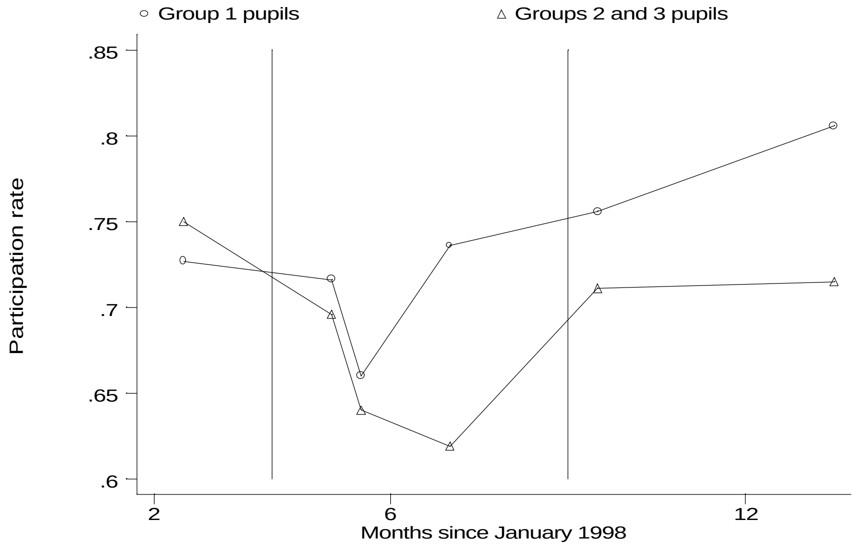
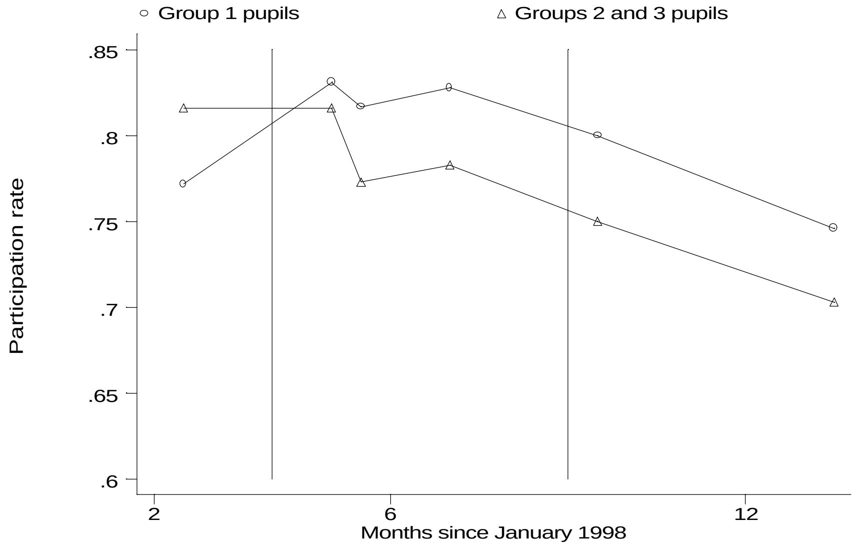


Figure 2: Participation rate from March 1998 to January 1999, pupils ineligible for medical treatment



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[*] Vertical lines denote approximate dates of 1998 medical treatment: March 1998 and October 1998.

Table 9: 1998 ICS Test score performance in Busia, Kenya primary schools in 1998 (S98_S)[*]

	Treated (25 schools)	Comparison (50 schools)	Treated – Comparison
All students	-0.103	0.083	-0.186[*] (0.106)
Eligible for treatment	-0.061	0.136	-0.198[*] (0.108)
Ineligible for treatment	-0.245	-0.086	-0.159 (0.113)

Table 10: Proportion of Std. 3-8 pupils who took the 1998 ICS Exam

	Treated (25 schools)	Comparison (50 schools)	Treated – Comparison
All students	0.879	0.852	0.027 (0.016)
Eligible for treatment	0.885	0.854	0.031[*] (0.017)
Ineligible for treatment	0.859	0.846	0.012 (0.022)
Pupils administered 1998 Pupil Questionnaire			
All students	0.908	0.898	0.009 (0.010)
Eligible for treatment	0.916	0.905	0.011 (0.010)
Ineligible for treatment	0.885	0.882	0.003 (0.014)

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[*] Notes: Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), 90 (*) % confidence.
Table 12: *S98_S* is the average ICS test score in three subjects (English, Maths, Science-Agriculture), standardized to Normal(0,1).
Table 13: the proportion of pupils who took the September 1998 ICS exam, among pupils registered in Standards 3 through 8 and drop-outs at least eight years of age.

Table 11: GLS estimation, dependent variable: 1998 ICS Exam Score (S98_S)[*]

	(1)	(2)	(3)	(4)	(5)	(6) Restricted
Treatment school (T)	-0.186***	-0.088	0.040	0.091	0.091	0.087
	(0.036)	(0.110)	(0.076)	(0.075)	(0.076)	(0.075)
Eligible for treatment (E)	0.264***	0.293***	0.292***	0.284***	0.498***	0.490***
	(0.025)	(0.023)	(0.023)	(0.065)	(0.127)	(0.127)
E*T	-0.045	-0.071*	-0.071*	0.032	-0.459***	-0.387**
	(0.041)	(0.037)	(0.037)	(0.086)	(0.161)	(0.160)
1996 District Mock exam score, school average			0.403***	0.434***	0.436***	0.431***
			(0.040)	(0.040)	(0.040)	(0.040)
Predicted likelihood of infection				-0.337	0.333	0.254
				(0.219)	(0.562)	(0.558)
(Predicted infection likelihood)^2					-0.780	-0.753
					(0.626)	(0.622)
Standards 6-8 indicator				-0.049	-0.042	-0.063
				(0.059)	(0.055)	(0.050)
School < 3 km of Lake Victoria				0.274***	0.276***	0.285***
				(0.095)	(0.096)	(0.095)
Weight-for-age Z-score				-0.070***	-0.067***	-0.068***
				(0.023)	(0.023)	(0.023)
E*(Predicted infection likelihood)				0.504**	-0.704	-0.680
				(0.223)	(0.664)	(0.660)
E*(Predicted infection likelihood)^2					1.406*	1.387*
					(0.747)	(0.742)
E*(Standards 6-8 indicator)				0.106**	0.103**	0.109**
				(0.050)	(0.050)	(0.050)
E*(School < 3 km of Lake Victoria)				-0.144**	-0.150**	-0.152**
				(0.072)	(0.072)	(0.072)
E*(Weight-for-age Z-score)				0.080***	0.075***	0.074***
				(0.028)	(0.028)	(0.028)
E*T*(Predicted infection likelihood)				-0.409	2.361***	2.104***
				(0.254)	(0.803)	(0.800)
E*T*(Predicted infection likelihood)^2					-3.258***	-2.948***
					(0.894)	(0.893)
E*T*(Standards 6-8 indicator)				0.073	0.094*	0.097*
				(0.052)	(0.052)	(0.052)
E*T*(School < 3 km of Lake Victoria)				0.104	0.153	0.168
				(0.110)	(0.111)	(0.111)
E*T*(Weight-for-age Z-score)				-0.049*	-0.037	-0.037**
				(0.028)	(0.028)	(0.027)
School random effects	No	Yes	Yes	Yes	Yes	Yes
Number of schools	74	74	74	74	74	74
Number of pupils	14301	14301	14301	11423	11423	11384
F-test, p-value	<0.001	0.066	0.161	0.008	<0.001	<0.001
Estimated treatment effect among eligible pupils, at mean characteristics	-0.231	-0.159	-0.031	0.015	0.017	0.040

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[*] Notes: Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The F-test examines the hypothesis that the coefficients on the T, E*T and all E*T*(covariate) interaction terms equal zero. The Predicted likelihood of infection if the predicted likelihood that an individual has a moderate to heavy infection, using modified WHO standards. Indicator variables for standards and for participation in the ICS School Assistance Program are included in all specifications. The Restricted Sample in (6) drops the bottom 1.2 percent of the ICS test score distribution among eligible pupils in treatment schools, as a correction for exam participation biases.

Table 12: 1998 Promotion rate in Busia, Kenya primary schools[*]

	Treated (25 schools)	Comparison (50 schools)	Treated – Comparison
All students	0.651	0.658	-0.007 (0.016)
Eligible for treatment	0.660	0.662	-0.001 (0.019)
Ineligible for treatment	0.599	0.624	-0.026 (0.025)
Pre-school to Standard 5			
All students	0.667	0.667	-0.000 (0.020)
Standards 6 to 8			
All students	0.604	0.629	-0.025 (0.022)

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[*] Notes: Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The promotion rate is computed among pupils enrolled in 1998. Pupils who drop out by the start of 1999 are counted as not promoted. Indicator variables for school participation in the ICS School Assistance Program are included in all regressions (coefficients not shown).

Table 13: Probit estimation with random effects:
Dependent variable: 1998 Promotion indicator**

	(1)	(2)	(3)
Treatment school (T)	-0.086*	-0.085	-0.065
	(0.044)	(0.057)	(0.059)
Eligible for treatment (E)	0.095***	0.092***	0.200*
	(0.028)	(0.029)	(0.104)
E*T	0.043	0.049	-0.070
	(0.048)	(0.048)	(0.128)
Standards 6-8			-0.049
			(0.046)
Zonal moderate-heavy infection rate			0.130
			(0.289)
< 3km from Lake Victoria			0.046
			(0.067)
E*(Standards 6-8)			0.061
			(0.055)
E*(Zonal moderate-heavy infection rate)			-0.284
			(0.283)
E*(< 3km from Lake Victoria)			-0.097
			(0.063)
T*E*(Standards 6-8)			-0.061
			(0.049)
T*E*(Zonal moderate-heavy infection rate)			0.297
			(0.338)
T*E*(< 3km from Lake Victoria)			0.042
			(0.080)
School random effects	No	Yes	Yes
Number of schools	74	74	74
Number of individuals	24892	24892	24892
F-test, p-value	0.011	0.332	0.450
Estimated treatment effect for eligible pupil, at mean pupil characteristics	-0.016	-0.013	-0.020

** Notes: Robust standard errors in parentheses. The F-test tests the hypothesis that coefficients on the T and E*T terms equal zero.