Using School Administration Data to Evaluate a Deworming Program: NTD Program in Mwanza, Tanzania

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Abstract

This report evaluates a deworming program implemented by a Korea-based international NGO in Tanzania, and measures the impacts of the program on a series of educational outcomes of the children. The program is designed to address schistosomiasis as well as the more common soil-transmitted intestinal worm infections. The challenge is steeper than is the case with the usual deworming programs that have only to deal with the latter. When the evaluation team from the KDI School Impact Evaluation Lab joined the operation early in 2012, the implementation had already been in progress since 2009, without a proper baseline study that should include an adequate control group. We try to overcome this difficulty by using school-level administration data collected from the local school district office whose jurisdiction covers both the treatment schools and other schools whose students should be exposed to similar risk factors. Quasi-experimental estimates based on the difference-in-differences identification strategy suggest fairly large and statistically significant impacts on children's school attendance and school completion, while finding no comparable impacts on the academic performance of children. A simple back-of-the-envelope type cost effectiveness calculation based on our estimates implies that about 3 extra child-school years could be bought for USD 100.

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Walter Cunningham's face told everybody in the first grade he had hookworms. His absence of shoes told us how he got them. People caught hookworms going barefooted in barnyards and hog wallows. (from Harper Lee, *To Kill a Mockingbird*)

1. Introduction

This report evaluates a deworming program in Mwanza, Tanzania, in the process of implementation by Good Neighbors, a Korea-based international NGO. The program has been administering deworming drugs to the children in 10 primary schools in Kome Island in Lake Victoria since the summer of 2009 in a five-year intervention scheduled to continue until 2013.[2] [3] The children have been getting treatment with two drugs: Albendazole to treat the usual soil-transmitted intestinal worm infections and Praziquantel to treat schistosomiasis, which is the main target of the program with its high level of prevalence in the region. The evaluation focuses on three educational outcomes: school attendance, school completion, and academic performance of the children being treated.

It should be noted at the outset that the evaluation is not based on a randomized controlled trial (RCT). What we do is a quasi-experimental evaluation, utilizing the difference-in-differences estimation and its variations for identification. When the KDI School Impact Evaluation Lab contacted the operation for collaboration for the program evaluation during the first half of 2012, the deworming program had already been in operation for three years, and there had been no baseline study covering a comparison group, let alone randomized treatment assignment. We try to overcome this difficulty by relying on the school administration data collected from the Sengerema School District Office in the program region. The school district encompasses both the treatment schools on Kome Island, the deworming program site, and the other schools along the lakeshore facing the island, which provide an arguably

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[2] While the NGO's program in the region as a whole is rather comprehensive, and meant to address challenges arising from the so-called Neglected Tropical Diseases (NTDs) in general, the component in the program this report concentrates on is a deworming program. NTDs are a pervasive public health challenge in many developing countries. The NTDs are responsible for about 500,000 deaths annually, and parasite disease is among the common NTD infections in Africa (Molyneux, 2005).

[3] In Tanzania, most NTDs are a devastating burden for people. Tanzania is endemic with all seven of common NTDs: schistosomiasis, soil-transmitted helminthes (hookworm, ascariasis, and trichuriasis), trachoma, lymphatic filariasis, and onchocerciasis. An accurate accounting of how many Tanzanians are infected with each of the NTDs has yet to be conducted, but it is estimated that the prevalence rates of schistosomiasis and soil-transmitted helminths are above 80% in some areas making these diseases as primary health burden. See http://www3.imperial.ac.uk/schisto/wherewework/tanzania, (accessed Nov. 25, 2012)

reasonable comparison group. In both parts of the district, the main industry is fisheries, and residents rely mostly on the body of the freshwater in the lake for their everyday water usage, a key risk factor for infection with schistosomiasis.

We estimate the difference-in-differences equation by pooled OLS, panel fixed effects model, and panel random effects model. Based on our estimation results, we find that the Kome Island deworming program had a significant positive impact on both school attendance and completion, but no statistically significant impact on academic achievement of children in the treatment schools. Our conservative estimate based on the results is that USD 100 spent in the Mwanza deworming program probably "bought" about 3 extra child-school years in the treatment group, and we have good reasons to believe that this is quite likely to be an understatement of the true impact.

There have been several prominent impact evaluation studies focused on school-based deworming programs, of course, including some based on RCTs. In the circle of development economists and practitioners, it is rather widely accepted that these programs are effective in promoting school attendance by children, and that, compared to other types of programs designed mainly to improve school attendance, they are highly cost-effective.[4][5][6] Nonetheless, we believe this paper contributes to the literature in at least three distinctive ways.

First, most of the deworming programs evaluated in the evaluation literature targeted the more common varieties of worms collectively known as soil-transmitted helminths, or intestinal worms in common parlance. These include well-known varieties of worms such as hookworms, whipworms, and giant roundworms (*Ascaris lumbricoides*). In contrast, the main target of the Mwanza deworming program is schistosomiasis, a parasitic disease caused by schistosomes that can cause malnutrition, anemia, damages in the liver and in tissues around the organ, and even premature death among patients.[7] Schistosomiasis is highly prevalent in the developing world, with a particularly heavy

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[4] Many authorities on public health believe that deworming can be the initial health activity in under-developed countries because it is "simple, effective, safe, and cheap" compared to other health programs (Lancet, 2004). WHO recommends treating all children at regular intervals with deworming drugs in regions where soil-transmitted helminth infection is endemic.

[5] It should be borne in mind that the cost-effectiveness of mass deworming programs still remains somewhat controversial. The literature review section will discuss this issue in more detail.

[6] In 2005, WHO aimed to achieve deworming treatment by 2010 for at least 75% of school-age children who are at risk of schistosomiasis and soil-transmitted helminths infections (WHO, 2005; Kobayashi et al., 2006), and UNDP in 2005 claimed that the global expansion of deworming treatment is crucial for benefiting school-age children, particularly in sub-Saharan Africa (UNDP, 2005; Kobayashi et al., 2006).

[7] The schistosomes prevalent in the Mwanza region require two different types of hosts to parasite on: humans and freshwater snails. In that regard, schistosomes are comparable to the malaria worms, which also require two different types of hosts (humans and mosquitoes) to complete their lifecycle. The schistosome eggs, after exiting the human body with the stool, hatch in the water, and then infiltrate a snail's body. Inside the snail's body, the worms multiply in an asexual fashion. When released from the snail's body, the young worms re-enter the

concentration in sub-Saharan Africa.[8]

Second, we rely exclusively on administrative data for our impact evaluation. Some of the leading evaluation practitioners have been promoting practical merits of this approach. Impact evaluation relying on administrative data is less costly, is less intrusive, and may be mounted with minimal interference with the design of implementation. All these traits make it easier for potential evaluators to tackle the challenges of an evaluation in a more expedient manner. Another merit is that one might evaluate a program either in progress or completed without a proper baseline study of treatment and comparison groups.

Third, we trace the changes in a group of educational outcome indicators, including, but not confined to, school attendance. Specifically, we have administration data on annual attendance rates, school completion rates, and academic test scores for every school in the district. Every child in Standard 7 (or seventh grade) is required by the country's law to sit in the mandatory, nationally standardized examination. School-level pass rates have been obtained for these annual exams. Crucially, the data goes back in time to 2007, two years before the launching of the deworming program on the island in the summer of 2009, allowing us to track the changes in the educational outcome indicators in both the treatment and the comparison regions before and after the intervention.

The rest of the report proceeds as follows. Section 2 will provide a brief review of the relevant literature. Section 3 will describe the intervention in greater detail and discuss the data and the identification strategy. Section 4 will present the main results. Section 5 will conclude with a back-of-the-envelope cost effectiveness calculation and explain supplementary intervention with some further remarks.

2. Literature review

It has long been recognized that there is correlation between health and education outcomes of school children and between intestinal worm infection and education outcomes in particular. For instance, studies have found that poor early childhood nutrition is associated with delayed primary school enrollment and reduced academic performance (Glewwe and Jacoby, 1995), and iron supplementation

human body through the surface tissue, and begin their phase of life as adult worms. While living in the blood vessels, they may not cause any acute syndrome. The eggs from the adult worms, however, "intentionally" provoke immune-allergic reactions and thus damage organs and tissues to create a chance to be released into the nature again. The lifespan of the worm is not exactly known, but it is supposed to be very long, maybe as long as 20 years or more. Various stool tests are the primary means of detecting infection. Ultra-sonar, urine, and blood tests are secondary to find out symptoms and consequences from the cumulative infection.

[8] It is estimated that there are 166 million infected cases in sub-Saharan Africa alone. (Van der Werf et. al., 2003)

improves academic outcomes of anemic children (Nokes, van den Boscj, and Bundy, 1998). Pollitt (1990) examined the performance of school-age children infected with intestinal helminths and schistosomiasis and argued that improving the nutrition and health of school-age children improved school participation and resulted in greater rewards for investment in primary education. A series of studies have shown that there are positive correlations between deworming and children's physical growth and fitness (Thein-Hlaing et al., 1991; Adams et al., 1994) and cognitive development (Watkins et al., 1996; Nokes et al., 1992). Also, there are consistent findings that serious worm infections have negative effects on educational achievement (Miguel, 2004; Bundy, 1994; Del Rosso et al., 1996; Drack et al., 1999; Stoltzfus et al., 1997). Nokes, van den Bosch, and Bundy (1998) argued that worms induce anemia that can seriously affect educational outcomes.

In a landmark study that helped launch the remarkable growth of the RCT-based evaluation literature in development economics, Miguel and Kremer (2004) examined the impact of deworming on rural primary school children utilizing randomized phase-in of school-based deworming across schools in Kenya and found that deworming treatment was highly effective in increasing school participation, and reducing school absenteeism by one quarter.[9] Kremer (2003) examined and compared school participation with several different programs in similar environment. His result showed that the deworming intervention cost only $3.50 per additional year of increasing school participation while provision of free uniforms and the school feeding program would cost $99 and $36 per additional year of schooling induced. Therefore, school-based deworming treatment may be one of the most cost effective programs to increase school participation (Kremer, 2003). A review by the Abdul Latif Jameel Poverty Action Lab at the Massachusetts Institute of Technology (2005) argued that the worm treatment was one of the most cost-effective ways to increase primary school participation (Bundy et al., 2009; the Abdul Latif Jameel Poverty Action Lab, 2005).

Long-term benefits from deworming are not easy to trace using RCTs. Bleakley (2002), in his study of the Rockefeller-sponsored deworming campaign against hookworm in the American South in the 1910s, was able to identify the long-term causal impact of childhood deworming on adult earnings by using census data and difference-in-differences analysis to measure the interaction effect of the pre-campaign prevalence rates in different parts of the US and the timing of a mass deworming campaign.[10] Bleakley's study attributed 2.1 years' gain educational attainment and 40% increase in

[9] In a precursor to Miguel and Kremer's experimental studies, Simeon et al. (1995) found that although there was no significant impact of treating Trichuris trichiura infections on growth, test of reading, spelling and arithmetic, and school attendance, the treatment reduced school absenteeism by one-third particularly with poor nutritional child groups and children with heavy infections in Jamaica (Simeon et al., 1995).

[10] The KDI School Impact Evaluation Lab is currently engaged in a study designed to replicate the Bleakley study with data from South Korea.

adult income to the eradication of hookworms resulting from the Rockefeller campaign. Since deworming drugs cost a mere fraction of a dollar per dose, this result implies that mass deworming makes an eminent economic sense in terms of cost-benefit analysis.[11]

We note however that quite a few studies have failed to register significant impacts of deworming interventions on children's educational outcomes. Watkin, Cruz and Pollitt (1996) conducted an experimental study of the effects of deworming on school performance in rural Guatemala. They found that the Ascaris treatment for 6 months did not show improvement in reading, vocabulary, or attendance for the treated primary school children. Dickson et al. (2000) systematically reviewed the effects of anthelminthic drug treatment on growth and cognitive performance in children aged 1-16 years covering 30 randomized trials in 17 countries in four continents and had this to say in conclusion: "the evidence of benefit for mass [anthelminthic drug] treatment of children related to positive effects on growth and cognitive performance is not convincing. In the light of these data, we would be unwilling to recommend that countries or regions invest in programmes that routinely treat children with anthelmintic drugs to improve their growth and cognitive performance" (Dickson et al, 2000).

Following in the footsteps of Dickson et al.'s earlier review, Taylor-Robinson, Jones, and Garner (2009) carried out a systematic review of longer follow-up randomized controlled trials (RCTs) taking into account stratification by intensity and prevalence of worm infection. Their review showed improvement in weight after a single dose of deworming but no significant effect in multiple dose trials. Also, they claimed that there is no convincing effect on school performance. According to their review, "deworming [treatment] applied to whole population may possibly have benefits in some circumstances, but not in others." Thus, researchers sometimes found evidences on benefits of deworming and sometimes not, and there are still limited empirical studies and evidences on effect of deworming treatment.

In response to these important critiques, Bundy et al. (2009) argued that treatment externalities in deworming may bias downward impact estimates from trials randomized at the level of individuals. In three studies that the authors identify that used randomization at the level of clusters, they found that

[11] According to Molyneux, Hotez and Fenwick (2005), the estimated costs of treating parasitic and infectious diseases, including drugs and delivery, is approximately $204 million for five years for curing almost 700 million population of sub-Saharan Africa. Treating schistosomiasis for 200 million targeted school-aged children costs about $80 million, costing Praziquantel at $0.25 per treatment and distribution cost at $0.15 per person. Also, intestinal helminths treatment for 400 million school-aged children costs about $52 million, costing Albendazole at $0.02 per treatment and $0.10 per person delivery (Molyneux et al., 2005).

all reported positive and significant impacts from deworming. Bundy et al. (2009) also cautioned about the potential attrition bias. As infected children are more likely to drop out of school, treatment effects as estimated among children retained in school may be downward biased in another way.

True, the results of the current study may be more difficult to interpret than the standard RCT-based results. In light of the Bundy et al. rejoinder, however, the geographical separation of treatment and comparison clusters in the Mwanza setting should help us better identify the true deworming impact. As well, the availability of school completion data should allow us to measure the deworming impact in a way that will not be affected by the potential attrition bias. As noted earlier, most of the deworming impact evaluation studies have focused on soil-transmitted intestinal worm infection. The Mwanza NTD program, in contrast, was designed to treat both geohelminth intestinal worm infection and schistosomiasis. Evaluation of such a program, in view of the high prevalence of schistosomiasis in the developing world and in sub-Saharan Africa in particular, should provide a valuable data point in the growing impact evaluation literature in the deworming arena.

3. Program implementation, data and identification strategy

As noted earlier, this report evaluates a deworming program that was implemented from 2009 to 2013 by a Korean NGO, Good Neighbors (GN), in Kome Island in Sengerema District[12] in Mwanza, Tanzania. The district has 178 primary schools in 33 wards, and Kome Island has 10 primary schools in 2 wards among them. The proximity of the schools in the district to Lake Victoria is likely to be an important contributing factor for the high prevalence rates of schistosomiasis and soil-transmitted helminths infection.

The GN organized the deworming treatment funded by KOICA in 10 primary schools in Kome Island beginning from the summer of 2009. The treatment consists of administering Praziquantel for schistosomiasis and Albendazole for soil-transmitted helminths in every 6 months during the planned 5-year operation. The mode of administration has been evolving, however. During the first two years (2009 and 2010), the program organized semi-annual communal gatherings to administer the deworming drugs in the island's villages. Beginning from 2011, the GN worked with Kome Island schools to organize school deworming day events. The detailed coverage data for these two distinct phases are provided in the two annex tables at the end of the report.

We investigate the impact of the deworming program on three educational outcomes indicators at the school level. The first is attendance. The attendance rate is measured as the percentage of child-school-days attended over the product of the total enrollment times the number of school days in a

[12] Tanzania is divided into 21 administrative regions, which are further divided into 120 districts.

given academic year.[13] The second outcome of interest is the school completion rate. The school completion rate in a given year is defined as the percentage of pupils that successfully graduated in that year over the total number of pupils that enrolled in the school seven years ago in the Standard 1. Lastly, we study the impact of deworming on the school-level national exam pass rates. All primary school students must take the Primary School Leaving Examination in October toward the end of the school year in standard 7 (the 7th grade). Only those who pass in the exam are allowed to attend public secondary schools, where tuition is much lower than in private secondary schools.[14]

We are aware that the literature has raised questions about the reliability of attendance rates data obtained from the administrative records, as the school officials may have an incentive to exaggerate the records. Some authors have advocated the need for random spot checks to ensure data quality, and we were not able to do that during our field visit. We have noted, however, that in all four of the homerooms that we visited in two Kome schools the homeroom teachers were quite meticulously keeping records of children's daily attendance. We presume that the school district office's administrative records are compiled from these daily attendance records. Nonetheless, the evaluation results that we report below regarding the school attendance rates should be taken with a grain of salt in view of the potential data quality problem. Regarding the school completion and the national exam pass rates data, however, we are on a firmer ground, as school completion records and exam performance data should not be as prone to manipulation by the administrators of the individual schools.

The unit of observation in the subsequent analysis is the school-year. We have official administration data collected from the Sengerema School District Office for six years from 2007 till 2012 for attendance rates and for five years from 2007 till 2011 for completion and national exam pass rates.

For attendance rates, we thus have 1,068 (=178*6) observations; for completion and pass rates, 890 observations (=178*5). The actual sample sizes may vary slightly, as the data contains some missing school-years for a small number of schools newly launched in the lakeshore area across the lake from the island. For sensitive checks, we exclude the 2009 observations in some specifications in consideration of the ambiguity of the results during that school year, since the deworming program was initiated in the middle of that year. The final number of observations in the working sample is 1030 for attendance rate, 834 for completion rates, and 839 for national exam pass rates.

Tables 1-3 present the changes in the outcome indicators in the Kome treatment schools and the comparison schools before and after the program.

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[13] A school year in Tanzania consists of 194 days..

[14] It is estimated that the average pass rate in Tanzania is from 70% to 90%, and of those who passed the exam in 2009, 90.4% were joined public secondary schools in 2010.

<Table 1> The changes in school attendance rates in the treatment and the comparison groups before and after the program implementation

	Before	**After**	**After-Before**
KOME Island Schools (T)	79.1333	82.7333	3.600
Non-KOME Schools (C)	81.0296	82.0322	1.0026
(T - C)	-1.8963	0.7011	**2.5974**
Observations	1030	1030	1030

Note: before=2007~2008, after=2010~2012

<Table 2> The changes in school completion rates in the treatment and the comparison groups before and after the program implementation

	Before	**After**	**After-Before**
KOME Island Schools (T)	90.0667	94.0999	4.0332
Non-KOME Schools (C)	91.3312	92.1931	0.8619
(T - C)	-1.2645	1.9068	**3.1713**
Observations	834	834	834

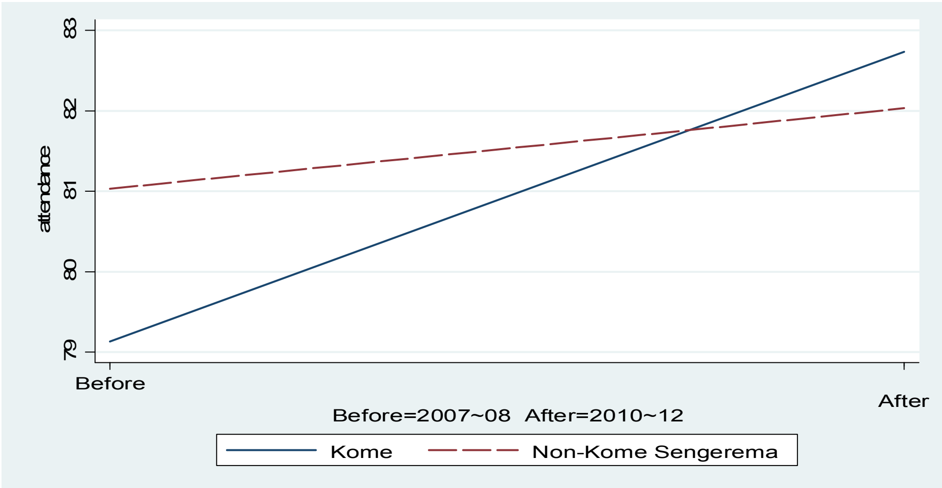
Note: before=2007~2008, after=2010~2012

<Table 3> The changes in national exam pass rates in the treatment and the comparison groups before and after the program implementation

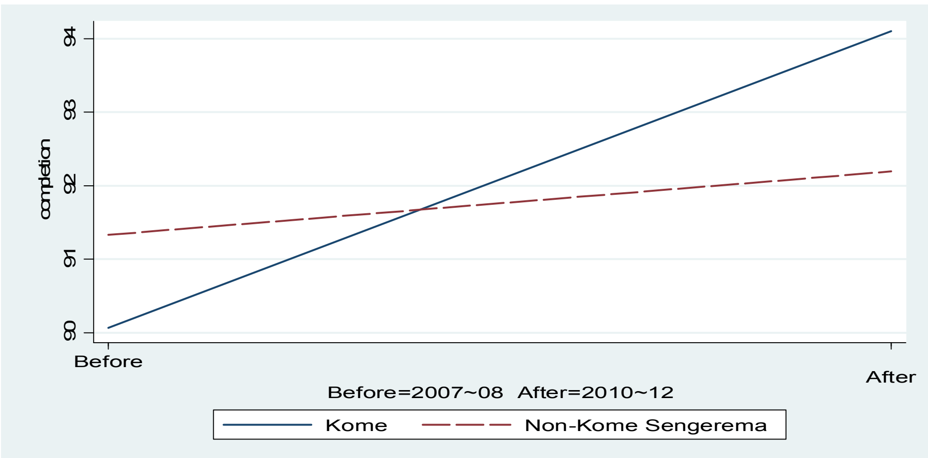
	Before	**After**	**After-Before**
KOME Island Schools (T)	58.2143	63.2501	5.0358
Non-KOME Schools (C)	45.703	50.0826	4.3796
(T - C)	12.5113	13.1675	**0.6562**
Observations	839	839	839

Note: before=2007~2008, after=2010~2012

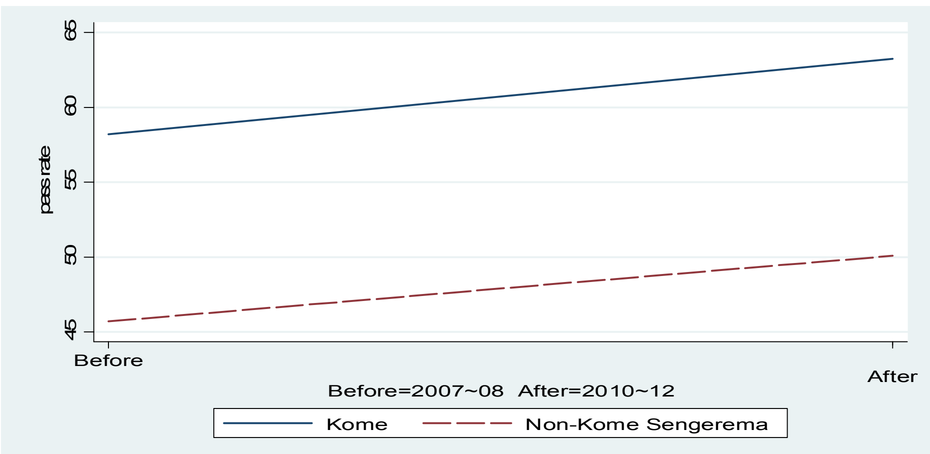
<Figure 1> Attendance rates in the treatment and the comparison schools before and after the program



<Figure 2> Completion rates in the treatment and the comparison schools before and after



<Figure 3> National exam pass rates in the treatment and the comparison schools before and after



non-Kome comparison schools before and after the beginning of the program in 2009, and calculate the difference-in-differences for each outcome measure. All three outcome indicators, that is attendance rates, completion rates, and national exam pass rates, register gains over the years in both the treatment and the comparison regions. However, the improvements are bigger for the Kome treatment schools. As a result, the difference-in-difference measures of the program impact are all positive for each of the outcome measures, as noted in the bottom right cells. These patterns are also visually presented in Figures 1-3.

To see whether these impacts are statistically significant, we implement the difference-in-differences identification strategy based on the following regression equation:

$$y_{it} = \beta_0 + \beta_1 after_t + \beta_2 Kome_i + \beta_3 * Kome_i * after_t + u_{it} \qquad (1)$$

where the dependent variable y_{it} is the outcome of interest such as attendance rate, completion rate, or national exam pass rate in school i in year t; $after_t$ is a dummy variable taking on the value of 1 for years 2010, 2011, and 2012 and 0 otherwise; $Kome_t$.is a dummy variable assuming the value of 1 for Kome island schools; and finally u_{it} is the statistical error. The deworming treatment effect should be captured by the coefficient estimate for β_3.

For our empirical strategy, the identifying assumption is that in the absence of the treatment the changes in the values of the outcome variables would have been similar between the treatment and the comparison groups. This assumption cannot be formally tested within the confines of the current data set. Yet, the changes in the values of the outcome variables between the two groups do look similar during the first two years of our data, prior to the beginning of the intervention. For instance, the group average attendance rate slightly improved for the lakeshore comparison schools from 81.7% in 2007 to 81.8% in 2008; the comparable rate for the Kome treatment schools also slightly improved from 77.4% to 77.7% over the same period.

Regression equation (1) is first estimated by pooled OLS. We also estimate panel fixed effects and panel random effects versions of the same model. These panel estimators recognize that the error term may be decomposed as the sum of the time invariant school-specific fixed effect α_i and the time-varying idiosyncratic error v_{it} as in the following equation. The panel estimation models assume that the idiosyncratic error is uncorrelated with the regressors, while allowing for possible correlation between the school fixed effect and the regressors.

$$y_{it} = \beta_0 + \beta_1 after_t + \beta_2 Kome_i + \beta_3 {*} Kome_i {*} after_t + \alpha_i + v_{it.} \qquad (2)$$

As is well known, the panel fixed effects estimator should provide consistent estimates in the presence of correlation between the school fixed effect and the regressors while the panel random effects estimator would be inconsistent. If there is no correlation between the school fixed effect and the regressors, both the estimators should be consistent, but the panel random effects estimator should be efficient as well.

4. Main results

Tables 4-6 present the main estimation results. Table 4 measures the impact of deworming on school attendance rates; Table 5 the impact on school completion rates; and Table 6 the impact on national exam pass rates. In each table, the difference-in-differences equation is estimated by pooled OLS (column (1)), by panel fixed effects (column (2)), and by panel random effects (column (3)).

If the school fixed effect is correlated with the regressors for any reason, then both pooled OLS and random effects specifications will return biased estimates. Only the panel fixed effects specification will be consistent. If there is no correlation between the school fixed effect and the regressors, then all three specifications will be consistent with the random effects estimation being most efficient. Pooled OLS estimation is dominated by either panel fixed effects or panel random effects, but its results are shown for the purpose of comparison. The deworming program impact is captured by the coefficient estimate for the interaction term between the "Kome" dummy (the treatment region dummy) and the "After" dummy (post-intervention period dummy).

In Table 4, measuring the impacts of deworming on school attendance, the estimated coefficients for the interaction term of interest are roughly similar to each other in terms of size. While the pooled OLS estimate is not statistically significant, the fixed effects and the random effects estimates are. In the Hausman specification test comparing the fixed effects and the random effects specifications, the value of the chi-squared statistic with 2 degrees of freedom was 0.71 with the p-value of 0.702. Thus we do not reject the null hypothesis that there is no correlation between the school fixed effect and the regressors. Thus among the results in Table 4, our preferred estimate is from random effects in column (3). The results imply that the deworming program increased the average school attendance rate in Kome island schools roughly by 2.5%.

<Table 4> Difference-in-differences estimates of the deworming impact on school attendance

	Pooled OLS	Fixed effects	Random effects
	(1)	(2)	(3)
Kome*After	**2.6**	**2.44**	**2.45**
	(2.43)	**(1.18)***	**(1.18)***
Kome	-1.9		-1.8
	(1.72)		(2.74)
After	1	1.16	1.15
	(0.59)+	(0.29)**	(0.29)**
Constant	81.03	80.85	80.94
	(0.42)**	(0.20)**	(0.65)**
Obs.	1,030	1,030	1,030

Notes: The numbers within the parentheses are standard errors. + significant at 10% level of significance; * significant at 5%; ** significant at 1%. The dependent variable is the average attendance rate in a given school in a given year.

<Table 5> Difference-in-differences estimates of the deworming impact on school completion

	Pooled OLS	Fixed effects	Random effects
	(1)	(2)	(3)
Kome*After	**3.17**	**3.17**	**3.17**
	(3.2)	**(1.51)***	**(1.51)***
Kome	-1.26		-1.28
	(2.02)		(3.22)
After	0.86	0.87	0.86
	(0.78)	(0.37)*	(0.37)*
Constant	91.33	91.25	91.34
	(0.50)**	(0.23)**	(0.78)**
Obs.	834	834	834

Notes: The numbers within the parentheses are standard errors. + significant at 10% level of significance; * significant at 5%; ** significant at 1%. The dependent variable is the average attendance rate in a given school in a given year.

<Table 6> Difference-in-differences estimates of the deworming impact on national exam pass rate

	Pooled OLS	Fixed effects	Random effects
	(1)	(2)	(3)
Kome*After	**0.66**	**0.27**	**0.4**
	(4.94)	**(3.95)**	**(3.94)**
Kome	12.51		12.77
	(3.19)**		(4.14)**
After	4.38	4.66	4.57
	(1.19)**	(0.95)**	(0.94)**
Constant	45.7	46.31	45.5
	(0.76)**	(0.59)**	(0.99)**
Obs.	839	839	839

Notes: The numbers within the parentheses are standard errors. + significant at 10% level of significance; * significant at 5%; ** significant at 1%. The dependent variable is the average national exam pass rate in a given school in a given year.

Next we turn to Table 5 reporting the impact estimates of deworming on school completion. Again, the coefficient estimates are quite similar across alternative specifications. The value of the Hausman

chi-squared statistic with 2 degrees of freedom was 0.06 and the p-value 0.97. The preferred random effects estimation results in column (3) suggest that the deworming program also had a positive impact on the average school completion rate in the Kome island treatment schools, raising the rate roughly by 3.2%.

In Table 6, looking at the impact estimates on the national exam pass rate, we find that none of the impact estimate is statistically distinguishable from 0. The estimated impact is positive throughout the specifications, but the sizes are small, and we cannot reject the null hypothesis that the impact is equal to zero.

In the regressions reported in Tables 4-6, years 2010, 2011, and 2012 are considered as post-intervention period and the three earlier years 2007, 2008, and 2009 as pre-intervention. As noted earlier, however, since the deworming program was launched in the summer of 2009, it is not clear whether we should place the outcomes from the year 2009 in the post-intervention pile or in the pre-

<Table 7> Program Duration and the impacts on attendance rates: difference-in-differences random effects estimation

	07-09 vs. 10-12	07-08 vs. 10-12	07-08 vs. 11-12	07-08 vs. 12
	(1)	(2)	(3)	(4)
Kome* After	**2.45**	**3.65**	**3.72**	**4.01**
	(1.18)*	**(1.34)****	**(1.54)***	**(1.96)***
Kome	-1.8	-3	-3.01	-3.06
	(2.74)	(2.82)	(2.85)	(2.93)
After	1.15	1.53	1.63	1.34
	(0.29)**	(0.33)**	(0.38)**	(0.48)**
Constant	80.94	80.55	80.56	80.61
	(0.65)**	(0.68)**	(0.68)**	(0.71)**
Obs.	1030	856	681	505

Notes: The numbers within the parentheses are standard errors. + significant at 10% level of significance; * significant at 5%; ** significant at 1%. The dependent variable is the average attendance rate in a given school in a given year. The results in column (1) are a reproduction of column (3) in Table 4. The results in column (2) are obtained by classifying the first two years (2007 and 2008) as pre-intervention and the three years 2010, 2011, and 2012 as post-intervention dropping the observations from the ambiguous year 2009. The results show that this reclassification does increase the estimated impact of deworming.on attendance. The estimation in column (3) compares the attendance rates in the pre-intervention 2007-8 against the observations from 2011-12; the results in column (4) compares between the pre-intervention 2007-08 vs. 2012.

intervention. It is likely that we will get bigger impact estimates when we omit the observations from that year, if the impacts do not take long before they manifest themselves. It would be interesting to be able to confirm this conjecture. It would be also interesting to see whether the impact estimates become larger when we further drop observations from 2010, and subsequently from 2011 as well. In other words, do the impacts get cumulatively larger with the duration of the program intervention?

To help answer these questions, Table 7 marshals four more estimation results. All the results in Table 7 are obtained from the panel random effects estimation of the difference-in-differences equation. The differences between the columns are in the specification of the pre- and post-intervention periods. The results in column (1) are a reproduction of column (3) in Table 4, presented for expedient comparison with the other results. In column (2), the observations from the ambiguous year 2009 are dropped, so that the pre-intervention period covers 2007 and 2008 only. The impact on the average attendance rate is shown to be substantially larger now. In column (3), we compare the attendance rates between the pre-intervention 2007-08 and the post-intervention 2011-12. In column (4), the pre-intervention 2007-08 rates are compared against those from year 2012. The results in columns (3) and (4) show that as we look toward the end of the program period, the estimated impact on the attendance rate grows. For instance, the results in column (4) suggest that exposure to the deworming program for three years (2009, 2010, and 2011) increased the attendance rate in the treatment schools in Kome by about 4% vis-à-vis the comparison schools.

If the immune system of a human body develops with age, the impact of deworming on the performance at school may vary across different age groups. There are seven grades in elementary school in Tanzania. We consider a model in which the program effect is allowed to differ for each grade as in equation (3).

$$y_{ijt} = \beta_0 + \sum_{k=1}^{7} \beta_{1k}\, Grade_k + \sum_{k=1}^{7} \beta_{2k} Kome_i * Grade_k + \sum_{k=1}^{7} \beta_{3k} After_t * Grade_k + \sum_{k=1}^{7} \beta_{4k} Kome_i * After_t * Grade_k + \alpha_i + \theta_j + \sigma_t + \varepsilon_{ijt} \qquad (3)$$

The estimation of the model in equation (3) is essentially the same as estimating the model of equation (2) for each grade groups. Due to the availability of data, only the attendance rate by grade is used as a dependent variable. [15] School-specific characteristics, α_i , could be controlled using either a fixed-effect model or random effect model. The latter is taken since Hausman test does not suggest a systematic difference between the estimates of the two models under the null hypothesis.

<Table 8> presents the estimation results for male students. In column (1), where the intervention period is defined to be from 2010 to 2012, the impact of deworming on attendance rate is estimated to be in the range of -6.47 to +3.28 percentage points for different grade groups, but none of them are estimated precisely. The results are similar when the pre-intervention period is restricted to be from 2007 to 2008 in column (2). Further, the impact of the program in the later stage of the intervention is not estimated to be different among grade groups as in column (3) and (4). The results for female students are qualitatively similar to those for male students (not reported). Therefore, no evidence on the differential impact of deworming on attendance across different ages is found.

[15] Although both the school-level data and the school-grade-level data were provided by the district education office, two data sets seem to be generated through different processes. Therefore, the consistency in these data sets needs to be verified.

<Table 8> Program Duration and the impacts on attendance rates by grade among male students: difference-in-differences random effects estimation

	07-09 vs. 10-12	07-08 vs. 10-12	07-08 vs. 11-12	07-08 vs. 12
	(1)	(2)	(3)	(4)
Kome*After*Grade 1	-1.11	-2.23	-4.18	-6.11
	(3.41)	(3.71)	(4.11)	(5.07)
Kome*After*Grade 2	2.68	3.82	2.20	3.90
	(3.54)	(3.95)	(4.32)	(5.25)
Kome*After*Grade 3	-2.90	-2.09	-2.96	3.63
	(3.54)	(3.95)	(4.32)	(5.25)
Kome*After*Grade 4	-0.69	-2.20	-0.76	5.42
	(3.54)	(3.95)	(4.32)	(5.25)
Kome*After*Grade 5	-6.47	-4.88	-5.85	-7.10
	(3.54)	(3.95)	(4.32)	(5.25)
Kome*After*Grade 6	3.28	5.58	3.43	0.56
	(3.54)	(3.95)	(4.32)	(5.25)
Kome*After*Grade 7	1.46	4.27	3.47	6.19
	(3.54)	(3.95)	(4.32)	(5.25)
Obs.	6,846	5,705	4,564	3,423

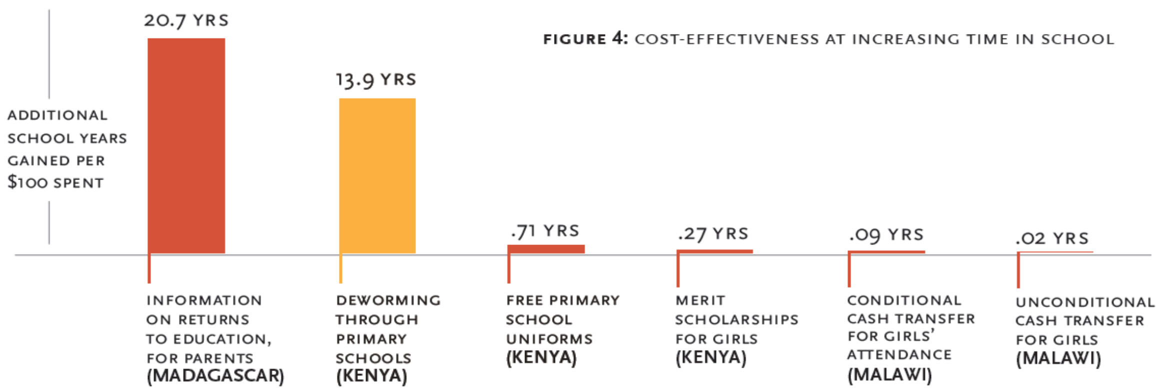
Notes: The numbers within the parentheses are standard errors. + significant at 10% level of significance; * significant at 5%; ** significant at 1%. The dependent variable is the average attendance rate in a given school in a given year by grade. The definition of intervention period in each column follows those in <Table 7>.

5. Cost-effectiveness and concluding remark

In this section we assay a back-of-the-envelope type cost-effectiveness calculation. Before we begin, it will be instructive to review how other types of interventions fare in the promotion of school attendance by school-age children. Figure 4 below is a reproduction from the March 2012 issue of the J-PAL Bulletin. The figure compares how many school years a given type of intervention might "buy" in additional school attendance when USD 100 is used for that intervention. The figure compares six different intervention strategies evaluated with RCTs in several sub-Saharan countries: imparting information on returns to education to parents (Madagascar); school-based deworming (Kenya); free school uniforms (Kenya); merit scholarship for girls (Kenya); CCT for girls' attendance (Malawi); and unconditional cash transfers for girls. The first two interventions simply dwarf the others in terms of cost effectiveness. We want to find out how the Mwanza program-style deworming stacks up against these other strategies.

We first need to determine which of the range of estimates to employ for our calculation. Maybe it

<Figure 4> Cost-effectiveness comparison for various interventions designed to promote school attendance



Source: March 2012 issue of the J-PAL Bulletin

would be reasonable and conservative enough to assume 3% increase in annual average attendance.

Earlier we saw that, depending on the treatment of the initial year of 2009, panel random effects estimation gives us either 2.45% boost (column 3, Table 4) or 3.65% (column 2, Table 7), even though there is some evidence that the true impact might be slightly higher toward the end of the program run (columns 3 and 4, Table 7).

The Good Neighbors deworming program in Kome Island, Mwanza, has been running for 4 years up to this point. How many extra child-school days, or child-school years, have we bought? A Tanzanian school year lasts approximately 200 days, and we have about 10,000 primary school children in the island. 3% increase in average annual attendance means extra 60,000 child-school days (60,000=0.03*200*10,000) *per year*. The cumulative purchase for the past four years then amounts to 240,000 child-school days.

We are told that the GN deworming operation in the island costs roughly USD 10,000 per year including costs of drugs and delivery costs including outlay for a simple meal taken by the children before the drug administration, even though the Mwanza NTD program as a whole is a lot more costly. Thus the total amount of money spent for the deworming drugs administration runs up to about USD 40,000 during the past four years.

So roughly speaking, USD 1 in the Mwanza-style deworming program can buy us 6 extra child-school days. To make this number comparable with those in Figure 4, which compares program impacts that one might buy with USD 100, we multiply 6 days by 100 to get 600 extra child-school days. Since the school year consists of about 200 days, the figure amounts to 3 extra child-school years.

This easily beats the rest of the competition in Figure 4, but is dominated by the first two. It is perhaps worthwhile to think about why the Mwanza deworming program is faring worse than the Kenya program in the diagram. We do not have definitive answers to this question, but it isn't difficult to line up some likely culprits.

First, Praziquantel is more expensive than Albendazole, and schistosomiasis is a disease more costly to cure than the usual intestinal worm infection.[16] The experiment in Kenya took place in a region where schistosomiasis does not have a significant presence and could focus on treating intestinal worm infection only. This would not have made much sense in Kome, however, since the majority of children were found to be infected with schistosomiasis with a relatively low prevalence rate for the intestinal worm infection.

Second, we should think about economies of scale and the spreading of overhead costs. The Kenyan experiment was much bigger than the Mwanza program: 56 schools were enrolled in the treatment group in Kenya vs. only 10 schools in Mwanza. On a comparable scale, the unit cost would be certainly lower with the Mwanza-type deworming, even though how much lower it could go is anyone's guess.

Third, we recall that the Mwanza program changed its implementation strategy along the way. It began as a community-based program to be transformed into a school-based program two years down the road. We are not aware of any rigorous cost effectiveness comparison between community-based and school-based mass deworming programs, but we believe it is a fair guess that the community version would be more costly to reach out to a given number of target population, especially a given number of school-age children.

Disregarding all other forms of benefits, including healthier life in the longer run, we might assume for the sake of argument that the sole purpose of the deworming program is promotion of school attendance. The authors of this report are persuaded that 3 extra child-school years for 100 dollars (a conservative estimate!) do sound like a good bargain. This estimated impact may not make the Mwanza-style deworming the most cost-effective intervention, but it certainly beats many other school children-focused programs.

[16] Treating schistosomiasis requires Praziquantel at $0.25 per treatment and distribution cost at $0.15 per person. Also, intestinal helminths treatment costs Albendazole at $0.02 per treatment and $0.10 per person delivery (Molyneux et al., 2005).

Last but not least, we really need to share this observation: the cost effectiveness measures for both our estimate and the one from the Kenyan study are most likely to be understatements due to a reason we have yet to discuss or allude to. Unlike some other programs that they are being compared with, they will most certainly have some lingering effects even after the suspension of the program itself. Since it will take at least some years before the population infection rate can climb back to its former plateau, in the meantime, the boost in school attendance and other benefits will continue to accrue.

Before we conclude this report, we want to share our plans for a couple of follow-up studies.

We plan to collect worm infection data from GN at the end of the intervention, July 2013. Using both households survey data and worn infection data, we will analyze the impact of the household environment on worm re-infection of children. In addition, we will conduct the evaluation of the educational outcomes at individual level. As the school based results showed positive significant impact on school attendance and completion rate, we will compare to see whether the results will be similar by using micro level data. We are hopeful that this richer data setting might enable us to better understand and better measure the impact of deworming on educational outcomes.

The household survey is designed to compare characteristics between treatment and control schools and to evaluate the impact of household environment on worm re-infection of children. All ten treatment schools in Kome Island are included as the targeted survey schools, and the Sengerema school district office and GN selected ten control schools considering school characteristics and geographic location, mainly nearby lakeshore. At each school, about 25 to 28 care givers of students who were at the 7th standard were interviewed and informed about the purpose of the surveys. Ten local volunteers were employed for ten days to go on-site survey and about 250 students were involved in each treatment and control group. The list of information of family, including participation of deworming program, residential environment, health and sanitation, agricultural production, and income and expenditure constitutes the household survey. Although it was not a baseline survey prior to the start of the program, the households and children in treatment and control schools were similar on most dimensions <Annex 3>.

If it is possible at all to drive the worm infection rate to zero (or below a certain threshold from below which the worm population cannot grow back to its usual stable equilibrium level), the best way to maximize the long-term benefit-cost ratio from a deworming program could be to sustain the campaign until the worm population is driven below the threshold. The Rockefeller campaign and the nation-wide deworming campaign in South Korea demonstrate that it is indeed possible. We at the KDI School Impact Evaluation Lab are planning to conduct a study based on the Korean episode that replicates Bleakley's study of the impact of the Rockefeller deworming and demonstrate how the conjecture given above fits the data.

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<Annex 1> Coverage of residents in the community-based phase of the program: 2009 to 2011

	Village	Eligible population			Treated						
		Total (A)	<2yrs old (B)	Eligible (C=A-B)	2009 (D)	2009 (E=D/C) %	2010 (F)	2010 (G=F/C) %	2011 (H)	2011 (I=H/C) %	2012 (J)
1	Lugata	10,538	527	10,011	6,458	64.51	3,851	38.47	2,890	28.87	
2	Kabaganga	3,040	158	2,882	1,774	61.55	1,078	37.40	1,031	35.77	
3	Bugoro	4,133	181	3,952	2,658	67.26	2,182	55.21	777	19.66	
4	Nyakabanga	2,665	129	2,536	1,629	64.24	1,838	72.48	997	39.31	
5	Nyakasasa	4,678	230	4,448	3,041	68.37	2,401	53.98	1,516	34.08	
6	Nyamiswi	2,148	126	2,022	1,476	73.00	1,534	75.87	734	36.30	
7	Isenyi	4,024	253	3,771	2,841	75.34	2,557	67.81	1,412	37.44	
8	Buhama	8,669	275	8,394	4,278	50.96	3,101	36.94	436	5.19	
							776*		6,965**		7,821 ***
Total		**39,895**	1,879	38,116	**23,906**	62.72	**19,318**	50.68	**16,758**	43.97	

Note: *: additional residents treated at the NTD health clinic after the community deworming event

** and ***: number of children treated through the school deworming day event

<Annex 2> Coverage of the school children in the school-based stage: 2011 and forward

NO	Primary School	2011 School Treatment			2012 School Treatment		
		Enrollment	Number treated	Coverage (%)	Enrollment	Number treated	Coverage (%)
1	Izindabo	525	401	76.38	583	436	74.79
2	Kabaganga	925	439	47.46	845	463	54.79
3	Isenyi	987	880	89.16	860	703	81.74
4	Nyamiswi	750	650	86.67	906	688	75.94
5	Nyakasasa	1400	738	52.71	1,083	925	85.41
6	Buhama	1257	666	52.98	1,003	695	69.29
7	Nyakabanga	790	516	65.32	762	564	74.02
8	Bugoro	881	333	37.80	826	600	72.64
9	Lugata	1200	544	45.33	1,000	748	74.80
10	Muungano	1500	595	39.67	1,037	996	96.05
	Total	10215	5762	56.41	8905	6818	76.56

<Annex3> Summary Statistics of Households Survey

	All	Treat	Comp
Kome / Non-Kome	501	255(50.9%)	246(49.1%)
Program Awareness	381(76.7%)	225(88.2%)	156(64.5%)
Taking Deworming Drugs _adults	364(75.1%)	228(92.3%)	136(57.1%)
_children	401(80.0%)	252(98.8%)	149(60.8%)
Average Number of Taking Drugs _adults	1.8 times	2.5	1.2
_children	1.9 times	2.8	1.0
Average age of children	15 years old	15	15
Female	48.5%	51.0%	46.1%
Average num. of total household members	8.6	8.5	8.8
Average num. of siblings	5.4	5.2	5.5
<u>Residence</u>			
Floor-cement	131(28.4%)	67(28.9%)	64(28.0%)
Floor-soil	348(71.6%)	181(73%)	167(70%)
Child wearing shoes	263(55.8%)	122(51.3%)	141(60.3%)
School-aged child not attending school	36 (7.25)	17(6.7%)	19(7.8%)
Average distance to school (minute)	25.9	24.3	27.4
<u>Health and Sanitation</u>			
Average num. of ill in household	1.3	1.2	1.3
Sanitary facility_ pit latrine	469(93.6%)	243(95.3%)	225(91.8%)
Sanitary facility _rubbish pit	421(84.4%)	223(87.5%)	197(81.1%)
Sanitary facility _bath shelter	480(95.8%)	243(95.3%)	236(96.3%)
Sanitary practice _soap after toilet	312(63.2%)	155(61.8%)	157(64.9%)
Sanitary practice _soap before eating	244(49.1%)	128(50.4%)	116(47.9%)
Sanitary practice _ soap before preparing food	186(37.8%)	99(39.6%)	87(36.1%)
Sanitary practice _soap after washing babies	294(59.5%)	148(59.2%)	145(59.7%)
Sanitary practice _washing food ingredient	435(88.1%)	227(90.4%)	208(85.9%)
Sanitary practice _ boiling drinking water	203(41.6%)	118(47.2%)	84(35.4%)
Sanitary practice _separate dwelling for livestock	387(83.8%)	212(91.4%)	174(76%)
Principal source of water for drinking			
_traditional well	335(67%)	136(53.5%)	198(80.8%)
_pump well	106(21.2%)	79(31.1%)	27(11%)
_improved well w/o pump	23(4.6%)	20(7.9%)	3(1.2%)
_rain	11(2.2%)	2(0.8%)	9(3.7%)
_river	-	-	-
_lake	23(5%)	17(6.7%)	8(3.3%)
Principal source of water for cooking			
_traditional well	317(63.3%)	128(50.2%)	188(76.7%)
_pump well	85(17%)	60(23.5%)	25(10.2%)
_improved well w/o pump	19(3.8%)	14(5.5%)	5(2%)
_rain	-	-	-
_river	6(1.2%)	-	6(2.5%)
_lake	74(14.8%)	53(20.8%)	21(8.6%)
Principal source of water for washing clothes			
_traditional well	288(57.5%)	107(42%)	180(73.5%)
_pump well	65(13%)	53(20.8%)	12(5%)
_improved well w/o pump	18(3.6%)	13(5.1%)	5(2%)
_rain	2(0.4%)	1(0.4%)	1(0.4%)
_river	26(5.2%)	7(2.8%)	19(7.8%)
_lake	102(20.4%)	74(29%)	28(11.4%)
Principal source of water for washing dishes			
_traditional well	307(61.3%)	119(46.7%)	187(76.3%)
_pump well	71(14.2%)	55(21.6%)	16(6.5%)
_improved well w/o pump	19(2.8%)	14(5.5%)	5(2%)

_rain	30.6%)	1(0.4%)	2(0.8%)
_river	13(2.6%)	1(0.4%)	12(5%)
_lake	88(17.6%)	65(25.5%)	23(9.4%)
Principal source of water for washing body			
_traditional well	292(58.4%)	110(43.1%)	181(74.2%)
_pump well	66(13.2%)	55(21.6%)	11(4.5%)
_improved well w/o pump	16(3.2%)	12(4.7%)	4(1.6%)
_rain	3(0.6%)	1(0.4%)	2(0.8%)
_river	24(4.8%)	5(2%)	19(7.8%)
_lake	99(19.8%)	72(28.2%)	27(11.1%)
Average distance to well (minute)	20.4	18.5	22.6
Average distance to Lake Victoria (minute)	44.8	38.3	52.8
Agricultural Production			
Agricultural activity _crop farming	483(97%)	244(96.1%)	238(98%)
Income & Expenditure			
Main source of income _Self-employment	468(95%)	239(94.5%)	228(95.4%)
Average annual income (US dollar)	837.8	824.9	856.3
Average household debt (US dollar)	136	141.5	129.3
Average medical expenses (US dollar)	15	15.2	14.8
Main cause of medical expenses			
_disability	4(1.8%)	1(0.9%)	3(2.7%)
_chronic diseases	23(11.1%)	4(3.7%)	20(17.1%)
_care of vulnerable	194(85.8%)	103(95.4%)	91(77.8%)
_ accidents	3(1.3%)	-	3(2.7%)
Main food _maize	467(94.7%)	241(95.3%)	226(94.1%)
Average times of full meal a day			
_ none	2(0.4%)	2(0.8%)	-
_1 time	11(2.2%)	5(2%)	5(2.1%)
_ 2 times	390(78.5%)	221(87%)	169(69.8%)
_ 3 times	94(18.9%)	26(10.2%)	68(28.1%)