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

## Guide to Replication of Miguel and Kremer (2004)

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Edward Miguel
Department of Economics
University of California, Berkeley
(emiguel@berkeley.edu)

Michael Kremer
Department of Economics
Harvard University
(mkremer@fas.harvard.edu)

# Table of Contents

# 1. Introduction

In order to facilitate replication of the analysis presented in Miguel and Kremer (2004), and to allow for further original analyses, the data and do-files employed in the published paper have been made available to interested researchers since January 2007. This document provides notes on the files which reproduce the results presented in Miguel and Kremer (2004), and discusses the fully corrected, updated version of these results. Background to the study, as well as notes on the data sets, can be found in companion documents entitled “Data User’s Guide” and “Codebooks”.

Each table in Miguel and Kremer (2004) can be replicated using a single corresponding do file. Additional “updated” do-files exist for Tables VII, VIII, and IX, as explained in Section 2 below. Several rounding, typographical, and other errors were discovered in the process of producing this documentation, and Section 3 details these errors. The key results of Miguel and Kremer (2004) – namely, that deworming improves the health and school participation of treated children, as well as untreated children in treatment schools and neighboring schools – remain, and we provide a discussion of the fully corrected, updated results, as well as some additional analysis, in Section 4. The fully updated set of tables which replicate the analysis of Miguel and Kremer (2004) are presented in Appendix A. Appendix B contains additional analysis.

We note that this manual was first made available to the public in January 2007, along with the data and do files to replicate Miguel and Kremer (2004). That original version of the manual contained nearly all of the content in Sections 2 and 3 below, including a discussion of the coding issues detected in the construction of the local density measures and the “intermediate” datasets found to have been used in some tables of the published paper. In addition, that original version of the manual contained the full set of revised tables presented in Appendix A. This version of the manual updates Sections 2 and 3 slightly, and adds Section 4 and Appendix B, which discuss and further explore the updated results from the analysis.

We summarize the most important substantive implications of the updated results here. The biggest change relative to Miguel and Kremer (2004) is that whereas that paper reported on externality impacts at 0-3 and 3-6 kilometers, these impacts were actually measured only within the 12 schools closest to the reference school. The latter, of course, constitutes a valid measure of externalities, and given that students interact either with pupils who attend the same school or with pupils who attend nearby schools, it is arguably sensible to restrict the number of nearby schools when exploring potential externalities. However, in this document we report on what happens when looking at externalities incorporating all schools located within 0-6 kilometers of the reference school. An additional coding issue was detected that resulted in incorrect local population density figures for two schools, and this error is corrected in the updated data and results presented here.

The updated results continue to suggest substantial effects of deworming – for both moderate-to-heavy worm infections and for school participation – on treated individuals, untreated individuals in treatment schools, and individuals attending schools within 3 kilometers of treatment schools. Whereas Miguel and Kremer (2004) additionally found statistically significant impacts on moderate-to-heavy worm infections for pupils attending schools within 3-6 kilometers of treatment schools, the revised results no longer find externality impacts beyond 3 kilometers. Neither the original paper nor the updated results find statistically significant externality impacts on school participation beyond 3 kilometers.

These updated findings suggest that an estimator for overall externalities that extends beyond 3 kilometers, and that puts extensive weight (due to the large numbers of schools beyond that distance) on the not statistically significant 3-6 kilometers externality estimate, adds large amounts of "noise" to the overall externality estimate. In Section 4.9, we demonstrate that, under reasonable assumptions, the estimator that excludes the 3-6 kilometers externalities is preferred under the standard statistical criterion of minimizing mean squared error. Calculation of the updated overall impact of deworming on worm infections and school participation results in findings similar to the original study. In particular, using the updated analysis, we find that **the overall deworming effect on worm infections is a reduction of 43.5 percentage points (s.e. 6.1, p-value≤0.01).** This is similar to the overall effect measured in Miguel and Kremer (2004) using the original data (46 percentage points, s.e. 5.5, p-value≤0.01). Furthermore, **the estimated overall effect of deworming on school participation is a gain of 8.5 percentage points (s.e. 1.6, p-value≤0.01).** This overall effect is larger than estimated in Miguel and Kremer (2004) using the original data (7.5 percentage points, s.e. 2.7, p-value≤0.01).

There are also some other differences between the updated results and the results as originally reported. The other important substantive result that changes is that related to anemia. As discussed in Miguel and Kremer (2004, page 174), anemia is unlikely to be the key channel through which deworming had an effect in this study since only 4% of students had severe anemia. However, the original paper reported a significant reduction in anemia as a result of the deworming treatment. In the revised analysis, the point estimate is the same, but the significance level drops, and is no longer significant at traditional confidence levels (p-value=0.19).

## 2. A Note on the Data Sets Used in the Published Paper

In revisiting the do files to prepare this document, we discovered that several results in the published version of the paper were produced using "intermediate", or earlier, versions of the data sets rather than the final version. Data cleaning, in both Kenya and the United States, was an ongoing process on these large, original data sets during 1998-2002, and this led to the existence of various "intermediate" versions of two data sets, versions that were progressively cleaner over time. Cleaning typically took the form of eliminating duplicate observations that had found their way into the data, correcting data entry errors through hard copy checks, and better matching across files. While the bulk of results in the paper use the "final" versions of the data, not all tables were completely updated during the journal revision process and some tables instead use "intermediate" versions of the data. The extent of data cleaning was only moderate, so that using versions of the data from 2000, 2001, and 2002, say, leads to almost identical results.

Specifically, the published versions of Table VII and Appendix Tables AII and AIII use an intermediate version of the "comply.dta" data set, Table VIII uses an intermediate version of the "namelist.dta" data set, and Table IX and Appendix Table AIV use intermediate versions of both the "comply.dta" and the "namelist.dta" data sets. Two sets of do files are provided for each of these tables – one which replicates the original published results (using some "intermediate", or not fully cleaned, data sets), and a second which updates these results using the "final" version of the data sets.

An updated version of the tables in Miguel and Kremer (2004) is presented in Appendix A of this document. These tables were produced using the "final" versions of all data sets, and correct the errors described in Section 3 below. Appendix B presents additional analysis, also utilizing the "final" versions of all data sets, and this analysis is discussed in detail in Section 4.

## 3. Rounding, Typographical, and Other Errors in the Published Paper

In the process of producing this documentation, several errors were discovered in the tables presented in Miguel and Kremer (2004). In what follows, we detail these errors in four categories: (i) rounding errors, (ii) statistical significance errors (wrong number of stars, some of which resulted from rounding errors), (iii) STATA coding errors, and (iv) other typos or errors. Rounding errors account for the bulk of the errors in the paper, and we start with these.

As we note in the introduction to this document, these errors affect little of the published paper's substantive results, with the exception of the anemia and 3-6 kilometer worm infection externality findings. An updated version of the tables in Miguel and Kremer (2004), incorporating the changes noted in Sections 2 and 3, is presented in Appendix A to this document. Section 4 discusses these updated findings, and also details further analysis that is presented in Appendix B to this document.

### *3.1 Rounding errors*

Rounding errors come in two varieties. First, we discovered that a fair number of estimates were "truncated" rather than rounded off (e.g., 0.787 became 0.78 rather than 0.79). Second, we found that several estimates were incorrectly rounded off when estimates were shortened, usually from three decimal points to two decimal points. In earlier versions of the paper (including the NBER Working Paper version, Miguel and Kremer 2001), a number of tables presented statistics with three decimal points, while the published version often uses two decimal points. In the process of shortening these figures, a number of errors were made. Consider the first entry of Table III (the upper left corner entry), 0.78. It turns out that the true value of this statistic is 0.7745. In an earlier version which presented data with three decimal points, this was presented as 0.775. When we shifted to two decimal points, this figure was incorrectly rounded up to 0.78 when it should have been rounded down to 0.77.

Rounding errors typically lead to minor changes in coefficient estimates. Unfortunately, in some circumstances rounding of coefficients or standard errors led to changes in estimated statistics and thus in stars used to report statistical significance. Rounding errors in reported means, coefficient estimates, and standard errors are detailed below, and errors in reporting of statistical significance are presented in Section 3.2.

***Table II:***
At least one infection, born since 1985, prevalence of infection: 0.93 (published version 0.92).

***Table III:***
TOP PANEL:
Any medical treatment in 1998, Group 1, eligibles: 0.77 (published version 0.78)
Any medical treatment in 1998, Group 1, ineligibles: 0.20 (published version 0.19)
Round 1 Albendazole 1998, Group 1, eligibles: 0.68 (published version 0.69)
MIDDLE PANEL:
Any medical treatment in 1999, Group 1, eligibles: 0.58 (published version 0.59)
Any medical treatment in 1999, Group 2, eligibles: 0.54 (published version 0.55)
Any medical treatment in 1999, Group 2, ineligibles: 0.09 (published version 0.10)
Round 1 Albendazole 1999, Group 2, ineligibles: 0.05 (published version 0.06)
Round 1 Praziquantel 1999, Group 3, eligibles: 0.00 (published version 0.01)

Round 2 Albendazole 1999, Group 1, eligibles: 0.52 (published version 0.53)
Round 2 Albendazole 1999, Group 2, eligibles: 0.50 (published version 0.51)
Round 2 Albendazole 1999, Group 2, ineligibles: 0.07 (published version 0.08)
BOTTOM PANEL:
Any medical treatment in 1999, Group 2, ineligibles: 0.14 (published version 0.13)
Round 1 Praziquantel 1999, Group 1, eligibles: 0.54 (published version 0.53)
Round 1 Praziquantel 1999, Group 1, ineligibles: 0.08 (published version 0.07)
Round 1 Praziquantel 1999, Group 2, eligibles: 0.46 (published version 0.45)
Round 1 Praziquantel 1999, Group 3, eligibles: 0.00 (published version 0.01)

***Table IV:***
Total transfers in Group 1 schools, 1998: 0.020 (published version 0.021)
Total transfers in Group 3 schools, 1998: 0.020 (published version 0.021)

***Table V:***
PANEL B:
Sick in past week, 1999, Group 1: 0.40 (published version 0.41)
Sick in past week, 1999, coefficient on Group 1 - Group 2: -0.05 (published version -0.04)
Height-for-age Z-score, 1999, coefficient on Group 1 - Group 2: 0.08 (published version 0.09)
Hemoglobin concentration, 1999, Group 1: 124.9 (published version 124.8)
Hemoglobin concentration, 1999, Group 2: 123.3 (published version 123.2)

***Table VI:***
PANEL A:
Proportion of 1998 parasitological sample tracked in 1999 sample, Group 1, Untreated: 0.35 (published version 0.36)
Access to latrine at home, 1998 for Group 1, Treated: 0.85 (published version 0.84)
PANEL B:
Hookworm moderate-heavy infection, 1999, coefficient on Group 1 untreated 1998 – Group 2 untreated 1999: -0.10 (published version -0.09)
Any moderate-heavy infection, 1999 for Group 1, Untreated Girls >=13 years: 0.44 (published version 0.43)
Any moderate-heavy infection, 1999, coefficient on Group 1 Untreated 1998 – Group 2 Untreated 1999: -0.09 (published version -0.10)

***Table VII:***[1]
Column (2), coefficient on "indicator for Group 1 (1998 treatment) school": -0.13 (published version -0.12)
Column (4), coefficient on "Group 1 pupils within 3-6 km": -0.19 (published version -0.18)
Column (4), coefficient on "Total pupils within 3 km": 0.12 (published version 0.11)
Column (5), coefficient on "Group 1 pupils within 3-6 km": -0.19 (published version -0.18)
Column (5), standard error on "received first year of deworming treatment, when offered": 0.01 (published version 0.02)

[1] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.

***Table IX:*** [2]
Column (4), coefficient on “first year as treatment school”: 0.063 (published version 0.062)
Column (4), root MSE: 0.224 (published version 0.223)
Column (5), coefficient on “1996 district exam score, school average”: 0.092 (published version 0.091)
Column (7), coefficient on “moderate-heavy infection, early 1999”: -0.204 (published version -0.203)
Column (7), coefficient on “1996 district exam score”: 0.004 (published version 0.003)
Column (7), standard error on “1996 district exam score”: 0.022 (published version 0.023)

***Table X:*** [3]
Column (1), mean of dependent variable: 0.019 (published version 0.020)
Column (2), standard error on “second year as treatment school”: 0.072 (published version 0.071)
Column (2), mean of dependent variable: 0.019 (published version 0.020)
Column (3), coefficient on “second year as treatment school”: 0.008 (published version 0.009)

***Appendix Table AIV:*** [4]
Column (1), coefficient on “indicator for group 1 school”: -0.13 (published version -0.12)
Column (2), coefficient on "indicator received first year of deworming treatment, when offered": -0.05 (published version -0.06)
Column (4), standard error on “total pupils within 3-6 km”: 0.026 (published version 0.027)

## *3.2 Statistical significance errors (wrong number of stars)*

In several cases the published paper either under- or overstated statistical significance. Some of these errors are typographical in nature, while others are due to the calculation of statistical significance using incorrectly rounded coefficients or standard errors (as in Section 3.1, above).

***Table I:***
PANEL B:
Sick often (self-reported), Group 1 - Group 3 difference is not statistically significant (p-value=0.181; published version reported significance at 95% confidence)
Sick often (self-reported), Group 2 - Group 3 difference is statistically significant at 90% confidence (p-value=0.065; published version reported significance at 95% confidence)

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[2] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.
[3] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.
[4] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.

***Table V:***
Schistosomiasis moderate-heavy infection, 1999, Group 1 – Group 2 difference is not statistically significant (p-value=0.101; published version reported significance at 90% confidence)[5]
Proportion anemic, 1999, Group 1 - Group 2 difference is not statistically significant (p-value=0.194; published version reported significance at 95% confidence)

***Table VI:***
PANEL A:
Grade progression, 1998, Group 1 Treated 1998 - Group 2 Treated 1998 difference is not statistically significant (p-value=0.160; published version reported significance at 95% confidence)
PANEL C:
School participation rate, May 1998 to March 1999, Group 1 Treated 1998 – Group 2 Treated 1999 difference is statistically significant at 90% confidence (p-value=0.060; published version reported significance at 95% confidence)

***Table VIII:***[6]
PANEL A:
Girls >= 13 years, Group 1 – Groups 2&3 difference is statistically significant at 90% confidence (p-value=0.054; published version reported significance at 95% confidence)

***Table IX:***[7]
Column (1), “treatment school” is statistically significant at 95% confidence (p-value=0.022; published version reported significance at 99% confidence)
Column (3), "second year as treatment school" is not statistically significant (p-value=0.111; published version reported significance at 90% confidence)
Column (4), "first year as treatment school" is statistically significant at 99% confidence (p-value=0.007; published version reported significance at 90% confidence)
Column (4), "1996 district exam score, school average" is significant at 90% confidence (p-value=0.072; published version reported this result to not be statistically significant)
Column (7), “moderate-heavy infection, early 1999” is significant at 95% confidence (p-value=0.038; published version reported significance at 90% confidence)

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[5] We thank Aiken *et al.* (2014) for pointing out this correction. For more information, see Aiken, A, Davey, C, Hayes, R and Hargreaves, J. (2014). “Re-analysis of health and educational impacts of a school-based deworming program in western Kenya: a pure replication”, 3ie Replication Paper 3, part 1. Washington, DC: International Initiative for Impact Evaluation (3ie).
[6] Note that these errors apply to the original version of the table, prior to utilizing the final data as described in Section 2. See Appendix A for the fully updated and corrected version of the table.
[7] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.

## 3.3 STATA coding issues

### 3.3.1 Local school and pupil population densities

Local school and pupil population measures are important in the estimation of cross-school externalities in Miguel and Kremer (2004). The data user will notice that in the "schoolvar.dta" data set, for each measure of the number of children or schools located within a certain distance (measures typically named "sch#_#km" or "pop#_#km" in the schoolvar.dta data set), there exist two variables. One variable has the suffix "_original" while the other variable has the suffix "_updated". The variables denoted "_original" were those used in the analysis in Miguel and Kremer (2004). However, during the preparation of this replication documentation, two coding issues were discovered in the creation of these original local density figures.

One coding issue truncated the number of schools that were counted in the school and population densities to twelve, rather than allowing all 74 other schools to be included in this count. Since there were no more than twelve schools located at distances of up to four kilometers from any given PSDP school, this issue does not affect school and population density figures in the published paper for distances of 0-3 kilometers. However, density figures for distances of 3-6 kilometers do change.[8] The key change is that Miguel and Kremer (2004) measured externalities among schools located within 3-6 kilometers that were among the 12 closest schools, rather than among all schools within 3-6 kilometers, as reported in the paper. While the former is a valid measure of externalities itself, we present an updated set of results here which consider all program schools located within 3-6 kilometers.

A second coding issue was discovered that miscalculated local density figures for three schools – identification numbers 108, 109, and 115. In particular, this error miscalculated densities in treatment group 1 for school 108, treatment group 2 for school 109, and treatment group 3 for school 115. For school 108 (a Group 3 school), the coding error resulted in ignoring all Group 1 schools in calculation of the local density terms – however, there were no Group 1 schools located within 6 kilometers of school 108, so the coding error literally had no effect on the data in this case. For school 109 (a Group 2 school), all Group 2 schools were ignored in calculation of the local density terms. There was only 1 Group 2 school located with 6 kilometers of school 109 (and no Group 2 schools located within 3 kilometers of school 109), so this error affected the 3-6 kilometers density term only (by missing one school), not the 0-3 kilometers term for this school. Finally, for school 115 (a Group 1 school), all Group 3 schools were ignored in calculation of the local density terms, and there were seven such schools within 6 kilometers of school 115. Hence, only two schools were affected by this coding error.

Due to these coding issues, use of these "_original" variables in future analysis is not recommended. The variables with the "_updated" suffix address these coding issues by incorporating all schools into the local school and population density calculations, and also employ

[8] In no case did a school have more than 12 schools within a 4 km radius, so externality terms up to that radius were correct. Three quarters of schools had twelve or fewer schools within 5 km. However, at distances greater than 5 km many schools are affected. The average school has 13 other schools within 6 km, and the maximum number of schools within 6 km of any school is 21.

a Geographic Information System (GIS) computer package to convert the GPS information into more precise measures of distance.[9]

Updating the local population density measures in this way affects results presented in Tables I (the last four rows), VII, IX, and X, as well as Appendix Tables AII-IV. Results in the paper do change somewhat once the local pupil density variables are updated. The tables in Appendix A to this document present the updated results, and we provide a discussion of these findings in Section 4. The key results of direct, within-school, and cross-school treatment externalities are still detected for both worm infections and for school participation.

#### *3.3.2 Moderate-heavy geohelminth infection, 1999*

Construction of the original "moderate-to-heavy geohelminth infection, 1999" variable contained a coding error which did not correctly incorporate roundworm moderate-to-heavy infections into this summary indicator variable. This mistake affects results in columns (7)-(9) of Table VII, although it does not change the substantive findings. The updated results, fixing this error, are provided in Appendix A of this document. We have included the original version of this variable in the data, named "any_geo99_original", for those who would like to replicate the original table. The variable "any_geo99_updated" contains the corrected data, and we recommend use of this corrected variable going forward.

#### *3.3.3 Table IX, "Treatment School Pupils within 3-6 km"*

A coding error was discovered in the calculation of a variable used only in column (3) of Table IX, "treatment school pupils within 3-6 km." This error summed Group 1 pupils within 0-3 kilometers and Group 2 pupils within 3-6 kilometers, rather than summing Group 1 and Group 2 pupils both within 3-6 kilometers. The error was corrected in the code written to produce Table IX, and the only substantive change in results was a loss of the marginal significance on the "second year as treatment school (T2)" term. The updated results can be seen in Appendix Table A9.

### *3.4 Other typos or errors*

The remaining errors appear to be typographical errors, mislabeling of results, or are due to our failure to fully update all empirical results during the journal revision process, combined with the use of "intermediate" versions of the data in earlier paper drafts.

***Table I:***
Panel A, Row 3: The Group 1, Group 2, and Group 3 means should read as -2.0, -1.8, and -2.0, respectively.

***Table II:***
It may be clearer to title the last column of this table "average worm load," rather than "average infection intensity" as it was originally titled.[10]

[9] The original variables were generated manually using a simple mathematical formula to covert GPS figures into distances. The updated variables now provide a more precise measure of local school and pupil population densities.
[10] We thank Aiken *et al.* (2014) for pointing out this clarification.

The figure listed as "at least two infections, prevalence of infection" in fact corresponds to "exactly two infections, prevalence of infection". The value for "at least two infections, prevalence of infection" would be 0.65.

The figure listed as "at least three infections, prevalence of infection" in fact corresponds to "exactly three infections, prevalence of infection". The value for "at least three infections, prevalence of infection" would be 0.34.

***Table V:***

Table notes, obs. for parasitological results: 1,466 for Group 2 (published version 1,467)

Table notes, obs. for hemoglobin results: 769 total (published version 778), 290 for Group 1 (published version 292), 479 for Group 2 (published version 486)

Table notes, obs. for 1999 Pupil Questionnaire health outcomes: 9,039 total (published version 9,102), 3,545 for Group 1 (published version 3,562), 5,497 for Group 2 and Group 3 (published version 5,540)

Column headings: Although the table notes in Miguel and Kremer (2004) did note that observations from Group 3 were included in the outcomes collected in the 1999 Pupil Questionnaire, it was not clear in the table that for these outcomes, the "Group 2" column actually summarizes data from Groups 2 and 3, and for the "Group 1 – Group 2" column, results are shown for "Group 1 – Groups 2&3". The affected outcome variables include "sick in past week", "height-for-age Z-scores", "weight-for-age Z-scores", "clean" and "days contact with fresh water in past week". We have annotated this table appropriately in the fully updated tables in Appendix A.[11]

***Table VI:***

PANEL A:

The difference between "malaria/fever in past week (self-reported), 1998" for Group 1 untreated 1998 and Group 2 untreated 1999 has a coefficient of 0.02 (published version -0.01)

PANEL B:

The difference between "whipworm moderate-heavy infection, 1999" for Group 1 Treated 1998 and Group 2 Treated 1999 has standard error 0.05 (published version 0.16)

The mean for "any moderate-heavy infection, 1998" for Group 1, Untreated Girls >=13 years is 0.30 (published version 0.28)

PANEL C:

The "school participation rate, May 1998 to March 1999" for group 1 untreated in 1998 is 0.774 (published version 0.764)

The "school participation rate, May 1998 to March 1999" for group 2 untreated in 1998 is 0.690 (published version 0.684)

The difference between "school participation rate, May 1998 to March 1999" for group 1 treated 1998 and group 2 treated 1999 has a standard error of 0.033 (published version 0.032)

The difference between "school participation rate, May 1998 to March 1999" for group 1 untreated 1998 and group 2 untreated 1999 has a coefficient of 0.084 (published version 0.080) and a standard error of 0.037 (published version 0.039)

TABLE NOTES:

[11] We thank Aiken *et al.* (2014) for pointing out this clarification.

Obs. for the parasitological survey: 669 Group 1 treated 1998 (published version 670), 76 Group 1 untreated 1998 (published version 77), 874 Group 2 treated 1999 (published version 873), 349 Group 2 untreated 1999 (published version 352)

***Table VII:*** [12]
Columns (7)-(9), Mean of dependent variable: 0.26 (published version 0.32)

***Table VIII:*** [13]
Panel A, Row 3: Column (1) 0.797 (published version 0.795), Column (2) 0.689 (published version 0.688), Column (3) 0.707 (published version 0.703)
Table Notes: The analysis in this table was weighted by the number of pupil observations, rather than the number of pupils per school as reported in the published version of the paper.[14]

***Table IX:***
Column (4), Mean of dependent variable: 0.793 (published version 0.784)
Column (5), Mean of dependent variable: 0.793 (published version 0.784)
Column (7), Root MSE: 0.069 (published version 0.773)
Table notes: Each pupil-year observation in this table was weighted by the number of times the pupil was observed in that year. Weighting was not described in the published version of this table.[15]

***Table X:***
Columns (1) and (2), Number of observations: 24979 (published version 24958)

***Appendix Table AII:***[16]
Column (1), standard error of "treatment school pupils within 3 km" is 0.08 (published version 0.06)
Column (1), standard error of "treatment school pupils within 3-6 km" is 0.06 (published version 0.07)
Column (1), standard error of "total pupils within 3 km" is 0.06 (published version 0.05)
Column (1), standard error of "total pupils within 3-6 km" is 0.04 (published version 0.06)
Column (1), mean of dependent variable is 0.76 (published version 0.66)
Column (2), standard error of "treatment school pupils within 3-6 km" is 0.06 (published version 0.05)
Column (2), standard error of "total pupils within 3 km" is 0.07 (published version 0.08)

***Appendix Table AIII:***[17]

[12] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.
[13] Note that these errors apply to the original version of the table, prior to utilizing the final data as described in Section 2. See Appendix A for the fully updated and corrected version of the table.
[14] We thank Aiken *et al.* (2014) for pointing out this correction.
[15] We thank Aiken *et al.* (2014) for pointing out this clarification.
[16] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.
[17] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.

Column (8), standard error on “group 1 pupils within 3 km”: 0.03 (published version 0.02)
Column (8), “Group 1 pupils within 3 km” is statistically significant at 95% confidence (published version 99% confidence)
Column (8), coefficient on “group 1 pupils within 3-6 km”: -0.06 (published version -0.05)
Column (8), standard error on “group 1 pupils within 3-6 km”: 0.02 (published version 0.01)
Column (8), standard error on “total pupils within 3 km”: 0.02 (published version 0.01)
Column (8), “total pupils within 3 km” is statistically significant at 90% confidence (published version 99% confidence)
Column (8), coefficient on “total pupils within 3-6 km”: 0.03 (published version 0.04)
Column (8), standard error on “total pupils within 3-6 km”: 0.02 (published version 0.01)
Column (8), “total pupils within 3-6 km” is statistically significant at 95% confidence (published version not significant)
Column (8), “moderated-heavy schistosomiasis infection, 1998” is statistically significant at 95% confidence (published version 99% confidence)
Columns (1), (3), (5) and (7), number of observations: 2328 (published version 2326)

***Appendix Table AIV:***[18]
Columns (1) and (2), number of observations: 2328 (published version 2326)
Column (2), root MSE: 0.447 (published version 0.446)
Columns (3) and (4), mean of dependent variable: 0.793 (published version 0.784)

[18] Note that these errors apply to the original version of the table, prior to correcting coding errors described in Section 3.3. See Appendix A for the fully updated and corrected version of the table.

## 4. Discussion of Updated Results and Additional Analysis

### *4.1 Overview*

Appendix A of this document presents the tables in Miguel and Kremer (2004), updated to: (1) use the "final" versions of all datasets, (2) define local treatment externalities among all 75 schools rather than a subset of schools, and (3) correct all rounding, significance level, typographical, and coding errors. Note that for clarity, in what follows we distinguish tables in the appendices of this document from table numbers in Miguel and Kremer (2004), which are listed using Roman numerals (i.e., I, II, etc.), by using Arabic numerals (i.e., A1, A2, …).

The results in tables A1-A6, A8, A10, and AA2 are almost identical to those in the published paper. Tables A7, A9, AA3, and AA4, using the updated data and local density measures as described in Sections 2 and 3 above, continue to show substantial impacts of deworming treatment on eradicating helminth infections and improving school participation, as well as positive externalities across both outcomes on untreated pupils in treatment schools, and on pupils within three kilometers of treatment schools. These findings support the two key claims made in Miguel and Kremer (2004), namely: (1) deworming creates positive epidemiological externalities, thus causing estimates of the impact of deworming based on individual randomization to be biased downwards; and (2) deworming increases school participation. In what follows, we discuss where the updated results differ from the original paper, and how we interpret these new findings.

### *4.2 Baseline characteristics – Tables I and II*

Tables I and II summarize the baseline characteristics of PSDP schools and pupils. The results presented in the updated version of these tables (in Appendix A of this document) are nearly identical those presented in Miguel and Kremer (2004).

Appendix Table A1 confirms that program groups were similar at baseline across most demographic, health, and socioeconomic characteristics. As in the published version of the paper, no statistically significant differences were detected in baseline gender, proportion of individuals eligible for treatment, school attendance (as reported in school registers), grade progression, assets, access to a latrine at home, weight-for-age, or self-reported malaria. School characteristics were also balanced across groups, with no statistically significant differences in baseline enrolment, average exam scores, sanitation facilities, zonal infection prevalence, distance to Lake Victoria, or density of students enrolled in nearby schools. Also in line with the published version of the analysis, to the extent that individuals in treatment and comparison schools did differ, those in treatment schools were relatively worse off – Group 1 students had significantly more self-reported blood in stool (a symptom of schistosomiasis infection) and were less likely to be described as "clean" by NGO field workers (a measure of health behavior). The only result in Appendix Table A1 that is substantively different from the published version of the paper is that on self-report "sick often" – the difference in self-reported health between Group 1 and Group 2 individuals is not statistically significant at traditional confidence levels (p=0.181), although the self-reported health of Group 2 pupils remains worse than that of Group 3 pupils (p=0.065, a lower level of confidence than in the published version).

Appendix Table A2 presents worm infection rates among Group 1 pupils at baseline. Results of this table are nearly identical to the published version. Ninety-two percent of screened pupils had at least one helminth infection, with rates higher among younger children and boys. Sixty-five percent of screened individuals had at least two infections, and 34% had at least three infections. (Note that the published version of this table incorrectly reported "exactly two infections" and "exactly three infections" rather than "at least"). Individuals living close to Lake Victoria were substantially more likely to have a schistosomiasis infection.

### *4.3 Treatment compliance and transfers across schools – Tables III and IV*

Appendix Table A3 provides a summary of treatment compliance during 1998 and 1999. The updated results are again nearly identical to the published version. Seventy-seven percent (published version: 78%) of individuals eligible and assigned to receive treatment in 1998 received at least some treatment. Twenty percent (published version: 19%) of girls aged thirteen or older who were assigned to receive medical treatment also received it in 1998. Among students still enrolled in school in 1999, compliance rates were fairly similar to the first year of treatment – among those eligible, 73% of Group 1 and 71% of Group 2 individuals received treatment. As in the published version, 1999 compliance among those enrolled in 1998 were substantially lower, due to individuals dropping out of school between years. Among girls under thirteen years of age and all boys enrolled in treatment schools in 1998, 56% (published version: 57%) received treatment at some point in 1999, while only 8% (published version: 9%) of girls aged 13 and older received treatment in 1999. Fewer than 2% of individuals in control group schools received treatment in 1998 or 1999.

Appendix Table A4 summarizes transfers across schools in different groups in 1998 and 1999. Again the updated results are essentially identical to the published version of the table. There is no evidence of asymmetric flows of students into treatment schools, with similar proportions transferring into all three groups of schools in both 1998 and 1999.

### *4.4 Health outcome differences, ignoring externalities – Table V*

Appendix Table A5 studies the differences in health outcomes and health behaviors in early 1999, comparing individuals assigned to 1998 treatment schools with those assigned to 1998 comparison schools without yet accounting for deworming treatment externalities. With regard to worm infection outcomes, results in the updated analysis are almost identical to those in the published version of the analysis. Twenty-seven percent of pupils in Group 1 (1998 treatment) schools had a moderate-to-heavy helminth infection in early 1999, compared to 52% in Group 2 (1998 comparison) schools (p-value≤0.01). Hookworm, roundworm, whipworm, and schistosomiasis moderate-to-heavy infections were all lower in Group 1 individuals, although this result is not statistically significant at traditional levels of confidence for the latter two helminthes.[19] (Note that the published version of the paper reported the schistosomiasis reduction as significant at 90% confidence, but the p-value is actually 0.101). Both the original and updated versions of Panel B thus suggest substantial benefits of deworming on helminth infections.

Panel B of Appendix Table A5 presents findings related to other nutritional and health outcomes. The original version of the tables reported a 4% (updated version: 5%) reduction in individuals reporting being "sick in past week" (p≤0.05) and a 3% reduction in reporting being "sick often" (p≤0.05). The original analysis also suggested an increase in height-for-age (p≤0.1) among treated individuals, which suggests nutritional improvements. Furthermore, there were no statistically

[19] Recall that treatment for schistosomiasis was only provided in the subset of schools with sufficient prevalence of the disease, typically in schools that were close to Lake Victoria.

significant differences detected in weight-for-age z-score or hemoglobin concentration. These results are the same in the updated analysis presented in Appendix A.

The original and updated results differ on anemia. The published paper reported a 2 percentage point reduction in the proportion of anemic individuals (on a 4 percentage point base) at 95% confidence, but this was based on dividing a rounded coefficient by a rounded standard error. When unrounded values of the coefficient and the standard error are used in the updated tables, the result is insignificant (p=0.19). Anemia was unlikely to be an import channel in any case – as stated in Miguel and Kremer (2004, page 174), severe anemia is relatively rare in the study area, in contrast to other regions where intestinal worm infections are prevalent.

Taking the results of Panel B together, both the published and updated versions of the analysis suggest gains in health and nutrition due to deworming treatment. Panel C of Appendix Table A5 explores treatment impacts on worm infection prevention behaviors, including personal cleanliness, wearing shoes, and contact with fresh water. No statistically significant impact was found on any of these behaviors (either in the published paper or the updated analysis).

### *4.5 Within-school externalities for worm infection outcomes – Table VI*

Appendix Table A6 provides evidence in support of several claims made in Miguel and Kremer (2004).

Page 178 of the main text indicates that sicker individuals were less likely to obtain deworming treatment, either because they were more likely to be absent on the day of treatment or because their households were less able or likely to invest in health. This result is unchanged in the updated tables. In particular, prior to treatment in 1998, 39% of eligible Group 1 individuals who would go on to be treated had a moderate-to-heavy helminth infection, and 44% of eligible Group 1 pupils who would not later be treated had such an infection. Similarly, prior to treatment in 1999, 51% of eligible Group 2 pupils who would go on to be treated had a moderate-to-heavy helminth infection, and 55% of eligible Group 2 pupils who would not later be treated had such an infection. Among girls aged 13 or older, who were ineligible for treatment, 1998 Group 1 infection rates were similar across those who would and would not be treated, while 1999 Group 2 infection rates were substantially higher among the group that would later receive no treatment.

The crux of Table VI explores with-in school externalities for worm infection outcomes, by comparing outcomes in early 1999 between untreated individuals in 1998 treatment and comparison schools. Panel A suggests that there are no statistically significant differences between these two groups at baseline across five characteristics likely to be associated with child health – latrine ownership, grade progression, weight-for-age, self-reported health status, and cleanliness – and that point estimates suggest that Group 1 untreated individuals are slightly worse off across these characteristics. This finding is unchanged in the updated version, Appendix Table A6. Panel B indicates that among eligible individuals (girls under age 13 and all boys), rates of moderate-to-heavy infections were 21 percentage points lower among Group 1 pupils who were not treated in 1998 than among Group 2 pupils who were untreated in 1999, and this difference is statistically significant ($p \leq 0.05$). Broken out by type of worm infection, these differences are statistically significant for hookworm ($p \leq 0.1$) and roundworm ($p \leq 0.05$) but not for schistosomiasis or whipworm. Again, these findings are unchanged in the updated table presented in Appendix A of this document. These results are consistent with substantial positive within-school deworming treatment externalities.

### *4.6 Cross-school externalities for worm infection outcomes – Table VII*

As described in Section 3.3.2, although Miguel and Kremer (2004) report on externalities among all schools located with 0-3 kilometers and 3-6 kilometers, they actually estimate externalities for only a subset of these schools. In Appendix A, we reproduce Tables VII, IX, and X, including all schools in the 0-3 and 3-6 kilometers externality terms. Although the substantive results remain – that deworming has substantial direct, within-school, and cross-school externality impacts on worm infections and on school participation – both the magnitudes and range of these effects are changed. We detail these changes in what follows.[20]

Appendix Table A7 estimates the direct, within- and cross-school impacts of deworming treatment on helminth infections, following Table VII of Miguel and Kremer (2004). A comparison of the published version and a version looking at effects at 3 and 3-6 kilometers reveals direct effects and within-school externality effects that are generally larger in magnitude and more precisely estimated than in the original paper for any moderate-to-heavy infections (left panel), moderate-to-heavy schistosomiasis infections (center panel), and moderate-to-heavy geohelminth infections (right panel). There is also strong evidence of cross-school externality impacts from treated pupils attending schools located 0-3 kilometers for any moderate-to-heavy helminth infections and moderate-to-heavy schistosomiasis infections, although the magnitude of this effect is slightly smaller than in the published paper in some cases. There is no longer any evidence of cross-school externality impacts for moderate-to-heavy geohelminth infections at a distance of 0-3 kilometers, a finding which was marginally significant in the published paper.

In the updated table, which uses fully finalized, corrected data and incorporates all schools in the externality measures, there is no evidence of cross-school externalities at a distance of 3-6 kilometers for any moderate-to-heavy helminth infections, a result which was statistically significant at 95% confidence in the published paper. There is evidence that the longer-range 3-6 kilometers externalities exist for schistosomiasis infections, consistent with the mode of disease transmission in comparison to that of geohelminths (p-value≤0.01 in both the published version and updated version). There was no evidence of cross-school externalities at a distance of 3-6 kilometers for moderate-to-heavy geohelminth infections in the published paper, and that remains the case in the updated analysis.

In sum, Appendix Table A7 continues to provide evidence for direct impacts of deworming on helminth infections, as well as within-school and cross-school externalities. Cross-school externalities are detected at a distance of 0-3 kilometers, but not beyond. We revisit this finding in the discussion of the calculation of the overall impacts of deworming on worm infections and school participation in Section 4.9 below.

### *4.7 School participation impacts - Tables VIII and IX*

Appendix Table A8 explores differences in school participation in the first two years of the program across years and groups, comparing individuals assigned to treatment schools with those

[20] It is worth noting that the approach in Miguel and Kremer (2004) still produces a well-defined statistic, i.e., an externality measure that focuses on up to the 12 closest schools. In fact, many influential recent empirical explorations of social effects employ related measures, for instance, measures of social networks that restrict attention to an individual's 10 or 15 "closest" acquaintances (see for instance, Conley and Udry, 2010). Hence the use of this statistic is still meaningful in assessing the presence of externalities, but it does of course have a different interpretation than the one provided in the original paper.

assigned to comparison schools without yet accounting for deworming externalities. Although several rounding errors are corrected, the substantive results of this table are unchanged from the analysis presented in Miguel and Kremer (2004), Table VIII. In particular, among eligible pupils (girls under 13 years old and all boys) the difference in school participation in the first year after treatment is 9.3 percentage points (same as the published version), and this is significantly different from zero at 99 percent confidence. This difference is larger than for that of older girls (5.6 percentage points; published version 5.7), few of whom were treated. In the second year of treatment, the difference in school participation among eligible pupils is 5.1 percentage points for Group 1 schools (published version: 5.0) and 5.4 percentage points for Group 2 schools (published version 5.5). Furthermore, following the findings of the published paper, school participation gains are largest among the youngest students. In 1998, the average difference in participation between treatment and comparison groups for preschool through grade 2 was 10.0 percentage points, while for pupils in grades 6 to 8 it was 5.8 percentage points (published version: 5.9). A similar pattern holds for the 1999 school participation data.

Appendix Table A9 explores externality impacts of deworming on school participation, updating Miguel and Kremer (2004) Table IX. Recall that use of the final data and updating calculations of the local population density terms to incorporate all nearby schools leads nearly every result in this table to change slightly. However, the substantive results are unchanged.

Columns (1) and (2) of Appendix Table A9 present "naïve" deworming treatment effects, ignoring externalities. Average school participation across both years of the program (1998-1999) is 5.7 percentage points higher in treatment schools (p-value≤0.01; published version: 5.1). Average participation is 6.3 percentage points higher for the first year of treatment (p-value≤0.01; published version: 6.2), and 3.9 percentage points higher for the second year of treatment (p-value≤0.1; published version: 4.0).

Column (3) estimates the cross-school externality impacts on school participation. Each additional thousand pupils attending treatment schools within 3 kilometers increases school participation by 4.0 percentage points (p-value≤0.1; published version: 4.4). The point estimate on the 3-6 kilometers externality term in the school participation analysis was negative but not statistically significant in the original Miguel and Kremer (2004) analysis, and remains so in the updated analysis. The fact that externalities on "any moderate–to-heavy infections" among all schools in the 3-6 kilometers range are not significant (with the updated data, see Appendix Table A7) suggests that we should not necessarily expect to find school participation externalities at this distance.

Columns (4) and (5) restrict the school participation analysis to just the first year of data, in order to explore within-school externalities. Column (5) reports a school participation gain of 5.6 percentage points for untreated individuals in treatment schools (p-value≤0.01).

Finally, columns (6) and (7) explore the relationship between moderate-to-heavy worm infections and school participation. Again, results match the published paper closely. OLS estimation reports that pupils with moderate-to-heavy worm infections in early 1999 had 2.5 percentage points (p-value≤0.05; published version: 2.8) lower school participation over the previous year. The corresponding finding using IV-2SLS estimation is a 19.5 percentage point reduction (p-value≤0.05; published version: 20.3).

### *4.8 Test score impacts - Table X*

Appendix Table A10 explores deworming impacts on test scores in the first two years of the program, following Miguel and Kremer (2004), Table X. Although estimated magnitudes change slightly, the substantive results are the same. In particular, differences in test scores across the treatment and comparison groups are not significant – the point estimates are -0.035 standard deviations (published version: -0.032) in the first year after treatment, and -0.015 standard deviations (published version: 0.001) in the second year after treatment – but neither of these findings is statistically significant in the updated analysis or the original analysis. Results restricting the sample to those who responded to the 1998 pupil survey (column 3) are similar.

### *4.9 Estimating average treatment externalities and the "overall effect" of deworming*

As described in Sections 4.6 and 4.7, the updated analysis presented in Appendix A suggests substantial deworming externalities, both for any moderate-to-heavy worm infections and for school participation, within schools and across schools up to a distance of 3 kilometers. In particular, Appendix Table A7 shows large within- and cross-school reductions in moderate-to-heavy helminth infections, on top of the direct impacts of deworming on treated individuals. The cross-school reductions in moderate-to-heavy infections are focused among schools located within 3 kilometers of treatment schools. Similarly, Appendix Table A9 shows significant impacts of deworming on school participation for treated individuals and untreated individuals in treatment schools. The impacts on individuals in schools located within 3 kilometers of treatment schools are similar in magnitude although somewhat weaker than reported in the original paper. Neither the original nor the updated tables suggest externality impacts on school participation for schools located 3-6 kilometers from treatment schools.

In thinking about the distance over which we might expect to see externalities, it is worth reviewing the nature of disease transmission for intestinal helminths. Geohelminths are deposited in stool, and while adults in the area typically use latrines, children are more likely to defecate in the open. This can lead to transmission of geohelminths when children defecate near their school or home – thus externalities should be fairly localized nearby. In contrast, schistosomiasis involves transmission through fresh water (via intermediate snail hosts) and in the study area can be transmitted when children travel to Lake Victoria to bathe or fish. It is thus likely to be transmissible over somewhat larger distances than geohelminths, particularly as part of the life cycle of the parasite occurs in snails and the snails themselves are mobile. Treatment for geohelminths was provided in all treatment schools, while treatment for schistosomiasis was only provided in those schools with sufficient prevalence of the disease, typically in schools that were located near Lake Victoria.

As described in Miguel and Kremer (2004, page 186), there are no clear *a priori* grounds pinning down the particular distance at which to test for externalities. In the initial stages of the analysis, we focused on the schools closest to the treatment schools. Finding evidence for positive deworming treatment effects on both worm infections and school participation at those distances – and knowing that effects could be biased downward if spillover effects were not included – impacts were then estimated at even greater distances from each school, as long as they could be estimated with sufficient precision. Note that the key test in Miguel and Kremer (2004) for the existence of externality effects lies in the statistical significance of externalities. As long as externalities are significant at any distance, simple treatment minus control estimates will underestimate program effects. While the original paper could not rule out externalities beyond 6 kilometers, estimating of externalities beyond this distance was not possible due to imprecision.

Appendix Tables B1 and B2 present the updated and original results for the impact of deworming on helminth infections and school participation, respectively, side by side (columns 3 and 6). As shown in Appendix Table B1, the standard error on the average overall 3-6 kilometers externality effect nearly doubles in the estimation of infection externalities, jumping from 0.042 (results from the original paper, in column 6) to 0.079 in column 3 (results using the updated data). Similarly, the standard error in the estimation of school participation effects is more than twice as large (comparing the standard error of 0.011 in column 6 to the standard error of 0.024 in column 3 of Appendix Table B2). This marked reduction in statistical precision is also clear visually in Appendix Figure B1, where the 95% confidence intervals increase substantially once the updated 3-6 kilometers externality effects are included, for both infection outcomes and school participation outcomes. These large confidence intervals are relatively uninformative, and also lead the estimate of total deworming impacts to be much less precisely estimated.

If we focus on the reasonably precise estimates of the overall effect, then consistent with our original approach, including the 3-6 kilometers effect is inappropriate with the updated data. The best way to think about this is that including these 3-6 kilometers externalities is like adding a very "noisy zero" estimate to what is otherwise quite a precise estimate. It is appropriate to focus on the estimator that includes the "naïve" treatment minus control difference plus the 0-3 kilometers externalities, since these are both precisely estimated, and these together constitute a lower bound on the overall effect of deworming under the reasonable assumption that deworming externality effects are non-negative. Even focusing on the precisely estimated "naïve" estimator – the simple treatment minus control difference – which is downward biased since it excludes all cross-school externality effects, would be preferable to employing the estimator that incorporates externalities from 3-6 kilometers, since the naïve estimator is precisely estimated and provides a lower bound on the magnitude of the true effect.

A more formal decision-making framework for considering the inclusion of additional externality estimates incorporates the usual goal of choosing an estimator that minimizes "mean squared error". Recall that mean squared error (MSE) is the sum of the variance of an estimator plus the square of its bias. Including further externality terms in the analysis helps reduce bias in the estimation of the overall effect (by capturing more of the externalities) but the analyst faces a trade-off if their inclusion increases the variance of the resulting estimator. In cases where standard errors increase dramatically with the inclusion of additional terms, MSE is reduced by focusing on precisely estimated effects that constitute a lower bound on the true overall effect.

The results presented in Appendix Tables B1 and B2 illustrate this point. (Note that we focus on estimates for "any moderate-to-heavy infection." Analyses focusing only on geohelminth or only on schistosomiasis outcomes would likely differ and would be a reasonable topic for future work.) Using the original data, including the 3-6 kilometers externality effect in the overall deworming effect does not appreciably increase the standard error on the overall effect on deworming: the standard error remains unchanged at 0.055 when this term is included in the worm infection analysis (as shown in the bottom row of columns 5 and 6, Appendix Table B1), and similarly the standard error on the overall effect remains nearly unchanged in the school participation analysis (comparing columns 5 and 6 of Appendix Table B2). Hence, with this data, there does not appear to be much of a trade-off between bias and statistical precision in moving beyond 3 kilometers at all. Moreover, with the original data the 3-6 kilometers externality effect is statistically significant on its own (Appendix Table B1, column 6), so it is natural to include it in the calculation of overall effects. While this externality effect is not significant for school participation using the original data (Appendix Table B2, column 6), it is reasonable to consider the possibility that there might be schooling externalities at that distance, given the worm infection externality gains at 3-6 kilometers.

In contrast, the pattern of results achieved after incorporating all schools within 3-6 kilometers indicates that it is not appropriate to include this in the calculation of overall deworming impacts. First, the 3-6 kilometers externality effect is not statistically significant for either worm infections (with a coefficient estimate of -0.050 and standard error of 0.077, implying a p-value of 0.52, in Appendix Table B1 column 3), or for school participation (Appendix Table B2, column 3). Second, there is a tremendous loss of statistical precision in the overall effect estimate when 3-6 kilometers externality effects are included in the calculation. For worm infections, the standard error on the overall effect estimate increases by 50% (from 0.061 to 0.091, Appendix Table B1 columns 2 and 3) when the 3-6 kilometers externality effect is included. For school participation, the standard error on the overall effect estimate nearly doubles, from 0.017 to 0.032 (Appendix Table B2, columns 2 and 3). This doubling of the standard error in the school participation analysis is equivalent to increasing the variance of the estimator roughly four-fold, so the reduction in bias from including the 3-6 kilometers externality effect would have to be very large to justify its inclusion under the criterion of minimizing the MSE. Yet it is unlikely that the 3-6 kilometers externality effect on school participation is substantial given the lack of worm infection externality impacts at 3-6 kilometers.

Indeed, some straightforward calculations suggest that the estimator that excludes the 3-6 kilometers externality terms from the calculation of overall deworming impacts on school participation is preferable under the criterion of minimizing MSE (assuming the alternative is only including 0-3 kilometers externalities). In particular, we show that the increase in MSE due to additional noise from including the 3-6 kilometers term is likely to be more than six times greater than any decrease in the MSE due to reducing bias.

To see this, define the estimator that includes the Treatment minus Control effect plus the 0-3 kilometers externality effect as $\beta_1$ (this is the estimate presented in the bottom row of Appendix Table B2, column 2), and the estimator that also includes the 3-6 kilometers externality effect as $\beta_2$ (column 3). An estimate of the variance of $\beta_1$ is the square of its standard error ($0.017^2$), and similarly for the variance of $\beta_2$ ($0.032^2$). For simplicity, we conservatively assume that $\text{Bias}(\beta_2) = 0$, in other words, all deworming externality effects are captured within 6 kilometers. The estimator that excludes the 3-6 kilometers externality terms is preferred under the mean squared criterion – in other words, $\text{MSE}(\beta_1) < \text{MSE}(\beta_2)$ – as long as $\text{Bias}(\beta_1)^2 < (0.032^2 - 0.017^2) = 0.000735$, or equivalently, if $\text{Bias}(\beta_1) - \text{Bias}(\beta_2) < (0.000735)^{1/2} = 0.027$.

Even if one makes the far weaker assumption that the overall externality effect on school participation at 3-6 kilometers is simply equal to or smaller than that from 0-3 kilometers, one reaches the same conclusion that MSE decreases when the 3-6 kilometers externality term is excluded. Recall from Appendix Table B2, column 2 that the overall 0-3 kilometers externality effect on school participation is also (coincidentally) 0.027. Thus the estimator that excludes the 3-6 kilometers externality effects ($\beta_1$) has a smaller MSE if the overall externality effect at 3-6 kilometers is smaller than the 0-3 kilometers effect. This is a very natural "monotonicity" assumption given the nature of worm transmission and reinfection, which tend to be locally concentrated and should fall at greater distances from a treatment school.

The comparison of columns 2 and 3 in Appendix Table B2 further illustrates this point. The total estimated effect incorporating the "naïve" treatment minus control difference plus the 0-3 kilometers effect is 0.085 (s.e. 0.017), significant at 99% confidence. The total estimated effect incorporating externalities out to 6 kilometers has a standard error of 0.032, nearly twice as large as the standard error only considering externalities out to 3 kilometers. Regarding the negative 3-6 kilometers point estimates, there is no obvious epidemiological reason to our knowledge why the 3-6 kilometers effects on school participation would be negative, especially given the large, positive and significant externality effects we estimate both within-schools and within 3 kilometers of treatment schools. We instead believe the negative and very far from statistically significant point estimates on the 3-6 kilometers school density are most likely to be "noisy zeros", as mentioned above. It is worth mentioning again that even in Miguel and Kremer (2004) the 3-6 kilometers externality effect on school participation was not statistically significant, but this ”zero” effect becomes considerably noisier with the updated data.

In fact, if one includes all schools within 3-6 kilometers, the "naïve plus 0-3 kilometers" effect is nearly unchanged for worm infections (comparing the column 2 and column 5 results at the bottom of Appendix Table B1), and the school participation effect is slightly larger when all schools within 3-6 kilometers are included with a somewhat smaller standard error than in the original estimation. Both the infection and school participation effects are large in magnitude and statistically significant at over 99% confidence considering externalities out to 3 kilometers (see column 2 of Appendix Table B1 and column 2 of Appendix Table B2, respectively). Thus there remains considerable evidence that deworming led to reductions in worm infections and large improvements in school participation. But the effects including all schools within 3-6 kilometers are simply too imprecisely estimated to be usefully employed in the analysis.

Since no particular distance at which to examine externalities was pre-specified in advance of analyzing the data for the published paper, readers might be concerned about the possibility of data mining and selective presentation of analytical results, and wonder just how robust the externality results truly are. It is straightforward to show that the positive deworming externality results across nearby schools are robust to using different distances and specifications. For worm infections, the externality effects are statistically significant at 95% confidence at distances of both 0-3 and 0-4 kilometers (Appendix Table B3, columns 3 and 4) and significant at 90% confidence at distances of 0-5 and 0-6 kilometers (columns 5 and 6). Note that as one gets further away, one would expect the spillovers from any given school to be smaller, but the "overall" effect from multiplying the average spillover times the number of schools to stay constant or grow. The magnitude of the "overall" cross-school externality benefits become larger at increasing distances, although they are estimated with considerably less precision, especially beyond 4 kilometers (Appendix Figure B2, Panel A). (Externality estimates are also imprecisely estimated for schools within 1 kilometers from the reference school, since very few schools are located this close together.)

The same pattern is evident for school participation externalities. The impact of cross-school externalities is positive and statistically significant at 95% confidence at distances of 0-2, 0-3 and 0-4 kilometers (Appendix Table B4, columns 2-4), and the magnitude is largest for the 4 kilometers radius. Once again externality effects increase at larger distances, in this case up to 4 kilometers, after which confidence intervals become considerably wider (Appendix Figure B2, Panel B). In all of these regression specifications, the naïve effect on treatment schools is nearly unchanged, ranging between gains of 0.057 and 0.063 and is significant at over 99% confidence.

### *4.10 Estimates of overall deworming effects on helminth infections and school participation*

In this section, we update the calculations for the "average cross school externality" effect and "overall" effect of deworming on any moderate-to-heavy helminth infections and on school participation. Applying the MSE decision-making framework presented in Section 4.9 to the updated analysis presented in Appendices A and B suggests that if one uses a fixed multiple of 3 kilometer cutoff rule, then calculations of the "overall" effect of deworming on worm infections and school participation should include estimates of deworming externalities in the 0-3 kilometers range, and not all schools within 3-6 kilometers. Appendix Tables B5-B7 reproduce the key results of Miguel and Kremer (2004), using the fully updated data and omitted the 3-6 kilometers externality terms, for moderate-to-heavy worm infections, school participation, and test scores. These tables contain our preferred[21] analysis of the updated data, and replace Tables VII, IX and X of the original paper.

When these 3-6 kilometers terms are omitted, externality effects are strong both within schools, and across schools up to 3 kilometers away, both for worm load and for school participation. As shown in column 2 of Appendix Table B1, using the updated data, **the estimated average cross-school externality effect of deworming on worm infections is a reduction of 10.2 percentage points (s.e. 4.3, p-value≤0.05), and the overall deworming effect on worm infections is a reduction of 43.5 percentage points (s.e. 6.1, p-value≤0.01).** This is similar to the overall effect measured in Miguel and Kremer (2004) using the original data (46 percentage points, s.e. 5.5, p-value≤0.01).

As shown in column 2 of Appendix Table B2, **the estimated average cross-school externality effect of deworming on school participation is a gain of 2.7 percentage points (s.e. 1.3, p-value≤0.05), and the overall effect of deworming on school participation is a gain of 8.5 percentage points (s.e. 1.6, p-value≤0.01).** This overall effect is larger than estimated in Miguel and Kremer (2004) using the original data (7.5 percentage points, s.e. 2.7, p-value≤0.01).

For those interested in policy implications, Appendix Figure B3 shows that the "cost-effectiveness" of deworming in terms of boosting school participation is nearly unchanged relative to the original paper, using the updated data and considering the direct effects and the externalities up to 3 kilometers, with 34.3 additional years of school participation per $100 of spending on deworming with the updated data (versus 29.1 additional years per $100 in the original analysis). Focusing on the most conservative treatment effect estimate, the "naïve" Treatment minus Control difference, also implies that deworming is a highly cost-effective approach to reducing school absenteeism in this setting, with 17.8 additional years of school participation per $100 of deworming spending, placing it among the most cost-effective interventions yet evaluated in education studies, as shown in the figure.

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[21] This is preferred within the restricted set of "multiples of 3 km." Future work could examine the globally preferred estimate according to the MSE criterion.

## 5. Appendix A: Updated Tables from Miguel and Kremer (2004)

This appendix includes all tables in Miguel and Kremer (2004), updated to: (1) use the "final" versions of all datasets, (2) define local treatment externalities among all program schools, and (3) correct all rounding, significance level, typographical, and coding errors. Note that for clarity, we distinguish the tables in this appendix from the tables in Miguel and Kremer (2004), which are listed using Roman numerals (i.e., I, II, etc.), by using Arabic numerals (i.e., A1, A2, …).

**Table A1: Miguel and Kremer (2004) Table I -**
**1998 Average pupil and school characteristics, pre-treatment†**

| | Group 1 (25 schools) | Group 2 (25 schools) | Group 3 (25 schools) | Group 1 – Group 3 | Group 2 – Group 3 |
|---|---|---|---|---|---|
| *Panel A: Pre-school to Grade 8* | | | | | |
| Male | 0.53 | 0.51 | 0.52 | 0.01 | -0.01 |
| | | | | (0.02) | (0.02) |
| Proportion girls < 13 years, and all boys | 0.89 | 0.89 | 0.88 | 0.00 | 0.01 |
| | | | | (0.01) | (0.01) |
| Grade progression (= Grade – (Age – 6)) | -2.0 | -1.8 | -2.0 | -0.0 | 0.1 |
| | | | | (0.1) | (0.1) |
| Year of birth | 1986.2 | 1986.5 | 1985.8 | 0.4** | 0.8*** |
| | | | | (0.2) | (0.2) |
| *Panel B: Grades 3 to 8* | | | | | |
| Attendance recorded in school registers (during the four weeks prior to the pupil survey) | 0.973 | 0.963 | 0.969 | 0.003 | -0.006 |
| | | | | (0.004) | (0.004) |
| Access to latrine at home | 0.82 | 0.81 | 0.82 | 0.00 | -0.01 |
| | | | | (0.03) | (0.03) |
| Have livestock (cows, goats, pigs, sheep) at home | 0.66 | 0.67 | 0.66 | -0.00 | 0.01 |
| | | | | (0.03) | (0.03) |
| Weight-for-age Z-score (low scores denote undernutrition) | -1.39 | -1.40 | -1.44 | 0.05 | 0.04 |
| | | | | (0.05) | (0.05) |
| Blood in stool (self-reported) | 0.26 | 0.22 | 0.19 | 0.07** | 0.03 |
| | | | | (0.03) | (0.03) |
| Sick often (self-reported) | 0.10 | 0.10 | 0.08 | 0.02 | 0.02* |
| | | | | (0.01) | (0.01) |
| Malaria/fever in past week (self-reported) | 0.37 | 0.38 | 0.40 | -0.03 | -0.02 |
| | | | | (0.03) | (0.03) |
| Clean (observed by field workers) | 0.60 | 0.66 | 0.67 | -0.07** | -0.01 |
| | | | | (0.03) | (0.03) |
| *Panel C: School characteristics* | | | | | |
| District exam score 1996, grades 5-8‡ | -0.10 | 0.09 | 0.01 | -0.11 | 0.08 |
| | | | | (0.12) | (0.12) |
| Distance to Lake Victoria | 10.0 | 9.9 | 9.5 | 0.6 | 0.5 |
| | | | | (1.9) | (1.9) |
| Pupil population | 392.7 | 403.8 | 375.9 | 16.8 | 27.9 |
| | | | | (57.6) | (57.6) |
| School latrines per pupil | 0.007 | 0.006 | 0.007 | 0.001 | -0.000 |
| | | | | (0.001) | (0.001) |
| Proportion moderate-heavy infections in zone | 0.37 | 0.37 | 0.36 | 0.01 | 0.01 |
| | | | | (0.03) | (0.03) |
| Group 1 pupils within 3 km†† | 430.4 | 433.2 | 344.5 | 85.9 | 88.7 |
| | | | | (116.2) | (116.2) |
| Group 1 pupils within 3-6 km | 1157.6 | 1043.0 | 1297.3 | -139.7 | -254.4 |
| | | | | (199.3) | (199.3) |
| Total primary school pupils within 3 km | 1272.7 | 1369.1 | 1151.9 | 120.8 | 217.2 |
| | | | | (208.1) | (208.1) |
| Total primary school pupils within 3-6 km | 3431.3 | 3259.8 | 3502.1 | -70.8 | -242.3 |
| | | | | (366.0) | (366.0) |

†School averages weighted by pupil population. Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Data from the 1998 ICS Pupil Namelist, 1998 Pupil Questionnaire and 1998 School Questionnaire.
‡1996 District exam scores have been normalized to be in units of individual level standard deviations, and so are comparable in units to the 1998 and 1999 ICS test scores (under the assumption that the decomposition of test score variance within and between schools was the same in 1996, 1998, and 1999).
†† This includes girls less than 13 years old, and all boys (those eligible for deworming in treatment schools).

**Table A2: Miguel and Kremer (2004) Table II –**
**January 1998 helminth infections, pre-treatment, Group 1 schools†**

| | Prevalence of infection | Prevalence of moderate-heavy infection | Average worm load, in eggs per gram (s.e.) |
|---|---|---|---|
| Hookworm | 0.77 | 0.15 | 426 |
| | | | (1055) |
| Roundworm | 0.42 | 0.16 | 2337 |
| | | | (5156) |
| Schistosomiasis, all schools | 0.22 | 0.07 | 91 |
| | | | (413) |
| Schistosomiasis, schools < 5km from Lake Victoria | 0.80 | 0.39 | 487 |
| | | | (879) |
| Whipworm | 0.55 | 0.10 | 161 |
| | | | (470) |
| At least one infection | 0.92 | 0.37 | - |
| Born since 1985 | 0.93 | 0.40 | - |
| Born before 1985 | 0.91 | 0.34 | - |
| Female | 0.91 | 0.34 | - |
| Male | 0.93 | 0.38 | - |
| At least two infections | 0.65 | 0.10 | - |
| At least three infections | 0.34 | 0.01 | - |

†These are averages of individual-level data, as presented in Brooker, et al. (2000b); correcting for the oversampling of the (numerically smaller) upper grades does not substantially change the results. Standard errors in parentheses. Sample size: 1894 pupils. Fifteen pupils per standard in grades 3 to 8 for Group 1 schools were randomly sampled. The bottom two rows of the column "Prevalence of moderate-heavy infection" should be interpreted as the proportion with at least two or at least three moderate-to-heavy helminth infections, respectively. The data were collected in January to March 1998 by the Kenya Ministry of Health, Division of Vector Borne Diseases (DVBD). The moderate infection thresholds for the various intestinal helminths are: 250 epg for *S. mansoni*, and 5,000 epg for Roundworm, both the WHO standard, and 750 epg for Hookworm and 400 epg for Whipworm, both somewhat lower than the WHO standard. Refer to Brooker, et al. (2000b) for a discussion of this parasitological survey and the infection cut-offs. All cases of schistosomiasis are *S. mansoni*.

**Table A3: Miguel and Kremer (2004) Table III –**
**Proportion of pupils receiving deworming treatment in PSDP†**

| | Group 1 | | Group 2 | | Group 3 | |
|---|---|---|---|---|---|---|
| | Girls < 13 years, and all boys | Girls ≥ 13 years | Girls < 13 years, and all boys | Girls ≥ 13 years | Girls < 13 years, and all boys | Girls ≥ 13 years |
| | *Treatment* | | *Comparison* | | *Comparison* | |
| Any medical treatment in 1998 | 0.77 | 0.20 | 0 | 0 | 0 | 0 |
| (For grades 1-8 in early 1998) | | | | | | |
| Round 1 (March-April 1998), Albendazole | 0.68 | 0.11 | 0 | 0 | 0 | 0 |
| Round 1 (March-April 1998), Praziquantel‡ | 0.64 | 0.34 | 0 | 0 | 0 | 0 |
| Round 2 (Oct.-Nov. 1998), 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 |
| (For grades 1-7 in early 1998) | | | | | | |
| Round 1 (March-June 1999), Albendazole | 0.44 | 0.06 | 0.35 | 0.05 | 0.01 | 0 |
| Round 1 (March-June 1999), Praziquantel‡ | 0.47 | 0.06 | 0.38 | 0.06 | 0.00 | 0 |
| Round 2 (Oct.-Nov. 1999), Albendazole | 0.52 | 0.06 | 0.50 | 0.07 | 0.01 | 0 |
| Any medical treatment in 1999 | 0.73 | 0.10 | 0.71 | 0.14 | 0.02 | 0 |
| (For grades 1-7 in early 1998), | | | | | | |
| among pupils enrolled in 1999 | | | | | | |
| Round 1 (March-June 1999), Albendazole | 0.55 | 0.08 | 0.46 | 0.08 | 0.01 | 0 |
| Round 1 (March-June 1999), Praziquantel‡ | 0.54 | 0.08 | 0.46 | 0.07 | 0.00 | 0 |
| Round 2 (Oct.-Nov. 1999), Albendazole | 0.65 | 0.09 | 0.66 | 0.11 | 0.01 | 0 |

†Data for grades 1-8. Since month of birth information is missing for most pupils, precise assignment of treatment eligibility status for girls born during the "threshold" year is often impossible; all girls who turn 13 during a given year are counted as 12 year olds (eligible for deworming treatment) throughout for consistency.
‡Praziquantel figures in Table 3 refer only to children in schools meeting the schistosomiasis treament threshold (30 percent prevalence) in that year.

**Table A4: Miguel and Kremer (2004) Table IV - Proportion of pupil transfers across schools**

| | 1998 transfer to a | | | 1999 transfer to a | | |
|---|---|---|---|---|---|---|
| School in early 1998 (pre-treatment) | Group 1 School | Group 2 School | Group 3 school | Group 1 school | Group 2 school | Group 3 school |
| Group 1 | 0.005 | 0.007 | 0.007 | 0.032 | 0.026 | 0.027 |
| Group 2 | 0.006 | 0.007 | 0.008 | 0.026 | 0.033 | 0.027 |
| Group 3 | 0.010 | 0.010 | 0.006 | 0.022 | 0.036 | 0.022 |
| Total transfers | 0.020 | 0.024 | 0.020 | 0.080 | 0.095 | 0.076 |

**Table A5: Miguel and Kremer (2004) Table V - January to March 1999, Health and Health Behavior Differences Between Group 1 (1998 Treatment) and Group 2 (1998 Comparison) Schools** †

| | Group 1 | Group 2° | Group 1 – Group 2° |
|---|---|---|---|
| *Panel A: Helminth Infection Rates* | | | |
| Any moderate-heavy infection, January – March 1998 | 0.38 | - | - |
| Any moderate-heavy infection, 1999 | 0.27 | 0.52 | -0.25*** |
| | | | (0.06) |
| Hookworm moderate-heavy infection, 1999 | 0.06 | 0.22 | -0.16*** |
| | | | (0.03) |
| Roundworm moderate-heavy infection, 1999 | 0.09 | 0.24 | -0.15*** |
| | | | (0.04) |
| Schistosomiasis moderate-heavy infection, 1999 | 0.08 | 0.18 | -0.10 |
| | | | (0.06) |
| Whipworm moderate-heavy infection, 1999 | 0.13 | 0.17 | -0.04 |
| | | | (0.05) |
| *Panel B: Other Nutritional and Health Outcomes* | | | |
| Sick in past week (self-reported), 1999 | 0.40 | 0.45 | -0.05** |
| | | | (0.02) |
| Sick often (self-reported), 1999 | 0.12 | 0.15 | -0.03** |
| | | | (0.01) |
| Height-for-age Z-score, 1999 | -1.13 | -1.22 | 0.08* |
| (low scores denote undernutrition) | | | (0.05) |
| Weight-for-age Z-score, 1999 | -1.25 | -1.25 | -0.00 |
| (low scores denote undernutrition) | | | (0.04) |
| Hemoglobin concentration (g/L), 1999 | 124.9 | 123.3 | 1.6 |
| | | | (1.4) |
| Proportion anemic (Hb < 100g/L), 1999 | 0.02 | 0.04 | -0.02 |
| | | | (0.01) |
| *Panel C: Worm Prevention Behaviors* | | | |
| Clean (observed by field worker), 1999 | 0.59 | 0.60 | -0.01 |
| | | | (0.02) |
| Wears shoes (observed by field worker), 1999 | 0.24 | 0.26 | -0.02 |
| | | | (0.03) |
| Days contact with fresh water in past week | 2.4 | 2.2 | 0.2 |
| (self-reported), 1999 | | | (0.3) |

†These are averages of individual-level data for grade 3-8 pupils; disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence.

Obs. for parasitological results: 2328 (862 Group 1,466 Group 2).

Obs. for hemoglobin results: 769 (290 Group 1, 479 Group 2).

Obs. for 1999 Pupil Questionnaire health outcomes: 9,039 (3545 Group 1, 5497 Group 2 and Group 3).

Following Brooker et al. (2000b), moderate-to-heavy infection thresholds for the various intestinal helminths are: 250 epg for *S. mansoni*, and 5,000 epg for Roundworm, both the WHO standard, and 750 epg for Hookworm and 400 epg for Whipworm, both somewhat lower than the WHO standard. Kenya Ministry of Health officials collected the parasitological data from January to March 1998 in Group 1 schools, and from January to March 1999 in Group 1 and Group 2 schools. A random subset of the original 1998 Group 1 parasitological sample was re-surveyed in 1999. Hb data were collected by Kenya Ministry of Health officials and ICS field officers using the portable Hemocue machine. The self-reported health outcomes were collected for all three groups of schools as part of Pupil Questionnaire administration.

°Note that for the outcomes collected in the 1999 Pupil Questionnaire, statistics in these columns also include Group 3 individuals.

**Table A6: Miguel and Kremer (2004) Table VI –**
**Deworming health externalities within schools, January to March 1999 †**

| | Group 1, Treated in 1998 | Group 1, Untreated in 1998 | Group 2, Treated in 1999 | Group 2, Untreated in 1999 | (Group 1 Treated 1998) – (Group 2, Treated 1999) | (Group 1, Untreated 1998) – (Group 2, Untreated 1999) |
|---|---|---|---|---|---|---|
| *Panel A: Selection into Treatment* | | | | | | |
| Any moderate-heavy infection, 1998 | 0.39 | 0.44 | - | - | - | - |
| Proportion of 1998 parasitological sample tracked to 1999 sample‡ | 0.36 | 0.35 | - | - | - | - |
| Access to latrine at home, 1998 | 0.85 | 0.80 | 0.81 | 0.86 | 0.03<br>(0.04) | -0.06<br>(0.05) |
| Grade progression (=Grade – (Age – 6)), 1998 | -2.0 | -1.8 | -1.8 | -1.8 | -0.2<br>(0.1) | -0.0<br>(0.2) |
| Weight-for-age (Z-score), 1998 (low scores denote undernutrition) | -1.58 | -1.52 | -1.57 | -1.46 | -0.01<br>(0.06) | -0.06<br>(0.11) |
| Malaria/fever in past week (self-reported), 1998 | 0.37 | 0.41 | 0.40 | 0.39 | -0.03<br>(0.04) | 0.02<br>(0.06) |
| Clean (observed by field worker), 1998 | 0.53 | 0.59 | 0.60 | 0.66 | -0.07<br>(0.05) | -0.07<br>(0.10) |
| *Panel B: Health Outcomes* | | | | | | |
| *Girls < 13 years, and all boys* | | | | | | |
| Any moderate-heavy infection, 1999 | 0.24 | 0.34 | 0.51 | 0.55 | -0.27***<br>(0.06) | -0.21**<br>(0.10) |
| Hookworm moderate-heavy infection, 1999 | 0.04 | 0.11 | 0.22 | 0.20 | -0.19***<br>(0.03) | -0.10*<br>(0.05) |
| Roundworm moderate-heavy infection, 1999 | 0.08 | 0.12 | 0.22 | 0.30 | -0.14***<br>(0.04) | -0.18**<br>(0.07) |
| Schistosomiasis moderate-heavy infection, 1999 | 0.09 | 0.08 | 0.20 | 0.13 | -0.11*<br>(0.06) | -0.05<br>(0.06) |
| Whipworm moderate-heavy infection, 1999 | 0.12 | 0.16 | 0.16 | 0.20 | -0.04<br>(0.05) | -0.05<br>(0.09) |
| *Girls ≥ 13 years* | | | | | | |
| Any moderate-heavy infection, 1998 | 0.31 | 0.30 | - | - | - | - |
| Any moderate-heavy infection, 1999 | 0.27 | 0.44 | 0.32 | 0.54 | -0.05<br>(0.17) | -0.09<br>(0.09) |
| *Panel C: School Participation* | | | | | | |
| School participation rate, May 1998 to March 1999†† | 0.872 | 0.774 | 0.808 | 0.690 | 0.064*<br>(0.033) | 0.084**<br>(0.037) |

†These are averages of individual-level data for grade 3-8 pupils in the parasitological survey subsample; disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The data are described in the footnote to Table 5. Obs. for the 1999 parasitological survey: 669 Group 1 treated 1998, 76 Group 1 untreated 1998, 874 Group 2 treated 1999, 349 Group 2 untreated 1999.

‡We attempted to track a random sample of half of the original 1998 parasitological sample. Because some pupils were absent, had dropped out, or had graduated, we were only able to re-survey 72 percent of this subsample.

††School averages weighted by pupil population. The participation rate is computed among pupils enrolled in the school at the start of 1998. Pupils present in school during an unannounced NGO visit are considered participants. Pupils had 3.8 participation observations per year on average. Participation rates are for grades 1 to 7; grade 8 pupils are excluded since many graduated after the 1998 school year, in which case their 1999 treatment status is irrelevant. Preschool pupils are excluded since they typically have missing compliance data. All 1998 pupil characteristics in Panel A are for grades 3 to 7, since younger pupils were not administered the Pupil Questionnaire.

**Table A7: Miguel and Kremer (2004) Table VII –**
**Deworming health externalities within and across schools, January to March 1999†**

| | Any moderate-heavy helminth infection, 1999 | | | Moderate-heavy schistosomiasis infection, 1999 | | | Moderate-heavy geohelminth infection, 1999 | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Indicator for Group 1 (1998 Treatment) School | -0.31*** | -0.18** | -0.21* | -0.09*** | -0.06 | -0.03 | -0.30*** | -0.19*** | -0.26*** |
| | (0.06) | (0.07) | (0.11) | (0.04) | (0.05) | (0.06) | (0.05) | (0.06) | (0.09) |
| Group 1 pupils within 3 km (per 1000 pupils) | -0.21** | -0.22** | -0.10 | -0.12*** | -0.12*** | -0.08 | -0.12 | -0.13 | -0.06 |
| | (0.10) | (0.11) | (0.14) | (0.05) | (0.05) | (0.07) | (0.09) | (0.10) | (0.12) |
| Group 1 pupils within 3-6 km (per 1000 pupils) | -0.05 | -0.04 | -0.08 | -0.15*** | -0.15*** | -0.13** | 0.06 | 0.08 | 0.03 |
| | (0.08) | (0.08) | (0.11) | (0.04) | (0.04) | (0.05) | (0.06) | (0.06) | (0.09) |
| Total pupils within 3 km (per 1000 pupils) | 0.05 | 0.05 | 0.05 | 0.08*** | 0.08*** | 0.08*** | -0.01 | -0.01 | -0.01 |
| | (0.04) | (0.04) | (0.03) | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Total pupils within 3-6 km (per 1000 pupils) | -0.02 | -0.03 | -0.02 | 0.04* | 0.04* | 0.04* | -0.04 | -0.05 | -0.04 |
| | (0.04) | (0.04) | (0.04) | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2) | | -0.06* | | | 0.04** | | | -0.10*** | |
| | | (0.03) | | | (0.02) | | | (0.03) | |
| (Group 1 Indicator) * Received treatment, when offered | | -0.15** | | | -0.04 | | | -0.11** | |
| | | (0.06) | | | (0.04) | | | (0.05) | |
| (Group 1 Indicator) * Group 1 pupils within 3 km (per 1000 pupils) | | | -0.27** | | | -0.07 | | | -0.16 |
| | | | (0.14) | | | (0.08) | | | (0.11) |
| (Group 1 Indicator) * Group 1 pupils within 3-6 km (per 1000 pupils) | | | 0.01 | | | -0.03 | | | 0.03 |
| | | | (0.09) | | | (0.06) | | | (0.07) |
| Grade indicators, school assistance controls, district exam score control | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of observations | 2330 | 2329 | 2330 | 2330 | 2329 | 2330 | 2330 | 2329 | 2330 |
| Mean of dependent variable | 0.41 | 0.41 | 0.41 | 0.16 | 0.16 | 0.16 | 0.32 | 0.32 | 0.32 |

†Grade 3-8 pupils. Probit estimation, robust standard errors in parentheses. Disturbance terms are clustered within schools. Observations are weighted by total school population. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The 1999 parasitological survey data are for Group 1 and Group 2 schools. The pupil population data is from the 1998 School Questionnaire. The geohelminths are hookworm, roundworm, and whipworm. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

**Table A8: Miguel and Kremer (2004) Table VIII –**
**School participation, school-level data**[†]

| | Group 1 (25 schools) | Group 2 (25 schools) | Group 3 (25 schools) | | |
|---|---|---|---|---|---|
| *Panel A: First year post-treatment (May 1998 to March 1999)* | *1st Year Treatment* | *Comparison* | *Comparison* | *Group 1 – (Groups 2 & 3)* | *Group 2 – Group 3* |
| Girls < 13 years, and all boys | 0.841 | 0.731 | 0.766 | 0.093*** | -0.035 |
| | | | | (0.030) | (0.035) |
| Girls ≥ 13 years | 0.868 | 0.804 | 0.820 | 0.056* | -0.016 |
| | | | | (0.031) | (0.036) |
| Preschool, Grade 1, Grade 2 in early 1998 | 0.797 | 0.689 | 0.707 | 0.100*** | -0.019 |
| | | | | (0.037) | (0.043) |
| Grade 3, Grade 4, Grade 5 in early 1998 | 0.877 | 0.788 | 0.827 | 0.071*** | -0.039 |
| | | | | (0.024) | (0.029) |
| Grade 6, Grade 7, Grade 8 in early 1998 | 0.934 | 0.859 | 0.891 | 0.058*** | -0.032 |
| | | | | (0.021) | (0.025) |
| Recorded as "dropped out" in early 1998 | 0.066 | 0.051 | 0.030 | 0.024 | 0.022 |
| | | | | (0.018) | (0.017) |
| Females[‡] | 0.855 | 0.771 | 0.789 | 0.076*** | -0.018 |
| | | | | (0.027) | (0.032) |
| Males | 0.844 | 0.736 | 0.780 | 0.088*** | -0.044 |
| | | | | (0.031) | (0.037) |
| *Panel B: Second year post-treatment (March to November 1999)* | *2nd Year Treatment* | *1st Year Treatment* | *Comparison* | *Group 1 – Group 3* | *Group 2 – Group 3* |
| Girls < 13 years, and all boys | 0.716 | 0.718 | 0.664 | 0.051* | 0.054* |
| | | | | (0.027) | (0.027) |
| Girls ≥ 14 years[††] | 0.627 | 0.649 | 0.588 | 0.039 | 0.061* |
| | | | | (0.035) | (0.035) |
| Preschool, Grade 1, Grade 2 in early 1998 | 0.692 | 0.725 | 0.641 | 0.051 | 0.084** |
| | | | | (0.034) | (0.034) |
| Grade 3, Grade 4, Grade 5 in early 1998 | 0.749 | 0.766 | 0.720 | 0.029 | 0.046** |
| | | | | (0.022) | (0.023) |
| Grade 6, Grade 7, Grade 8 in early 1998 | 0.781 | 0.790 | 0.754 | 0.027 | 0.036 |
| | | | | (0.025) | (0.026) |
| Recorded as "dropped out" in early 1998 | 0.188 | 0.130 | 0.062 | 0.126* | 0.068 |
| | | | | (0.066) | (0.056) |
| Females[‡] | 0.716 | 0.746 | 0.649 | 0.067** | 0.097*** |
| | | | | (0.027) | (0.027) |
| Males | 0.698 | 0.695 | 0.655 | 0.043 | 0.040 |
| | | | | (0.028) | (0.029) |

[†]The results are school averages weighted by number of pupil observations. Standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The participation rate is computed among all pupils enrolled in the school at the start of 1998. Pupils who are present in school on the day of an unannounced NGO visit are considered participants. Pupils had 3.8 participation observations per year on average. The figures for the "Preschool-Grade 2"; "Grade 3-5"; "Grade 6-8"; and "Dropout" rows are for girls < 13 years, and all boys.

[‡]Some pupils in the sample are missing information on gender. For this reason, the average of the female and male participation rates does not equal the overall average.

[††]Examining girls ≥14 years old eliminates the cohort of girls in Group 1 schools (12 year olds in 1998) who were supposed to receive deworming treatment in 1998.

**Table A9: Miguel and Kremer (2004) Table IX –**
**School participation, direct effects and externalities†**
**Dependent variable: Average individual school participation, by year**

| | OLS (1) | OLS (2) | OLS (3) | OLS (4) May 98-March 99 | OLS (5) May 98-March 99 | OLS (6) May 98-March 99 | IV-2SLS (7) May 98-March 99 |
|---|---|---|---|---|---|---|---|
| Moderate-heavy infection, early 1999 | | | | | | -0.025$^{**}$ | -0.195$^{**}$ |
| | | | | | | (0.010) | (0.096) |
| Treatment school (T) | 0.057$^{***}$ | | | | | | |
| | (0.014) | | | | | | |
| First year as treatment school (T1) | | 0.063$^{***}$ | 0.062$^{***}$ | 0.062$^{***}$ | 0.056$^{***}$ | | |
| | | (0.015) | (0.014) | (0.022) | (0.020) | | |
| Second year as treatment school (T2) | | 0.039$^{*}$ | 0.033 | | | | |
| | | (0.021) | (0.021) | | | | |
| Treatment school pupils within 3 km | | | 0.040$^{*}$ | | 0.022 | | |
| (per 1000 pupils) | | | (0.022) | | (0.032) | | |
| Treatment school pupils within 3-6 km | | | -0.024 | | -0.067$^{***}$ | | |
| (per 1000 pupils) | | | (0.015) | | (0.020) | | |
| Total pupils within 3 km | | | -0.031$^{**}$ | | -0.040$^{**}$ | 0.014 | -0.029$^{*}$ |
| (per 1000 pupils) | | | (0.012) | | (0.016) | (0.014) | (0.016) |
| Total pupils within 3-6 km | | | 0.012 | | 0.035$^{***}$ | 0.016$^{*}$ | 0.008 |
| (per 1000 pupils) | | | (0.009) | | (0.011) | (0.009) | (0.009) |
| Indicator received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2) | | | | | 0.104$^{***}$ | | |
| | | | | | (0.014) | | |
| (First year as treatment school Indicator)* (Received treatment, when offered) | | | | | -0.013 | | |
| | | | | | (0.020) | | |
| 1996 district exam score, school average | 0.071$^{***}$ | 0.070$^{***}$ | 0.077$^{***}$ | 0.058$^{*}$ | 0.106$^{***}$ | 0.020 | -0.000 |
| | (0.021) | (0.021) | (0.022) | (0.032) | (0.034) | (0.024) | (0.022) |
| Grade indicators, school assistance controls, and time controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.22 | 0.22 | 0.22 | 0.33 | 0.37 | 0.29 | - |
| Root MSE | 0.279 | 0.279 | 0.278 | 0.223 | 0.217 | 0.150 | 0.069 |
| Number of observations | 56496 | 56496 | 56496 | 18215 | 18215 | 2327 | 49 (schools) |
| Mean of dependent variable | 0.747 | 0.747 | 0.747 | 0.793 | 0.793 | 0.884 | 0.884 |

† The dependent variable is average individual school participation in each year of the program (Year 1 is to March 1999, and Year 2 is May 1999 to November 1999); disturbance terms are clustered within schools. Observations are weighted by the number of times the pupil was observed in that year. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Additional explanatory variables include an indicator variable for girls < 13 years and all boys, and the rate of moderate-heavy infections in geographic zone, by grade (zonal infection rates among grade 3 and 4 pupils are used for pupils in grades 4 and below and for pupils initially recorded as drop-outs as there is no parasitological data for pupils below grade 3; zonal infection rates among grade 5 and 6 pupils are used for pupils in grades 5 and 6, and similarly for grades 7 and 8). Participation is computed among all pupils enrolled at the start of the 1998 school year. Pupils present during an unannounced NGO school visit are considered participants. Pupils had approximately 3.8 attendance observations per year. Regressions 6 and 7 include pupils with parasitological information from early 1999, restricting the sample to a random subset of Group 1 and Group 2 pupils. The number of treatment school pupils from May 1998 to March 1999 is the number of Group 1 pupils, and the number of treatment school pupils after March 1999 is the number of Group 1 and Group 2 pupils.
The instrumental variables in regression 7 are the Group 1 (treatment) indicator variable, Treatment school pupils within 3 km, Treatment school pupils within 3-6 km, and the remaining explanatory variables. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

**Table A10: Miguel and Kremer (2004) Table X –**
**Academic examinations, individual-level data†**

| | Dependent variable: ICS Exam Score (normalized by standard) | | |
|---|---|---|---|
| | (1) | (2) | (3) Among those who filled in the 1998 pupil survey |
| Average school participation (during the year of the exam) | 0.63*** | | |
| | (0.07) | | |
| First year as treatment school (T1) | | -0.035 | -0.036 |
| | | (0.047) | (0.049) |
| Second year as treatment school (T2) | | -0.015 | -0.013 |
| | | (0.079) | (0.088) |
| 1996 District exam score, school average | 0.74*** | 0.72*** | 0.75*** |
| | (0.07) | (0.07) | (0.07) |
| Grade indicators, school assistance controls, and local pupil density controls | Yes | Yes | Yes |
| $R^2$ | 0.14 | 0.13 | 0.15 |
| Root MSE | 0.919 | 0.923 | 0.916 |
| Number of observations | 24979 | 24979 | 19072 |
| Mean of dependent variable | 0.019 | 0.019 | 0.039 |

† Each data point is the individual-level exam result in a given year of the program (either 1998, or 1999); disturbance terms are clustered within schools. Linear regression, robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Regression 3 includes only pupils who completed the 1998 Pupil Questionnaire. Additional explanatory variables include an indicator variable for girls < 13 years and all boys, and the rate of moderate-to-heavy infections in geographic zone, by grade (zonal infection rates among grade 3 and 4 pupils are used for pupils in grades 4 and below and for pupils initially recorded as dropouts as there is no parasitological data for pupils below grade 3; zonal infection rates among grade 5 and 6 pupils are used for pupils in grades 5 and 6, and similarly for grades 7 and 8). The local pupil density terms include treatment school pupils within 3 km (per 1000 pupils), total pupils within 3 km (per 1000 pupils), treatment school pupils within 3-6 km (per 1000 pupils), and total pupils within 3-6 km (per 1000 pupils). We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.
The ICS tests for 1998 and 1999 were similar in content, but differed in two important respects. First, the 1998 exam featured multiple-choice questions while the 1999 test featured short answers. Second, while each grade in 1998 was administered a different exam, in 1999 the same exam – featuring questions across a range of difficulty levels – was administered to all pupils in grades 3 to 8. Government district exams in English, Maths, Science-Agriculture, Kiswahili, Geography-History, Home Science, and Arts-Crafts were also administered in both years. Treatment effect estimates are similar for both sets of exams (results not shown).

**Table AA2: Miguel and Kremer (2004) Appendix Table AII –**
**Local densities of other primary schools and deworming compliance rates†**

| | Dependent variable: | |
|---|---|---|
| | 1998 Compliance rate (any medical treatment) | 1999 Compliance rate (any medical treatment) |
| | OLS | OLS |
| | (1) | (2) |
| Treatment school pupils within 3 km (per 1000 pupils) | -0.03<br>(0.06) | -0.07<br>(0.08) |
| Treatment school pupils within 3-6 km (per 1000 pupils) | 0.10*<br>(0.05) | -0.01<br>(0.04) |
| Total pupils within 3 km (per 1000 pupils) | 0.09**<br>(0.03) | 0.05<br>(0.06) |
| Total pupils within 3-6 km (per 1000 pupils) | -0.04<br>(0.03) | 0.00<br>(0.02) |
| Grade indicators, school assistance controls, district exam score control | Yes | Yes |
| $R^2$ | 0.69 | 0.68 |
| Root MSE | 0.070 | 0.108 |
| Number of observations | 25 | 49 |
| Mean of dependent variable | 0.76 | 0.51 |

†Robust standard errors in parentheses. Observations are weighted by total school population. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The 1998 compliance data is for Group 1 schools, and the 1999 compliance data is for Group 1 and Group 2 schools. The pupil population data is from the 1998 School Questionnaire. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools. The number of treatment school pupils in 1998 is the number of Group 1 pupils, and the number of treatment school pupils in March 1999 is the number of Group 1 and Group 2 pupils.

**Table AA3: Miguel and Kremer (2004) Appendix Table AIII –**
**Deworming health externalities– Robustness Checks** †

| | Any moderate-heavy helminth infection, 1999 | | | | Moderate-heavy schistomiasis infection, 1999 | | | |
|---|---|---|---|---|---|---|---|---|
| | Probit | OLS, spatial s.e. | Probit | Probit (Group 1 only) | Probit | OLS, spatial s.e. | Probit | Probit (Group 1 only) |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Indicator for Group 1 (1998 Treatment) School | -0.31*** | -0.28*** | -0.32*** | | -0.09*** | -0.13** | -0.08** | |
| | (0.06) | (0.06) | (0.06) | | (0.04) | (0.06) | (0.04) | |
| Group 1 pupils within 3 km (per 1000 pupils) | -0.21** | -0.20** | | -0.28*** | -0.12*** | -0.17*** | | -0.06** |
| | (0.10) | (0.09) | | (0.08) | (0.05) | (0.04) | | (0.03) |
| Group 1 pupils within 3-6 km (per 1000 pupils) | -0.05 | -0.11 | | -0.02 | -0.15*** | -0.14* | | -0.06*** |
| | (0.08) | (0.07) | | (0.06) | (0.04) | (0.07) | | (0.02) |
| Total pupils within 3 km (per 1000 pupils) | 0.05 | 0.05 | 0.00 | 0.02 | 0.08*** | 0.12*** | 0.06*** | 0.02** |
| | (0.04) | (0.06) | (0.04) | (0.02) | (0.02) | (0.04) | (0.02) | (0.01) |
| Total pupils within 3-6 km (per 1000 pupils) | -0.02 | 0.02 | -0.05* | -0.02 | 0.04* | 0.04 | -0.01 | 0.01 |
| | (0.04) | (0.05) | (0.03) | (0.02) | (0.02) | (0.04) | (0.02) | (0.01) |
| (Group 1 pupils within 3 km) / (Total pupils within 3 km) | | | -0.21* | | | | -0.10 | |
| | | | (0.12) | | | | (0.09) | |
| (Group 1 pupils within 3-6 km) / (Total pupils within 3-6 km) | | | -0.10 | | | | -0.46*** | |
| | | | (0.23) | | | | (0.12) | |
| Any moderate-heavy helminth infection, 1998 | | | | 0.25*** | | | | |
| | | | | (0.03) | | | | |
| Moderate-heavy schistosomiasis infection, 1998 | | | | | | | | 0.25*** |
| | | | | | | | | (0.10) |
| Grade indicators, school assistance controls, district exam score control | Yes | No | Yes | Yes | Yes | No | Yes | Yes |
| $R^2$ | - | 0.46 | - | - | - | 0.48 | - | - |
| Root MSE | - | 0.200 | - | - | - | 0.169 | - | - |
| Number of observations | 2330 (pupils) | 49 (schools) | 2330 (pupils) | 603 (pupils) | 2330 (pupils) | 49 (schools) | 2330 (pupils) | 512 (pupils) |
| Mean of dependent variable | 0.41 | 0.41 | 0.41 | 0.25 | 0.16 | 0.16 | 0.16 | 0.09 |

†Grade 3-8 pupils. Robust standard errors in parentheses. Disturbance terms are clustered within schools for regressions 1, 3, 4, 5, 7, and 8. Disturbance terms are allowed to be correlated across spaces using the method in Conley (1999) in regressions 2 and 6. Observations are weighted by total school population. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The 1999 parasitological survey data are for Group 1 and Group 2 schools. The pupil population data is from the 1998 School Questionnaire. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

**Table AA4: Miguel and Kremer (2004) Table AIV –**
**IV estimates of health and school participation externalities†**

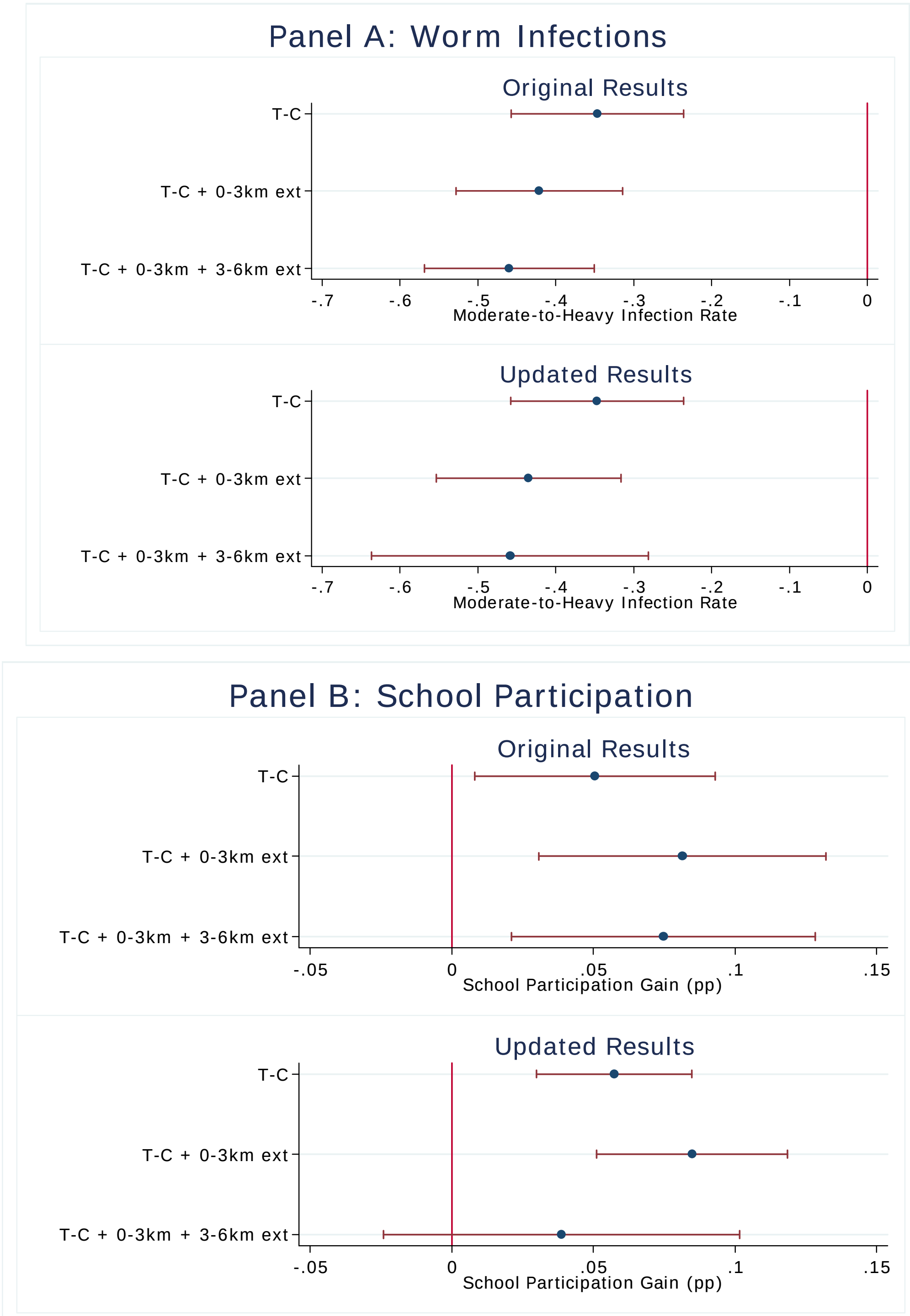
| | Any moderate-heavy helminth infection, January - March 99 | | Average individual school participation, May 98-March 99 | |
|---|---|---|---|---|
| | Probit | IV-2SLS | OLS | IV-2SLS |
| | (1) | (2) | (3) | (4) |
| Indicator for Group 1 (1998 Treatment) School | -0.18** | -0.07 | 0.056*** | 0.024 |
| | (0.07) | (0.10) | (0.020) | (0.027) |
| Group 1 pupils within 3 km (per 1000 pupils) | -0.22** | -0.19** | 0.022 | 0.019 |
| | (0.11) | (0.09) | (0.032) | (0.032) |
| Group 1 pupils within 3-6 km (per 1000 pupils) | -0.04 | -0.03 | -0.067*** | -0.065*** |
| | (0.08) | (0.07) | (0.020) | (0.020) |
| Total pupils within 3 km (per 1000 pupils) | 0.05 | 0.05 | -0.040** | -0.037** |
| | (0.04) | (0.03) | 0.016) | (0.017) |
| Total pupils within 3-6 km (per 1000 pupils) | -0.03 | -0.02 | 0.035*** | 0.034*** |
| | (0.04) | (0.04) | (0.011) | (0.011) |
| Indicator received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2) | -0.06* | -0.06 | 0.104*** | 0.022 |
| | (0.03) | (0.05) | (0.014) | (0.031) |
| (First year as treatment school Indicator)* (Received treatment, when offered) | -0.15** | -0.26** | -0.016 | 0.056 |
| | (0.06) | (0.12) | (0.020) | (0.045) |
| Grade indicators, school assistance controls, district exam score control | Yes | Yes | Yes | Yes |
| Time controls | No | No | Yes | Yes |
| $R^2$ | - | - | 0.37 | - |
| Root MSE | - | 0.450 | 0.217 | 0.218 |
| Number of observations | 2329 | 2329 | 18215 | 18215 |
| Mean of dependent variable | 0.41 | 0.41 | 0.793 | 0.793 |

† Disturbance terms are clustered within schools. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The two instrumental variables are an indicator for girls under age 13 and all boys (ELG), and (ELG)*(Group 1 indicator). The coefficient on the Group 1 school indicator variable serves as an estimate of the within-school externality effect in 1998. This IV approach could overestimate the treatment effect if the treatment effect is heterogeneous, with sicker pupils benefiting most from treatment, and if among the girls over 13, the sickest girls are most likely to be treated in treatment schools. However, among the sub-sample of older girls, the compliance rate was not significantly related to infection status in 1998 (Table 6), and in 1999 under ten percent of older girls were treated (Table 3). We find similar effects even when we exclude the schools near the lake where older girls were likely to be treated (results not shown). Note that the IV estimates of within-school participation externalities should be interpreted as local average treatment effects for the older girls. Since school participation treatment effects are largest for younger pupils, it is not surprising that the IV externality estimates among the older girls are smaller than the OLS estimates, which are for the entire population. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

## 6. Appendix B: Additional Analysis for Miguel and Kremer (2004)

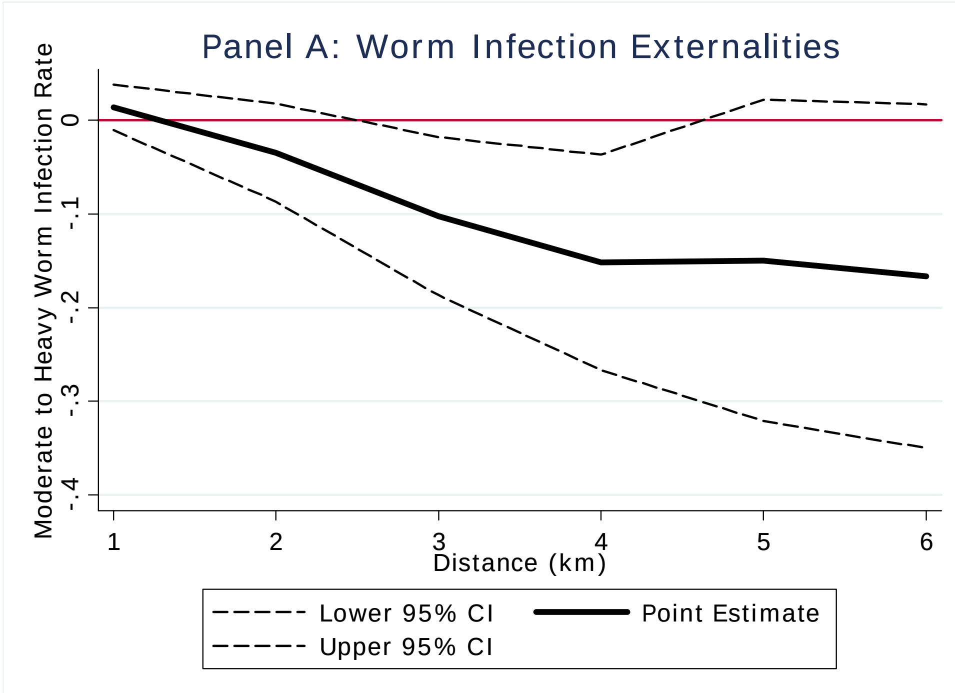
This appendix provides additional analysis, to supplement what is presented in Miguel and Kremer (2004). The data used in this appendix is the same updated, finalized data that is used in Appendix A. As discussed in Section 4.9, since it is not possible to precisely estimate externalities out to 6 km, we include externalities only out to a distance of 3 km. This change affects Tables VII, IX, and X from the original paper. The corresponding tables here are Appendix Tables B5-B7. We further present additional results for clarity of the exposition in Section 4.

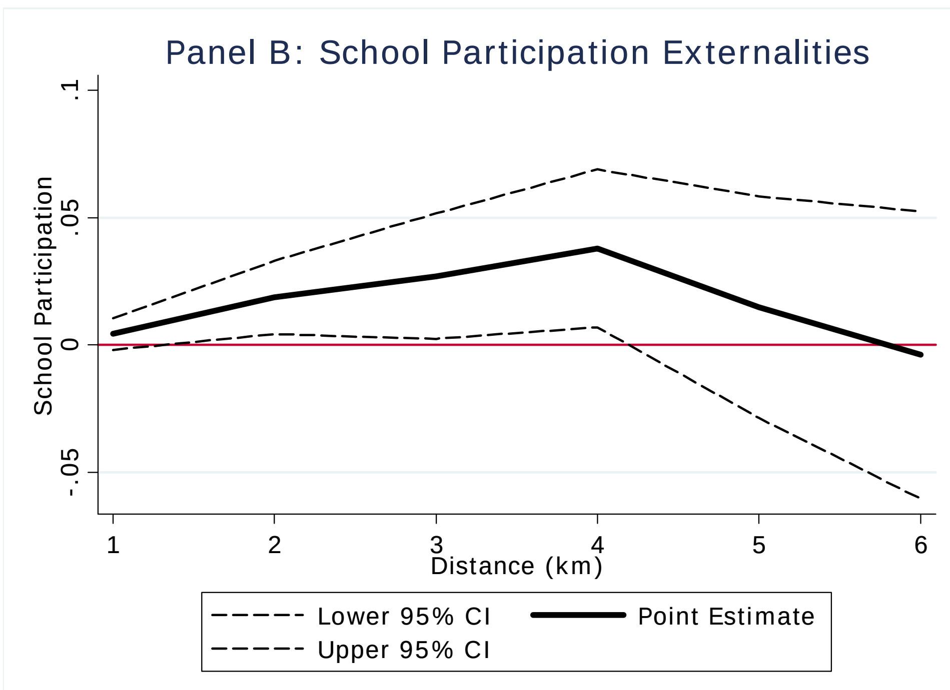
**Figure B1. Original vs. updated "overall effect", with 95% confidence intervals**




Note: Panel A displays the "overall effect" of deworming, as calculated in the bottom panel of Appendix Table B1 (for worm infections) and Panel B displays the "overall effect" of deworming from Appendix Table B2 (for school participation). See the notes under these tables for details on the regressions.

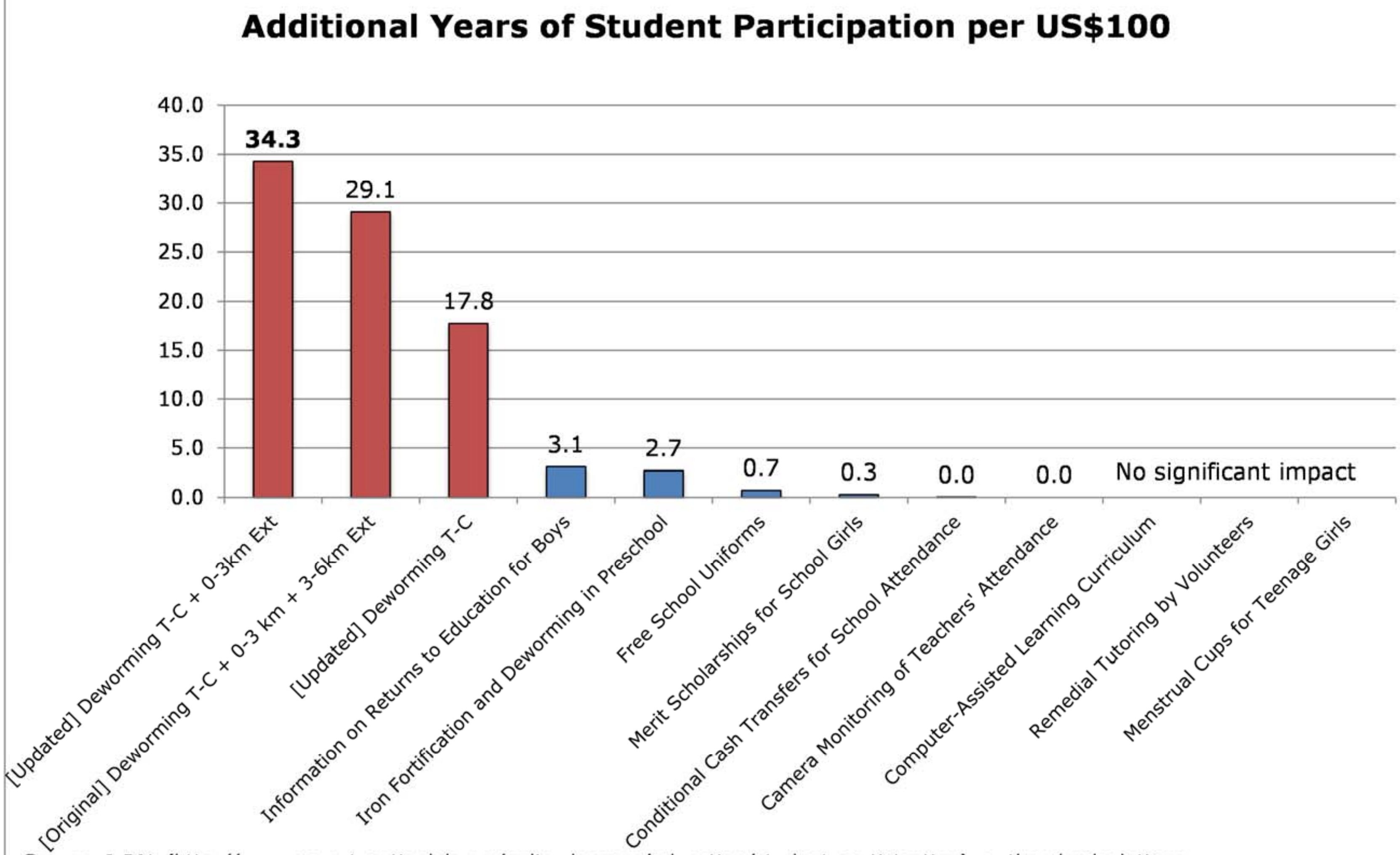
**Figure B2. Average externality impacts at various distances**




Note: Panel A plots the "average externality effect" estimates presented in Table 3 (for worm infections) and Panel B plots the "average externality effect" estimates from Table 4 (for school participation). See the notes to these tables for details on the regressions.

**Figure B3: Cost-effectiveness of school participation interventions**




*Source*: J-PAL (http://www.povertyactionlab.org/policy-lessons/education/student-participation), authors' calculations.
*Notes*: Some values are adjusted for inflation but the deworming costs are not. The cost of deworming is US$ 0.49, as in Miguel and Kremer (2004). This is likely an overestimate, since the per-child cost in the 2009 Kenya National School-Based Deworming Program was US$0.36 (http://www.dewormtheworld.org/our-work/kenya-national-school-based-deworming-program for more details).

**Table B1: Summary of any moderate-to-heavy helminth infection results, updated and original**

| | UPDATED | | | ORIGINAL | | |
|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| Treatment Indicator | -0.347*** | -0.333*** | -0.313*** | -0.347*** | -0.311*** | -0.247*** |
| | (0.052) | (0.052) | (0.057) | (0.052) | (0.052) | (0.053) |
| Treatment pupils w/in 3 km | | -0.234** | -0.212** | | -0.249*** | -0.256*** |
| (per 1000 pupils) | | (0.097) | (0.104) | | (0.085) | (0.087) |
| Treatment pupils w/in 3 - 6 km | | | -0.050 | | | -0.140** |
| (per 1000 pupils) | | | (0.077) | | | (0.060) |
| Total PSDP 'eligible' students w/in 3 km | | 0.069* | 0.046 | | 0.074** | 0.109*** |
| (per 1000 pupils) | | (0.037) | (0.036) | | (0.033) | (0.040) |
| Total PSDP 'eligible' students w/in 3-6 km | | | -0.022 | | | 0.133** |
| (per 1000 pupils) | | | (0.039) | | | (0.056) |
| *Calculated Effects* | | | | | | |
| Average 0-3 km externality effect | | -0.102** | -0.090** | | -0.111*** | -0.106*** |
| | | (0.043) | (0.044) | | (0.038) | (0.037) |
| Average 3-6 km externality effect | | | -0.052 | | | -0.096** |
| | | | (0.079) | | | (0.042) |
| Average overall cross-school externality effect | | -0.102** | -0.146 | | -0.111*** | -0.212*** |
| | | (0.043) | (0.110) | | (0.038) | (0.065) |
| Overall deworming effect | -0.347*** | -0.435*** | -0.459*** | -0.347*** | -0.421*** | -0.460*** |
| | (0.057) | (0.061) | (0.091) | (0.057) | (0.055) | (0.055) |

Note: The sample size in columns (1)-(3) is 2,330, and in (4)-(6) is 2,328. The sample includes pupils in grades 3–8, in 1999 Group 1 and Group 2 schools. Results are from probit estimation, where observations are weighted by total school population. The dependent variable is an indicator for moderate-to-heavy infection. Eligible pupils include girls less than 13 years old and all boys. Additional explanatory variables include indicators for 1998 grade and school SAP participation. Robust standard errors are in parentheses, and disturbance terms are clustered within schools. Stars denote statistical significance at 99 (***), 95 (**), and 90 (*) percent confidence.

**Table B2: Summary of school participation results, updated and original**

| | UPDATED | | | ORIGINAL | | |
|---|---|---|---|---|---|---|
| | **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6)** |
| Treatment Indicator | 0.057*** | 0.058*** | 0.055*** | 0.051** | 0.054** | 0.055** |
| | (0.014) | (0.014) | (0.014) | (0.022) | (0.023) | (0.023) |
| Treatment pupils w/in 3 km | | 0.045** | 0.038* | | 0.046** | 0.048** |
| (per 1000 pupils) | | (0.021) | (0.021) | | (0.018) | (0.019) |
| Treatment pupils w/in 3 - 6 km | | | -0.024 | | | -0.013 |
| (per 1000 pupils) | | | (0.015) | | | (0.015) |
| Total PSDP 'eligible' students w/in 3 km | | -0.030** | -0.030** | | -0.031*** | -0.037*** |
| (per 1000 pupils) | | (0.013) | (0.012) | | (0.012) | (0.012) |
| Total PSDP 'eligible' students w/in 3-6 km | | | 0.012 | | | -0.014 |
| (per 1000 pupils) | | | (0.009) | | | (0.012) |
| *Calculated Effects* | | | | | | |
| Average 0-3 km externality effect | | 0.027** | 0.023* | | 0.028** | 0.029** |
| | | (0.013) | (0.013) | | (0.011) | (0.012) |
| Average 3-6 km externality effect | | | -0.040 | | | -0.009 |
| | | | (0.024) | | | (0.011) |
| Average overall cross-school externality effect | | 0.027** | -0.017 | | 0.028** | 0.020 |
| | | (0.013) | (0.030) | | (0.011) | (0.013) |
| Overall deworming effect | 0.057*** | 0.085*** | 0.039 | 0.051** | 0.081*** | 0.075*** |
| | (0.014) | (0.017) | (0.032) | (0.022) | (0.026) | (0.027) |

Note: The sample size in columns (1)-(3) is 56,496, and in (4)-(6) is 56,487. The dependent variable is average school participation in each year (Year 1: May 1998 - March 1999; Year 2: May 1999 - November 1999). Participation is computed among all pupils enrolled at the start of the 1998 school year; pupils present during an unannounced NGO school visit are considered participants. Additional controls include an indicator for girls < 13 years and all boys; the rate of moderate-heavy infections in geographic zone, by grade (zonal infection rates among grade 3 and 4 pupils are used for pupils initially recorded as drop-outs; rates among grade 5 and 6 pupils are used for grades 5 and 6, and similarly for grades 7 and 8); 1996 school average test score; indicators for participation in the SAP, alone and interacted with an indicator for 1998; indicators for 1998 grade of pupil; and indicators for semester of observation. Robust standard errors are in parentheses, and disturbances are clustered within schools. Observations are weighted by the number of times the pupil was observed in that year. Stars denote statistical significance at 99 (***), 95 (**), and 90 (*) percent confidence.

**Table B3: Worm infection regressions, with externalities at various radii**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | **w/in 1 km** | **w/in 2 km** | **w/in 3 km** | **w/in 4 km** | **w/in 5 km** | **w/in 6 km** |
| Treatment indicator | -0.325*** | -0.354*** | -0.333*** | -0.296*** | -0.283*** | -0.306*** |
| | (0.047) | (0.051) | (0.052) | (0.057) | (0.064) | (0.056) |
| Treatment pupils within XX km | 0.581 | -0.236 | -0.234** | -0.201*** | -0.124* | -0.112* |
| (per 1000 pupils) | (0.535) | (0.180) | (0.097) | (0.077) | (0.072) | (0.063) |
| Total pupils within XX km | -0.248 | 0.110 | 0.069* | 0.044 | -0.011 | -0.001 |
| (per 1000 pupils) | (0.357) | (0.085) | (0.037) | (0.036) | (0.030) | (0.032) |
| *Calculated Effects* | | | | | | |
| Average XX km externality effect | 0.013 | -0.035 | -0.102** | -0.152*** | -0.150* | -0.166* |
| | (0.012) | (0.027) | (0.043) | (0.059) | (0.087) | (0.094) |
| Overall effect | -0.311*** | -0.389*** | -0.435*** | -0.448*** | -0.432*** | -0.472*** |
| | (0.052) | (0.062) | (0.061) | (0.062) | (0.068) | (0.085) |

Note: This table uses the fully corrected, updated data from Miguel and Kremer (2004). Regressions are as specified in Appendix Table B1, with the exception that we allow the radius at which externalities are considered to vary across the columns as indicated.

**Table B4: School participation regressions, with externalities at various radii**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | **w/in 1 km** | **w/in 2 km** | **w/in 3 km** | **w/in 4 km** | **w/in 5 km** | **w/in 6 km** |
| Treatment indicator | 0.061*** | 0.063*** | 0.058*** | 0.059*** | 0.058*** | 0.057*** |
| | (0.014) | (0.014) | (0.014) | (0.014) | (0.014) | (0.014) |
| Treatment pupils within XX km | 0.179 | 0.093** | 0.045** | 0.034** | 0.009 | -0.002 |
| (per 1000 pupils) | (0.131) | (0.037) | (0.021) | (0.014) | (0.013) | (0.013) |
| Total pupils within XX km | -0.117 | -0.064*** | -0.030** | -0.022** | -0.009 | -0.002 |
| (per 1000 pupils) | (0.109) | (0.025) | (0.013) | (0.009) | (0.009) | (0.008) |
| *Calculated Effects* | | | | | | |
| Average XX km externality effect | 0.004 | 0.019** | 0.027** | 0.038** | 0.015 | -0.004 |
| | (0.003) | (0.007) | (0.013) | (0.016) | (0.022) | (0.029) |
| Overall effect | 0.065*** | 0.081*** | 0.085*** | 0.097*** | 0.073*** | 0.053 |
| | (0.014) | (0.015) | (0.017) | (0.020) | (0.024) | (0.033) |

Note: This table uses the fully corrected, updated data from Miguel and Kremer (2004). Regressions are as specified in Appendix Table B2, with the exception that we allow the radius at which externalities are considered to vary across the columns as indicated.

**Table B5: Miguel and Kremer (2004) Table VII with 0-3 km externalities only**

| | Any moderate-heavy helminth infection, 1999 | | | Moderate-heavy schistosomiasis infection, 1999 | | | Moderate-heavy geohelminth infection, 1999 | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Indicator for Group 1 (1998 Treatment) School | -0.33*** | -0.20*** | -0.24*** | -0.12*** | -0.08 | -0.10* | -0.29*** | -0.18*** | -0.22*** |
| | (0.05) | (0.07) | (0.06) | (0.04) | (0.05) | (0.06) | (0.04) | (0.06) | (0.05) |
| Group 1 pupils within 3 km (per 1000 pupils) | -0.23** | -0.25** | -0.14 | -0.13** | -0.13** | -0.10 | -0.14 | -0.15 | -0.07 |
| | (0.10) | (0.10) | (0.12) | (0.05) | (0.05) | (0.08) | (0.09) | (0.10) | (0.12) |
| Total pupils within 3 km (per 1000 pupils) | 0.07* | 0.08** | 0.07** | 0.10*** | 0.10*** | 0.10*** | -0.01 | -0.00 | -0.01 |
| | (0.04) | (0.04) | (0.03) | (0.02) | (0.02) | (0.02) | (0.03) | (0.03) | (0.03) |
| Received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2) | | -0.06** | | | 0.04* | | | -0.10*** | |
| | | (0.03) | | | (0.02) | | | (0.03) | |
| (Group 1 Indicator) * Received treatment, when offered | | -0.14** | | | -0.05 | | | -0.11** | |
| | | (0.07) | | | (0.04) | | | (0.05) | |
| (Group 1 Indicator) * Group 1 pupils within 3 km (per 1000 pupils) | | | -0.23* | | | -0.06 | | | -0.18 |
| | | | (0.13) | | | (0.08) | | | (0.12) |
| Grade indicators, school assistance controls, district exam score control | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of observations | 2330 | 2329 | 2330 | 2330 | 2329 | 2330 | 2330 | 2329 | 2330 |
| Mean of dependent variable | 0.41 | 0.41 | 0.41 | 0.16 | 0.16 | 0.16 | 0.32 | 0.32 | 0.32 |

Note: Grade 3-8 pupils. Probit estimation, robust standard errors in parentheses. Disturbance terms are clustered within schools. Observations are weighted by total school population. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. The 1999 parasitological survey data are for Group 1 and Group 2 schools. The pupil population data is from the 1998 School Questionnaire. The geohelminths are hookworm, roundworm, and whipworm. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

**Table B6: Miguel and Kremer (2004) Table IX with 0-3 km externalities only**

| | OLS (1) | OLS (2) | OLS (3) | OLS (4) May 98-March 99 | OLS (5) May 98-March 99 | OLS (6) May 98-March 99 | IV-2SLS (7) May 98-March 99 |
|---|---|---|---|---|---|---|---|
| Moderate-heavy infection, early 1999 | | | | | | -0.028*** | -0.282** |
| | | | | | | (0.009) | (0.111) |
| Treatment school (T) | 0.057*** | | | | | | |
| | (0.014) | | | | | | |
| First year as treatment school (T1) | | 0.063*** | 0.065*** | 0.062*** | 0.044* | | |
| | | (0.015) | (0.014) | (0.022) | (0.024) | | |
| Second year as treatment school (T2) | | 0.039* | 0.036* | | | | |
| | | (0.021) | (0.021) | | | | |
| Treatment school pupils within 3 km (per 1000 pupils) | | | 0.046** | | 0.027 | | |
| | | | (0.022) | | (0.040) | | |
| Total pupils within 3 km (per 1000 pupils) | | | -0.031** | | -0.034* | 0.016 | -0.032* |
| | | | (0.013) | | (0.019) | (0.015) | (0.017) |
| Indicator received first year of deworming treatment, when offered (1998 for Group 1, 1999 for Group 2) | | | | | 0.104*** | | |
| | | | | | (0.014) | | |
| (First year as treatment school Indicator)* (Received treatment, when offered) | | | | | -0.013 | | |
| | | | | | (0.020) | | |
| 1996 district exam score, school average | 0.071*** | 0.070*** | 0.070*** | 0.058* | 0.060* | 0.016 | -0.004 |
| | (0.021) | (0.021) | (0.022) | (0.032) | (0.031) | (0.024) | (0.021) |
| Grade indicators, school assistance controls, and time controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.22 | 0.22 | 0.22 | 0.33 | 0.36 | 0.28 | - |
| Root MSE | 0.279 | 0.279 | 0.278 | 0.223 | 0.218 | 0.150 | 0.071 |
| Number of observations | 56496 | 56496 | 56496 | 18215 | 18215 | 2327 | 49 (schools) |
| Mean of dependent variable | 0.747 | 0.747 | 0.747 | 0.793 | 0.793 | 0.884 | 0.884 |

Note: The dependent variable is average individual school participation in each year of the program (Year 1 is to March 1999, and Year 2 is May 1999 to November 1999); disturbance terms are clustered within schools. Observations are weighted by the number of times the pupil was observed in that year. Robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Additional explanatory variables include an indicator variable for girls < 13 years and all boys, and the rate of moderate-heavy infections in geographic zone, by grade (zonal infection rates among grade 3 and 4 pupils are used for pupils in grades 4 and below and for pupils initially recorded as drop-outs as there is no parasitological data for pupils below grade 3; zonal infection rates among grade 5 and 6 pupils are used for pupils in grades 5 and 6, and similarly for grades 7 and 8). Participation is computed among all pupils enrolled at the start of the 1998 school year. Pupils present during an unannounced NGO school visit are considered participants. Pupils had approximately 3.8 attendance observations per year. Regressions 6 and 7 include pupils with parasitological information from early 1999, restricting the sample to a random subset of Group 1 and Group 2 pupils. The number of treatment school pupils from May 1998 to March 1999 is the number of Group 1 pupils, and the number of treatment school pupils after March 1999 is the number of Group 1 and Group 2 pupils. The instrumental variables in regression 7 are the Group 1 (treatment) indicator variable, Treatment school pupils within 3 km, and the remaining explanatory variables. We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools.

**Table B7: Miguel and Kremer (2004) Table X with 0-3km externalities only**

| | Dependent variable: ICS Exam Score (normalized by standard) | | |
|---|---|---|---|
| | (1) | (2) | (3) Among those who filled in the 1998 pupil survey |
| Average school participation (during the year of the exam) | 0.63*** | | |
| | (0.07) | | |
| First year as treatment school (T1) | | -0.042 | -0.043 |
| | | (0.048) | (0.051) |
| Second year as treatment school (T2) | | -0.014 | -0.011 |
| | | (0.075) | (0.085) |
| 1996 District exam score, school average | 0.74*** | 0.75*** | 0.78*** |
| | (0.07) | (0.06) | (0.07) |
| Grade indicators, school assistance controls, and local pupil density controls | Yes | Yes | Yes |
| $R^2$ | 0.14 | 0.13 | 0.14 |
| Root MSE | 0.919 | 0.924 | 0.918 |
| Number of observations | 24979 | 24979 | 19072 |
| Mean of dependent variable | 0.019 | 0.019 | 0.039 |

Note: Each data point is the individual-level exam result in a given year of the program (either 1998, or 1999); disturbance terms are clustered within schools. Linear regression, robust standard errors in parentheses. Significantly different than zero at 99 (***), 95 (**), and 90 (*) percent confidence. Regression 3 includes only pupils who completed the 1998 Pupil Questionnaire. Additional explanatory variables include an indicator variable for girls < 13 years and all boys, and the rate of moderate-to-heavy infections in geographic zone, by grade (zonal infection rates among grade 3 and 4 pupils are used for pupils in grades 4 and below and for pupils initially recorded as dropouts as there is no parasitological data for pupils below grade 3; zonal infection rates among grade 5 and 6 pupils are used for pupils in grades 5 and 6, and similarly for grades 7 and 8). The local pupil density terms include treatment school pupils within 3 km (per 1000 pupils), and total pupils within 3 km (per 1000 pupils). We use the number of girls less than 13 years old and all boys (the pupils eligible for deworming in the treatment schools) as the school population for all schools. The ICS tests for 1998 and 1999 were similar in content, but differed in two important respects. First, the 1998 exam featured multiple-choice questions while the 1999 test featured short answers. Second, while each grade in 1998 was administered a different exam, in 1999 the same exam – featuring questions across a range of difficulty levels – was administered to all pupils in grades 3 to 8. Government district exams in English, Maths, Science-Agriculture, Kiswahili, Geography-History, Home Science, and Arts-Crafts were also administered in both years. Treatment effect estimates are similar for both sets of exams (results not shown).