Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities

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Introduction

Background and Overall Purpose

The main purpose of the article is to examine the impact of a program in the presence of treatment externalities, which is about deworming treatment in primary schools in a random order in Kenya.

Kenya's school-based deworming program has increased the primary participation rate of treatment schools by an average of 7.5 percent, thereby reducing school absenteeism by at least a quarter. Treatment created positive health and school participation externalities for students without treatment. This article discusses the impact of the program on health, school participation, and test scores, respectively. The main concern of the research is the impact evaluation of social programs, specifically, effect of externalities on estimated effect. Individual-level treatment randomization underestimation of health program benefits, because externality benefits to the comparison group (reduced disease transmission). Underestimation of benefits for the treatment group may lead to misleading policy recommendations.

This article provides its own literature review. This essay reviews the existing literature on helminths and education. The existing research suffers from several disadvantages. First, their within-school randomization designs prevent existing studies from credibly estimating externality benefits. Second, existing research does not test other meaningful outcomes of interests. Based on this, the authors are motivated to evaluate the Primary School Deworming Project (PSDP).

Study Design Overview

In this randomized control trial, the unit of analysis is the school, allowing estimation of overall program effects. There are seventy-five project schools which were randomly divided into three groups of twenty-five schools each. Among the 75 schools, there is a total enrollment of over 30,000 pupils between ages six to eighteen constitute nearly all rural primary schools in this area. The project took place in southern Busia, a poor and densely-settled farming region in western Kenya, in an area with the highest helminth infection rates in Busia district.

Data description and Baseline Characteristics

The data was collected twice by the organizers, International Christelijk Steunfonds Africa (ICS). They conducted school questionnaires in early 1998 and again in early 1999. Panel data includes baseline data and two rounds of surveys. In early 1998, before the first round of drug treatment, groups had mostly similar nutritional, demographic, and socioeconomic characteristics. However, despite undertaking randomized assignment, which depicts groups that have closely similar characteristics, pupils in group 1 as indicated in Table 1 appeared to be worse off than pupils in group 2 and 3. This means treatment schools seem to be worse off initially. There does not exist any statistically significant differences among groups 1, 2, and 3 concerning their enrolment, school sanitation facilities, distance to Lake Victoria, asset ownership, pupils' weight-for-age and finally malaria that was self-reported.

Rates of Helminth infection across all the groups in the surrounding demographic zones are almost similar. There is no significant difference in school attendance rates in early 1998 before the first round of the treatment begins. Nonetheless, the authors stated that the information on baseline attendance are collected from school registers, which are not very reliable in Kenya. Due to concerns about the potential teratogenicity of the medicine, the medical program does not require the treatment of most girls over 13 years of age. In 1998, the students assigned to receive intervention were 78% of girls under 13 years old and all boys in treatment schools, and 19% of girls over 13 years old. In 1999, a relatively small percentage of school students (72% of girls under 13 and all boys) took the treatment. According to Table1, grade progression among the three groups are very close to each other. The means for each group ranges from -1.82to -1.9. There is a high rate of attendence between the three groups ranging from 0.96 to 0.97.

Table 1: 1998 Average Pupil and School Characteristics without weight, Pre-Treatment

	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)	Group 1-Group 3	Group2-Group3	P-values, Group 1-Group 3	P-value, Group2-Group3
Panel A: Pre-school to Grade 8							
Male	0.5312	0.5108	0.5193	0.0118	-0.012	0.515	0.639
				(0.1817)	(0.0183)		
Proportion girls<13 years, and all boys	0.8872	0.8977	0.8826	0.0046	0.0151	0.558	0.66
				(0.0079)	(0.0079)		
Grade progression (=grade-(age-6))	-1.998	-1.884	-1.884	-0.0242	0.096	0.805	0.356
				(0.0975)	(0.0975)		
Year of birth	1986.23	1986.56	1985.75	0.478	0.8041	0.008	0.00
				(0.1739)	(0.1739)		
Panel B: Grade 3 to 8							

Attendance recorded in school registers (during the four weeks prior to the pupil survey)	0.9738	0.9618	0.9695	0.0043 (0.0041)	0.0076 (0.0041)	0.303	0.07
Access to latrine at home	0.8187	0.7956	0.8096	0.009 (0.0377)	10.014 (0.0377)	0.81	0.71
Have Livestock(cows, goats, pigs, sheep) at home	0.6483	0.6738	0.6748	-0.0265 (0.0316)	-0.0009 (0.0316)	0.406	0.975
Weight-for-age Z-score (low scores denote undernutrition)	-1.3891	-1.4262	-1.4401	0.0495 (0.0455)	0.0374 (0.0463)	0.306	0.78
Blood in stool (self-reported)	0.2592	0.2285	0.2043	0.07 (0.032)	0.0271 (0.0331)	0.139	0.512
Sick Often 9self-reported)	0.0919	0.1073	0.0777	0.0165 (0.0122)	0.0234 (0.0124)	0.274	0.025
Malaria/fever in past week (self-reported)	0.3618	0.4119	0.4012	-0.0341 (0.027)	-0.0177 (0.0281)	0.201	0.728
Clean (observed by field workers)	0.5878	0.6588	0.6523	-0.0664 (0.0321)	-0.0124 (0.032)	0.07	0.854
Panel C: School characteristics							
District exam score 1996, grades 5-8th	-0.1029	0.9184	0.0111	-0.1141 (0.1227)	0.0807 (0.1227)	0.356	0.513
Distance to lake Victoria	10.0335	9.9229	9.4554	0.578 (1.9)	0.4674 (1.9)	0.762	0.808

Pupil Population	392.72	403.8	375.88	16.84 (57.64)	27.92 (75.64)	0.771	0.63
School Latrines per pupil	0.0074	0.0061	0.0065	0.0008 (0.0099)	-0.0004 (0.001)	0.403	0.693
Proportion moderate-heavy infections in zone	0.3688	0.3665	0.36	0.0088 (0.0296)	0.0064 (0.029)	0.766	0.828

When we weight the average by school population the results are presented in Table 2. As evident, the grade progressions in each group are very similar to grade progression results presented in Table 1. The means of the three groups for having livestock at home are closely related to means of the same groups when the average characteristics were examined without weight. Similarly, as for as attendance is concerned, the means of attendance for the three groups in weighted scenario are between 0.96 to 0.97, which is almost exactly what we got in without weighted results in Table 1. Weight-for-age Z-score for the three groups in weighted scenario are almost the same as presented for without weight case. Now let us compare the coefficients for Group1 average -Group3 average and Group2 average -Group3 average in both weighted and without weight cases. The results of t-tests in both with weight and without weight scenario in Table 2 and 1 respectively, show that the coefficients for each characteristic are slightly different. For example, the coefficient for Group1-Group3 average grade progression under without weight scenario is -0.024; however, under weighted case the coefficient for Group1-Group3 average grade progression is -0.0027. Thus, they are slightly different but the differences are not big enough to affect the overall results.

When we run the t-tests for both weighted and without weight cases, the P-values for Group1 average -Group3 average and Group2 average -Group3 average are also slightly different, however the differences are statistically indistinguishable under 95% confidence level. Let us look at an example, of p-value for Group1-Group3 average grade progression under without weight case. Its P-value is 0.805 and for the same group and same characteristics in weighted case, the p-value is 0.977. Similarly, the P- value for Group1-Group2 average attendance in without weight case is 0.303 and in weighted case its p-value is 0.399. As we look at Table1 and Table 2 for other school characteristics, when we weight the average by school population, the difference in the P-values is statistically indistinguishable, which means the counterfactual in this study is valid. Having a valid counterfactual in this study is highly important, because otherwise the results or the impact of the treatment on treated group can be biased. Therefore, the counterfactual and the treatment groups have closely similar baseline characteristics as the difference in their P-values are not statistically significant at 95% confidence level.

Table 2: 1998 Average Pupil and School Characteristics with weight, Pre-Treatment

	Group 1 (25 schools)	Group 2 (25 schools)	Group 3 (25 schools)	Group 1-Group 3	Group2-Group3	P-values, Group 1-Group 3	P-value, Group2-Group3
Panel A: Pre-school to Grade 8							
Male	0.5329	0.5096	0.5221	0.0108	-0.012	0.559	0.498
				(0.0184)	(0.0183)		
Proportion girls<13 years, and all boys	0.8858	0.8919	0.8842	0.0016	0.0077	0.803	0.246
				(0.0066)	(0.0066)		
Grade progression (=grade-(age-6))	-1.9725	-1.822	-1.969	-0.0027	0.1475	0.977	0.123
				(0.0952)	(0.0945)		
Year of birth	1986.19	1986.54	1985.78	0.406	0.7554	0.016	0.00
				(0.1648)	(0.1648)		
Panel B: Grade 3-8							
Attendance recorded in school registers	0.9727	0.9632	0.9694	0.0033 (0.0038)	0.0061 (0.0039)	0.399	0.124
Access to latrine at home	0.8223	0.8083	0.8181	0.0041	-0.0098	0.904	0.779
				(0.0342)	(0.0349)		
Have Livestock (cows, goats, pigs, sheep) at home	0.659	0.6725	0.664	-0.0049	0.0084	0.871	0.786
				(0.0304)	(0.031)		
Weight-for-age Z-score (low scores denote	-1.3901	-1.4021	-1.4396	0.0495	0.0374	0.28	0.422

undernutrition)				(0.0455)	(0.0463)		
Blood in stool (self-reported)	0.2635	0.2206	0.1934	0.07	0.0271	0.034	0.415
				(0.032)	(0.0331)		
Sick Often (self-reported)	0.0976	0.1044	0.081	0.0165	0.0234	0.181	0.065
				(0.0122)	(0.0124)		
Malaria/fever in past week (self-reported)	0.3676	0.384	0.4018	-0.0341	-0.0177	0.221	0.53
				(0.027)	(0.0281)		
Clean (observed by field workers)	0.6032	0.6572	0.6697	-0.0664	-0.0124	0.043	0.706
				(0.0321)	(0.032)		
Panel C: School characteristics							
District exam score 1996, grades 5-8th	-0.1029	0.0911	0.0111	-0.1141	0.0807	0.356	0.513
				(0.1227)	(0.1227)		
Distance to lake Victoria	10.0335	9.9229	9.4554	0.578	0.4674		
				(1.9)	(1.9)	0.762	0.808
Pupil Population	392.72	403.8	375.88	16.84	27.92	0.771	0.63
				(57.64)	(75.64)		
School Latrines per pupil	0.0074	0.0061	0.0065	0.0008	-0.0004	0.403	0.693
				(0.0099)	(0.001)		
Proportion moderate-heavy infections in zone	0.3688	0.3665	0.36	0.0088	0.0064	0.766	0.828
				(0.0296)	(0.029)		

At the baseline treatment schools were worse off. Group 1had significantly reported higher symptom of schistosomiasis infection. They had also reported to be often sick than pupils in group 3 and they were also not as clean as pupils in group 2 and 3. On 1996 Kenyan examinations that were taken for primary school, group 1 had lower scores than group 2 and 3 schools. However, there is at traditional confidence level, the difference in average scores is not significant. In January and February of 1998, before the treatment begins, a sample of ninety pupils in grade three to eight from group 1 schools were randomly selected. This sample participated in a parasitological survey, which was undertaken by the Kenya Ministry of Health. 92% of the surveyed pupils had reported at least one helminth infection. 37% had one moderate to heavy helminth infection, which are indicated in Table 3. According to the authors, on the day of the survey, children who were heavily infected by the disease more likely did not attend their classes. Younger pupils, particularly boys are more vulnerable to moderate-to-heavy worm infections.

Table 3: January 1998 Helminth Infections, Pre-Treatment, Group 1 Schools

	Prevalence of infection	Prevalence of moderate-heavy infection	Average infection intensity, in eggs per gram (s.e.)
Hookworm	0.7729	0.1541	425.69 (1055.28)
Roundworm	0.4239	0.1573	2336.52 (5155.71)
Schistosomiasis, all schools	.02175	0.0712	90.54 (412.96)
Whipworm	0.5517	0.0982	161.31 (469.65)
At least one infection	0.9155	0.3658	-
Born since 1985	0.9306	0.3990	-
Born before 1985	0.9077	0.3382	-
Female	0.9051	0.3433	-
Male	0.9268	0.3824	-
At least two infections	0.6484	0.1034	-
At least three infections	0.3405	0.0116	-

Methodology and Econometrics Strategy

The survey used mainly quantitative data collection method. Even when there are externalities within the school, the study used randomized deworming treatment among schools to estimate the overall impact of the deworming intervention by comparing treatment schools and comparison schools. There were two kinds of externalities in this treatment: within-school externalities and cross-school externalities. “Within-school externality” means even non-treated pupils in the treatment school benefited. “Cross-school externality” means pupils who were not in a treatment school but were in its neighboring schools benefited. Miguel and Kramer distinguished those two externalities by the following strategies.

First, since the deworming treatment was randomized across schools, equation (1) was able to identify both the overall program effect and the cross-school externality:

$$(1)\quad Y_{ijt} = \alpha + \beta_1 \cdot T_{1it} + \beta_2 \cdot T_{2it} + X'_{ijt}\delta + \textstyle\sum_d (\gamma_d \cdot N^T_{dit}) + \sum_d (\phi_d \cdot N_{dit}) + u_i + e_{ijt} \qquad [1]$$

where γ_d represented the “cross-school externality” of the deworming treatment, $\beta_1 + \sum_d(\gamma_d \cdot \acute{N}^T_{dit})$ represented the average effect of the deworming treatment in the first year (1998), and $\beta_2 + \sum_d(\gamma_d \cdot \acute{N}^T_{dit})$ represented the similar effect in the second year (1999).

However, since in equation (1), $\beta_1 + \beta_2$ represented both direct effects of deworming treatment and “within-school externalities” which cannot be separated, Miguel and Kramer developed another equation (2) to distinguish “within-school externality” from direct effects of deworming treatment in 1998. They assumed that $E(e_{ij})$ is the same for Group 1 pupils who did not receive deworming treatment in 1998, and Group 2 was pupils who did not receive the treatment in 1999:

$$(2)\quad Y_{ijt} = \alpha + \beta_1 \cdot T_{1it} + b_1 \cdot D_{1ij} + b_2 \cdot (T_{1it} * D_{1ij}) + X'_{ijt}\delta + \textstyle\sum_d (\gamma_d \cdot N^T_{dit}) + \sum_d (\phi_d \cdot N_{dit}) + u_i + e_{ijt} \qquad [2]$$

Where β_1 represented the “within-school externality” on the untreated, and $\beta_1 + b_2$ overall represented “within-school externality” plus the additional direct effect of deworming treatment on the treated.

Data Analysis Procedures

Data was originally collected using the questionnaires. We then tailored the dataset towards our analysis, and these data outputs are used to generate the narrative of this report.

First of all we examine the prevalent of helminth infections in Group 1 for male pupils schools before they received treatment. We compare the prevalence of

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[1] Y_{ijt} : the individual health or education outcomes (i: schools, j: student, t∈ $\{1,2\} the year of the program$); T_{1it}: = 1 if school i was assigned to treatment in the first year (1998) of deworming treatment; = 0 otherwise. T_{2it}: = 1 if school i was assigned to treatment in the second year (1999) of deworming treatment; = 0 otherwise. X_{ijt}: school and pupil characteristics; N_{dit}: the total number of pupils in primary schools at distance d from school I in year t; N^T_{dit}: the number of these pupils in schools randomly assigned to deworming treatment; u_i: school effect; e_{ijt}: reflects differences among households in ability and willingness to take action to improve their children’s health. Individual disturbance terms are assumed to be independent across schools.

[2] D_{1ij} represents whether the pupil received treatment in 1998. It equals to 1 when treated, and equals to 0 when untreate.

infection, moderate-heavy infection, and the average infection intensity (eggs per gram) for each of the four helminths measured. We check what proportion of pupils had at least one, two, or three infections? What proportion of pupils had at least one, two, or three moderate-to-heavy infections?

Second, we valuate compliance with the assigned treatment and address the below questions: How severe was non-compliance in the treatment group and contamination of the control group? That is, for each round of treatment in 1998 and 1999 what percentage of pupils in treatment schools received treatment? What percentage of pupils in non-treatment schools received treatment? How we think these will affect your estimates of the treatment effect?

Third we compare pupils in Group 1 and Group 2 schools from January to March 1999 to see if there are significant differences in the prevalence of any moderate-heavy helminth infection? if the treatment appears to have affected other health and nutrition outcomes. If students in Group 1 schools adopted more worm prevention behaviour.

Fourth, using a probit regression, we estimate the impact of being in a Group 1 school on the probability of having a) any moderate-heavy infection b) a moderate-heavy schistosomiasis infection c) a moderate-heavy geohelminth (hookworm, roundworm, or whipworm) infection in January to March 1999. We also check what is the effect of receiving treatment for pupils in Group 1 schools?

Fifth, we construct a school-level measure of participation (average attendance at the school level) and compare for the different treatment groups. Weight school averages by pupil population to see if there are significant differences between Group 1, 2 and 3 schools in the first year post-treatment (May 1998 to March 1999) and in the second year post-treatment (March to November 1999).

Finally, we construct a pupil-level measure of school participation (average attendance of each pupil level based on “observed” visits) with two periods: first year of treatment (May 1998 to March 1999) and the second year of treatment (March to November 1999). We estimate the ITT impact of the deworming program on school participation at the pupil level. We check what is the effect of being in a treatment school. We check if the effect higher in the first or second year of treatment and cluster standard errors at the 1998 school level

Main Results

The prevalence of infection for group 1 schools for male pupils before the treatment was high and the statistics are presented in Table 4. . 93% of the male pupils had reported at least one prevalence helminth infection. 66% of male pupils had reported at least two prevalence helminth infections and 34% had reported at least three prevalence infections. 38% of male pupils had one moderate to heavy helminth infection, 11% had reported two moderate-to-heavy infections and 1.2% had reported three moderate-to-heavy infections. The prevalence of infection for Hookworm among male pupils was 79.5%. The prevalence of infection for Roundworm, Schistosomiasis, and Whipworm among male pupils were 42%, 24%, and 55.8%

respectively. Table 4 highlights that prevalence of Hookworm infection compared to other three ones is very high followed by Whipworm being the second. The prevalence of moderate-to-heavy infections for Hookworm, Roundworm, Schistosomiasis, and Whipworm are 17%, 15%, 8.5%, and 9.9% respectively. These statistics indicate that among the four infections, Hookworm infection has higher moderate-to-heavy prevalence. The average infection intensity (eggs per gram) for each of Hookworm, Roundworm, Schistosomiasis, and Whipworm are 469.93, 2224.35, 108.36, and 134.71 eggs per gram respectively. The average infection intensity for Roundworm is comparatively higher.

Table 4: January 1998 Helminth Infections, Pre-Treatment, Group 1 Schools, Male Pupils

	Prevalence of infection	Prevalence of moderate-heavy infection	Average infection intensity, in eggs per gram (s.e.)
Hookworm	0.7952	0.1721	469.93 (1122.21)
Roundworm	0.4213	0.1513	2224.35 (4943.90)
Schistosomiasis, all schools	0.2462	0.0850	108.36 (444.27)
Whipworm	0.5588	0.0999	143.71 (364.44)
At least one infection	0.9268	0.3827	-
Born since 1985	0.9308	0.4148	-
Born before 1985	0.9276	0.3636	-
At least two infections	0.6676	0.1127	-
At least three infections	0.3481	0.0128	-

Compliance.

Seventy six percent of those pupils assigned to receive treatment actually received at least some medical treatment through the program in 1998, as shown in Table 3. Most of noncompliance was caused by absence at school at the day of the treatment. Twenty percent of girls that are older than thirteen years old also received treatment in 1998, mostly because of uncertainly of pupil age. In control schools none of the pupils received treatment in 1998. In 1999 treatment rate has slightly decreased, only about 58% of pupils received any medication. In control group medication was received by less than one percent of pupils. Regarding males (Table 4), 83% of them received any medication in 1998, and compliance rate also decreased in 1999, approximately 60%. Male pupils in comparison groups almost did not receive any treatment in both years. Overall, such compliance rates can lead to underestimation of the program effects.

Table 5. Proportion of pupils receiving treatment

	Group 1		*Group 2*		*Group 3*	
	Eligible	*Non-eligible*	*Eligible*	*Non-eligible*	*Eligible*	*Non-eligible*
	Treatment		*Comparison*		*Comparison*	
Any medical treatment in 1998	0.76	0.20	0	0	0	0
Round 1 Albendazole	0.68	0.11	0	0	0	0
Praziquantel	0.64	0.34	0	0	0	0
Round 2 Albendazole	0.56	0.07	0	0	0	0
	Treatment		*Treatment*		*Comparison*	
Any medical treatment in 1999	0.58	0.07	0.54	0.09	0.01	0
Round 1 Albendazole	0.44	0.06	0.35	0.05	0.01	0
Praziquantel	0.48	0.06	0.38	0.06	0.00	0
Round 1 Albendazole	0.52	0.06	0.50	0.07	0.01	0

Table 6. Proportion of male pupils receiving treatment

	Group 1	*Group 2*	*Group 3*
	Treatment	*Comparison*	*Comparison*
Any medical treatment in 1998	0.83	0	0
Round 1 Albendazole	0.74	0	0
Praziquantel	0.70	0	0
Round 2 Albendazole	0.59	0	0
	Treatment	*Treatment*	*Comparison*
Any medical treatment in 1999	0.60	0.57	0.01
Round 1 Albendazole	0.46	0.38	0
Praziquantel	0.49	0.39	0
Round 1 Albendazole	0.53	0.51	0.01

If there are deworming treatment externalities across schools, these differences understate overall treatment effects. Thus, we need to compare pupils in Group 1 and Group 2 schools from January to March 1999. The results are shown in ***Table** 7* as follows.

Overall, 27 percent of pupils in Group 1 (1998 treatment) schools had a moderate-to-heavy helminth infection in early 1999 compared to 52 percent in Group 2 (1998 comparison) schools, and this difference is significantly different than zero at 99 percent confidence. The prevalence of moderate-to-heavy hookworm, roundworm, schistosomiasis, and whipworm infections were all lower in Group 1 (1998 treatment) schools than in Group 2 (1998 comparison) schools. The program was somewhat less effective against whipworm, perhaps as a result of the lower efficacy of albendazole treatments for whipworm infections, as discussed above.

Group 1 pupils also reported better health outcomes after the first year of deworming treatment: 2 percent fewer Group 1 pupils reported being sick in the past week, and 2 percent fewer pupils reported being sick of- ten (these differences are significantly different than zero at 95 percent confidence). Group 1 pupils also had significantly better height-for-age-a measure of nutritional status-by early 1999, though weight-for-age was no greater on average. There is no significant difference between Group 1 and Group 2 pupils in hemoglobin concentrations in early 1999.

Health education had a minimal impact on behavior. There are no significant differences across treatment and comparison school pupils in early 1999 in three worm prevention behaviors: observed pupil cleanliness, the proportion of pupils wearing shoes, or self-reported exposure to fresh water.

Table 7 January to March, Health and Health Behavior Differences Between Group1 (1998 Treatment) and Group 2(1998 Comparison) schools

	Group 1	Group 2	Group1-Group2	Std.Err.
Any moderate-heavy infection	0.27	0.52	-0.26	0.06
Hookworm moderate-heavy infection(hw)	0.06	0.22	-0.16	0.02
Roundworm moderate-heavy infection(al)	0.09	0.24	-0.15	0.04
Schistosomiasis moderate-heavy infection(sm)	0.08	0.18	-0.10	0.06
Whipworm moderate-heavy infection(tt)	0.12	0.17	-0.05	0.05
Sick Often,1999	1.96	1.99	-0.02	0.03
Height-for-age Z-score	-1.13	-1.11	-0.02	0.05
Weight-for-age-Z-score	-1.25	-1.22	-0.02	0.05
Hemoglobin (Hb),1999	124.81	123.04	1.77	1.24

Proportion anemia (Hb < 100 g/L),1999	0.02	0.04	-0.02	0.01
Clean (observed by field worker),1999	1.47	1.42	0.05	0.03
Wears shoes (observed by field worker),1999	2.66	2.59	0.07	0.02
Days contact with fresh water in past week	0.39	0.42	0.07	0.02

Similarly, among the eligible male pupils, the prevalence of moderate-to-heavy hookworm, roundworm, schistosomiasis, and whipworm infections were all lower in Group 1 (1998 treatment) schools than in Group 2 (1998 comparison) schools. The program was somewhat less effective against whipworm. The results are shown in ***Table 8*** as follows. 25 percent of pupils in Group 1 (1998 treatment) schools had a moderate-to-heavy helminth infection in early 1999 compared to 54 percent in Group 2 (1998 comparison) schools, and this difference is significantly different than zero at 99 percent confidence. Health education had a minimal impact on behavior. There are no significant differences across treatment and comparison school pupils in early 1999 in three worm prevention behaviors: observed pupil cleanliness, the proportion of pupils wearing shoes, or self-reported exposure to fresh water.

Different from the whole sample, Group 1 pupils did not report better health outcomes after the first year of deworming treatment: the male pupils in the two group are nearly the same at reporting being sick in the past week. Group 1 pupils also had significantly better height-for-age-a measure of nutritional status-by early 1999, though weight-for-age was no greater on average. There is no significant difference between Group 1 and Group 2 pupils in hemoglobin concentrations in early 1999.

Table 8 January to March, Health and Health Behavior Differences Between Male pupils in Group1 (1998 Treatment) and Group 2(1998 Comparison) schools

	Male 1	Male 2	Male1-Male2	Std.Err
Any moderate-heavy infection	0.25	0.54	-0.29	0.06
Hookworm moderate-heavy infection(hw)	0.05	0.26	-0.21	0.03
Roundworm moderate-heavy infection(al)	0.08	0.22	-0.14	0.04
Schistosomiasis moderate-heavy infection(sm)	0.09	0.18	-0.09	0.06
Whipworm moderate-heavy infection(tt)	0.12	0.17	-0.05	0.06
Sick Often,1999	1.96	1.96	0.00	0.04

Height-for-age Z-score	-1.32	-1.40	0.08	0.05
Weight-for-age-Z-score	-1.45	-1.50	0.06	0.06
Hemoglobin (Hb),1999	125.65	122.66	2.99	1.55
Proportion anemia (Hb < 100 g/L),1999	0.01	0.04	-0.03	0.01
Clean (observed by field worker),1999	1.58	1.51	0.07	0.04
Wears shoes (observed by field worker),1999	2.74	2.76	-0.01	0.05
Days contact with fresh water in past week	0.38	0.40	-0.03	0.03

Deworming Treatment Effects on Health and Nutrition

First, we perform analysis on the whole sample which is the Group1 here. As for the subsample, we just need to use code keep if sex==1 to get the results for eligible male pupils.

The project confirms that children in deworming schools receive a range of health benefits and provides evidence that these benefits extend to untreated students in treatment schools as well as to students in nearby schools.

The results in ***Table 9*** indicate the deworming treatment effects on infection for group 1. In 1999, the proportion of pupils with moderate to heavy infection is 27.35 percentage points lower in Group 1 schools than Group 2 schools in early 1999 and this effect is statistically significant at 99 percent confidence. Moderate-heavy schistosomiasis infection rate in Group 1 is lower than Group 2 by 9.65 percent points. And moderate-heavy geohelminth infection (hookworm, roundworm, or whipworm) is 26.10% lower than that of group 2 at that time. In conclusion, this deworming program has greater effect on geohelminth infection than schistosomiasis infection.

Table 9 Deworming Health Externalities Within and Across schools, January to March 1999

	Group 1	Std.Err
Any moderate-heavy helminth infection	-0.2735	0.06
Moderate-heavy schistosomiasis infection	-0.0965	0.06
Moderate-heavy geohelminth infection	-0.2610	0.05

For the subsample, namely the eligible males, we can draw similar conclusion. The results in ***Table 10*** indicates that infection rate in Group 1 is 27.9% lower than Group 2 for any moderate-heavy helminth infection.

As for moderate-heavy schistosomiasis infection, Group1 is 9.8% lower than that of Group 2 at that time. And moderate-heavy geohelminth infection (hookworm, roundworm, or whipworm) is 26.7% lower than that of group 2. Similarly, it indicates that deworming program has greater effect on geohelminth infection than schistosomiasis infection.

Table 10 Deworming Health Externalities Within and Across schools on Male pupils, January to March 1999

	Male 1	Std.Err
Any moderate-heavy helminth infection	-0.2794	0.06
Moderate-heavy schistosomiasis infection	-0.0978	0.07
Moderate-heavy geohelminth infection	-0.2673	0.05

School participation, school level.

```
keep if (visit>981 & visit<993 & elg98==1)
collapse prs wgrp* (count) np = pupid, by(sch98v1)
bys wgrp: summ prs [aw=np]
tab wgrp, gen(wgrp)
regress prs wgrp1 [aw=np]
regress prs wgrp1 wgrp2 [aw=np]
```

The difference in school participation at school level in the first year after treatment is 9.3 percentage points, and this is significantly different from zero at 99 percent confidence level, as shown in Table 11. In this case, Group 1 is a treatment group, and Group 2&3 are combined control group. Male pupils participation rate also was significantly higher, almost 9% In second year school participation in Group 1 and Group 3has increased by more than 5 percentage points compared to Group 3, however, these differences are significantly different only at 90 percent confidence level. In male pupils there was no statistically significant difference between treatment and control groups in 1999.

Table 11. School participation, school-level.

First year post-treatment (May 1998 to March1999)	*Group 1* *1st Year Treatment*	*Group 2* *Comparison*	*Group 3* *Comparison*	*Group1 - (Groups2&3)*	*Group2 - Group3*

Girls <13, and all boys	*0.841*	*0.731*	*0.766*	*0.093**** *(0.03)*	*-0.04* *(0.04)*
Males	0.844	0.736	0.78	0,088*** (0.031)	-0.044 (0.037)
Second year post-treatment (March to November1999)	*2nd Year Treatment*	*1st Year Treatment*	*Comparison*	*Group1 - Group3*	*Group2 - Group3*
Girls <13, and all boys	*0.716*	*0.718*	*0.664*	*0.051** *(0.027)*	*0.054** *(0.027)*
Males	0.698	0.695	0.655	0.043 (0.028)	0.04 (0.029)

Speaking of impact of deworming program on the school participation on the pupil level, the effect of being in a treatment school at any time is 4.8 percentage point, which is statistically significant at 99% confidence level, which is represented in Table 12. Point estimates are 5.7% for the first year of treatment and 2.4% for the second year, however only first year estimate is statistically significant at 99% confidence level. As for male pupils, being in treatment school increases school participation by 4.6% (95% confidence level). Point estimates are 5.3% for the first year of treatment and 2.5% for the second year, and again, only first year estimate is significant at 99% confidence level. We can conclude that the deworming treatment effect is higher for the first year of treatment for both male pupil and the whole sample.

Table 12. Dependant variable: Average individual School participation

	Dependent variable: Average individual School participation
Whole sample	
Treatment school	0.048*** (0.0166)
First year as treatment School	0.057*** (0.0166)
Second year as treatment School	0.024 (0.026)
Males	

Treatment school	0.046** (0.018)
First year as treatment School	0.053*** (0.018)
Second year as treatment School	0.025 (0.026)

Conclusion

Miguel and Kramer analyzed the deworming treatment effects on health and nutrition, school performance, and test scores, by mainly using moderate-heavy helminth infection rate, school participation rate, and standardized scores, respectively, as indicators.

The results show that not only pupils in deworming treatment schools experienced a wide range of health benefits, but the pupils in neighboring schools had been spilled over benefits as well. And it is notable that geohelminth externalities were primarily within schools, while schistosomiasis externalities were primarily across schools. Their estimates imply that at the beginning of 1999, the proportion of moderate to severely infected students in the first group of schools was 25% lower than that of the second group of schools, and with a 99% confidence level, this effect was statistically significant. The average cross-school externality effect for untreated pupils is 9% lower. Thus, ignoring cross-school externalities leads to underestimation of program effects on infection rates in treatment schools (one quarter). Deworming also increased school attendance (average individual school participation) in treatment schools by at least seven percentage points. This is the positive externality both within and across schools.

Moreover, the article explored the issue regarding whether the majority of school-based deworming treatment should be a public policy priority for the poorest countries with four kinds of cost-effective analysis. The conclusion includes health cost-effectiveness (externality benefits account for 76% of the above result), educational cost-effectiveness ($3.50 per additional year of school participation), and optimal subsidies (net present value of wages increased by over $30 per treated child at a cost of $0.49).

In conclusion, there are several findings in the study. Firstly, the deworming program substantially improved health and school participation among untreated children in both treatment schools and neighboring schools, and these externalities are large enough to justify subsidizing related projects. However, we do not find evidence that deworming improved academic test scores. Secondly, individual-level randomization doubly underestimates the effects of deworming programs. Instead, group-level randomization allows identification of cross-group externalities. Thirdly, In the presence of substantial spillovers, public subsidies may be optimal. That is to say, we could allow provision at higher (district, provincial) levels.

Recommendations

There were several internal factors, which may bias the real effects of the deworming program. For instance, Group 1 pupils' characteristics were slightly worse-off than the characteristics of its comparison group, and the treated group did not include girls older than 13. Also, external factors may affect the results of the deworming intervention. For example, since Busia was relatively small, the authors were unable to measure across-school externalities in untreated schools farther than 6 km from a treated school. The mechanism of consent also changed from "community consent" to "individual parental consent", which may increase the cost for a child to get treated and consequently reduce the participation rate. Due to the financial constraints, the deworming intervention had to be phased in over several years, which implies that the deworming intervention could have had a better design if the financial funds were sufficient. More importantly, this study only measured short-term indicators like school participation rate, test scores, and infection rate. Long-term indicators were not included. But Miguel and Kramer updated this research in 2014 adding more long-term indicators and fixing some code error.

Reference

Edward Miguel, Michael Kremer, Worms: Identifying Impacts on Education and Health in the Presence of Treatment Externalities." *Econometrica, Vol. 72, No. 1 (Jan., 2004), pp. 159-217*