EVALUATING IMAPCT OF A DEWORMING PROGRAM ON EDUCATIONAL OUTCOMES: THE CASE OF THE NEGLECTED TROPICAL DISEASES (NTD) PROGRAM IN TANZANIA

By

Jin Young Hyun

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

DOTOR OF PHILOSOPHY

IN PUBLIC POLICY

2014

EVALUATING IMAPCT OF A DEWORMING PROGRAM ON EDUCATIONAL OUTCOMES: THE CASE OF THE NEGLECTED TROPICAL DISEASES (NTD) PROGRAM IN TANZANIA

By

Jin Young Hyun

THESIS

Submitted to

KDI School of Public Policy and Management

in partial fulfillment of the requirements

for the degree of

DOTOR OF PHILOSOPHY

IN PUBLIC POLICY

2014

Professor Taejong Kim

EVALUATING IMAPCT OF A DEWORMING PROGRAM ON EDUCATIONAL OUTCOMES: THE CASE OF THE NEGLECTED TROPICAL DISEASES (NTD) PROGRAM IN TANZANIA

By

Jin Young Hyun

THESIS

Submitted to
KDI School of Public Policy and Management in
partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY
IN PUBLIC POLICY

Committee in charge:

Professor Taejong KIM, Supervisor

Professor Jong-Il YOU

Professor Kye Woo LEE

Professor Shun WANG

Professor Jungho KIM

Approval as of December, 2014

ABSTRACT

EVALUATING IMAPCT OF A DEWORMING PROGRAM ON EDUCATIONAL OUTCOMES: THE CASE OF THE NEGLECTED TROPICAL DISEASES (NTD) PROGRAM IN TANZANIA

By

Jin Young Hyun

About one quarter of the world's population is infected by soil-transmitted helminths and schistosomes, commonly known as intestinal worms, with the preponderance of infection occurring in the developing world. Worm infections cause anemia, stunted growth, or organ damages, and impede physical and mental development of children. This study evaluates educational impacts of a deworming program in Tanzania implemented by a Korea-based international NGO, Good Neighbors (GN). The GN intervention was a school-based deworming treatment, providing deworming drugs to primary schoolchildren in Kome Island, Tanzania, for five years from 2009 to 2013.

This thesis conducts two different levels of analyses, school-level and individual student-level, utilizing (a) school administrative data collected from the local school district office and (b) results from an individual student survey. I consider a range of educational outcomes including school attendance, completion, and academic performance. The main methodological concern is the potential bias due to unobserved individual heterogeneity. This study addresses the concern by adopting the difference-in-differences strategy with panel fixed effects in the school-level

analysis, and the instrumental variables strategy in the individual-level analysis. The results from the school-level analysis suggest that the deworming program had significant impacts on school attendance and school completion, while those from the individual-level analysis show significant positive impacts on learning outcomes as measured by test scores in the mandatory national primary school graduation exam. In addition, I find evidences for the positive effects on increased awareness and greater use of deworming treatment among residents in the program region.

ACKNOWLEDGMENTS

I would like to thank my supervisor Prof. Taejong Kim and my advisors, Prof. Kye-woo Lee, Prof. Jong-Il You, Prof. Shun Wang, and Prof. Jungho Kim, for their academic insights, guidance and encouragement. I would also like to thank President Joon-Kyung Kim of Korea Development Institute (KDI) who led me to KDI School and gave me an opportunity in the impact evaluation study.

I am thankful for Good Neighbors, especially Tanzania office managers, Yun Sook Ko and Paelun No, for helping me to organize this study and to Dr. Keeseon S. Eom, Dr. Tai-soon Yong, Dr. Jong-Yil Chai and Dr. Duk-Young Min. I was deeply impressed by their devotion, commitment, and wonderful work in Mwanza. Also, my work was possible with the support of Mwanza educational administrative officers and local staffs, Grace, Ibra, Elizabeth and all who assisted this work.

I also acknowledge the financial and administrative support of KDI School Impact Evaluation Lab and the evaluation team. This work would not have been possible without contributions and cooperation of each one of them, and I have been very fortunate to have them while I was working on this study as a Ph.D candidate at KDI School.

To my dad and mom, thank you for everything.

TABLE OF CONTENTS

1. Introduction: Deworming in the Literature and the NTD Program in Tanzania

1.1 Introduction……………………………………………………..…………….…1

1.2 Literature review……………………………………………………..……..…7

1.3 Background and program design……………………………………………….10

2. Deworming and Educational Outcomes: School-Level Analysis

2.1 Introduction…………………………………………………………….………19

2.2 Identification strategy…………………………………………….……….20

2.3 Econometric modeling…………………………………………..……...28

2.4 Main results…………………………………………………….….........30

2.4.1 School attendance……………………………………….…..….34

2.4.2 School completion…………………………..……………….……36

2.4.3 Educational achievement………..…...…………………………..……..38

2.5 Conclusion……….……………………………………………….…….40

3. Deworming and Educational Achievement: Individual-Level Analysis

3.1 Introduction……………………………………………………………..43

3.2 Study design and methods……………………………………………45

3.3 Results……………………………………………………………..55

3.3.1 National exam results……………………………………………55

3.3.2 Individual subject scores……………………………………...62

3.4 Conclusion…………………………………………………………68

4. Deworming Intervention and Recipients' Involvement

4.1 Introduction…………………………………………………………………….……..71

4.2 Background and study design…………………………………………………..…..72

4.3 Econometric modeling and results……………………..…………………………..…..80

4.3.1 Awareness of deworming…………………………………………………….…..80

4.3.2 Participation of deworming drugs taken.......………………………………………84

4.4 Conclusion...............…………………………………………………………………......94

5. Concluding Remarks...96

Bibliography……………………………………………………………………........109

LIST OF TABLES

Table 1. STH and SM infection rates of schoolchildren in Kome Island (2009 vs. 2013)…........18

Table 2. Summary statistics of households and children by the treatment status........................22

Table 3. Difference-in-differences estimate of the effect on school attendance rate……...........31

Table 4. Difference-in-differences estimate of the effect on school completion rate……..........31

Table 5. Difference-in-differences estimate of the effect on national exam pass rate…......……31

Table 6. Difference-in-differences estimates of the deworming impacts with lakeshore schools as the control ……………………………………..……34

Table 7. Deworming impacts on school attendance rate: D-in-D estimates with panel fixed effects and panel random effects...36

Table 8. Deworming impacts on school completion rate: D-in-D estimates with panel fixed effects and panel random effects ………………..........................…………..…..……37

Table 9. Deworming impacts on national exam pass rate: D-in-D estimates with panel fixed effects and panel random effects ……………..........................…………...…...………39

Table 10. Comparison of student characteristics by treatment status……………………..….....48

Table 11. Average test scores in the national exam …………....…....…………………………..49

Table 12. The estimates of the effects of deworming intervention on national exam pass results: logit and probit results………………...............................…………………56

Table 13. Marginal effects deworming intervention on national exam pass results: logit and probit results………………..….57

Table 14. The effects of the number of deworming drugs taken on national exam pass results....60

Table 15. Marginal effects the number of deworming drugs taken on national exam pass results: logit and probit results………..................................………….....…………….61

Table 16. Effects of the deworming treatment on national exam scores: OLS estimates ....…63

Table 17. Effects of the deworming treatment on national exam z-scores: OLS estimates 64

Table 18. The OLS and IV estimates of national exam scores for deworming drugs taken.........66

Table 19. The OLS and IV estimates of z-scores for deworming drugs taken ………….……...67

Table 20. Awareness and participation of adults, 2009-2012…................……………………......77

Table 21. Awareness and participation of students, 2009-2012……………………...................78

Table 22. The logit and probit estimates of the GN's program impact on awareness: adults…...82

Table 23. The average marginal effects on awareness: adults……………………………...…83

Table 24. The logit and probit estimates of the GN's program impact on deworming drugs taken: adults………………………………………………………………….………86

Table 25. The logit and probit estimates on the GN's program impact on deworming drugs taken: students………..87

Table 26. The average marginal effects on deworming drugs taken: adults and students………88

Table 27. The average attendance rates by standard: 2007-2012………………......………........90

Table 28. Marginal effects on deworming drugs taken: ordered logit results …………………..93

LIST OF FIGURES

Figure 1. Location of Kome Island in Lake Victoria, Tanzania……………………………………13

Figure 2. Location of primary schools in Kome Island……………………………………….15

Figure 3. Decrease of SM and STH infection rates in Kome Island (2009-2012)……………18

Figure 4. Attendance rates before and after the program…………………………………...32

Figure 5. Completion rates before and after the program…………………………………..32

Figure 6. National exam pass rates before and after the program……………………….....32

Figure 7. The means of the national exam results by the number of deworming drugs taken…. 59

Figure 8. The number of deworming drugs taken by the treatment status:

adults and schoolchildren……...………………………........79

LIST OF ANNEXES

Annex 1. Coverage of residents in the community-based phase of the program……………..100

Annex 2. Coverage of the school children in the school-based stage…………….………..101

Annex 3. NTD infection and number of people treated in the world………….……………...102

Annex 4. Questionnaire for the 2013 survey …………………..………………..……….…...103

Chapter 1. Introduction:

Deworming in the Literature and the NTD Program in Tanzania

1.1 Introduction

Official Development Assistance (ODA) volume has increased since the 1960s. Africa is the top recipient region of ODA, and many private and non-government donors participate in aid activities in Africa. In order to increase the effects of development aid, the ODA should strategically distribute part of the budget in cooperation with private or non-government sectors. It is crucial to estimate how well the ODA organizes and allocates that budget to various aid programs and projects.

About one quarter of the world's population is infected by soil-transmitted helminths and schistosomes, commonly known as intestinal worms, with the preponderance of infection occurring in the developing world. Worm infection may cause anemia, stunted growth, or organ damages, and thus may impede development of children, physical and otherwise. This thesis is an evaluation of educational impacts of a deworming program in Tanzania implemented by a Korea-based international NGO, Good Neighbors (GN). The GN intervention was a school-based deworming treatment, providing deworming drugs to primary schoolchildren in Kome Island, Tanzania, for the duration of five years between 2009 and 2013.

This study conducts two different levels of analysis, school-level and individual student-level, utilizing (a) school administrative data collected from the school district office and (b) results from an individual student survey. I consider a range of educational outcomes including school attendance, completion, and learning achievement. The main methodological concern is the potential bias due to unobserved individual heterogeneity. This study addresses the concern by adopting the difference-in-differences strategy with panel fixed effects in the school-level analysis, and the instrumental variables strategy in the individual-level analysis.

Many prominent impact evaluation studies of ODA and aid interventions revealed the effectiveness of programs, including many involving deworming programs. Impacts of deworming interventions may vary depending on a wide range of factors including the prevalent worm types, the features of the local ecological system, and the initial rates of infection. Thus, the international development community can better allocate its scarce resources with accumulation of evaluation results from different locales. Beyond presenting one additional, significant data point for such purposes, this thesis contributes to the international development assistance evaluation literature in three significant ways.

First, this is the first rigorous attempt to evaluate the impacts of the Korean government-funded development assistance program. Korea is a new donor country with its total ODA volume increased from USD 5 million in 1987 to USD 1.74 billion in 2013. The global share of new donors including China and India has been growing, and it is more important to accumulate evidences on effectiveness of aid engagements on the part of the new players. In the case of Korea, the Korean government and development agencies allocate more than 40% of the total ODA budget to the social sector including health and education.[1] However, no systematic evaluation has been carried out to measure the impact of ODA activities on recipients, and the

[1] South Korea has joined as an OECD DAC member in 2010, and according to the DAC statistics in 2012, the Korea government allocates about half of its ODA budget to social infrastructure sector: about 17.3% to education, 10.2% to health 10% to water and sanitation and about 20 percent on other social infrastructure.

allocation of the ODA budget generally lacks foundation of rigorous scientific evidence.

Second, my study utilizes administrative data as well as survey data, which made the evaluation possible and flexible to compare the impact of program on academic performance at both school- and individual-levels. The basis of evaluation studies of development programs are primarily on randomized controlled trials (RCT) from the literature. Previous RCTs evaluating the impact of deworming programs on educational outcomes focused on either on school-level results or individual-level results separately. Because this study relied mainly on administrative data, it was less costly and could utilize both annual panel data and individual data to analyze primary educational achievement as measured by the national graduation exam results.

Third, my study recognizes the crucial importance of ownership by recipients for the long-term viability of development assistance programs and sustainable development in aid recipient countries, and measures the impacts of the NTD program on recipient awareness and participation, over and beyond the immediate impacts on the schoolchildren who were the immediate target beneficiaries. The conventional evaluation literature seldom pays attention to the changes in the recipient behavior and aspirations, given that the celebrated DAC principles emphasize the importance of ownership for aid effectiveness.

In the health sector, soil-transmitted helminthes(STH) and schistosomiasis infection is one of great health concerns in Africa. About one quarter of the world's population has soil-transmitted helminthes and schistosomiasis infections, which not only affect the health of adults and young children but also increase morbidity in developing countries. Furthermore, infected school-aged children may participate less and not perform well in schools.

In this thesis, I examined the impact of a deworming program on the education of primary school children. The deworming program was organized by a Korea-based NGO, Good Neighbors(GN), in cooperation with the Korean government as a public-private partnership ODA program and provided deworming treatment in primary schools in Tanzania for five years. The objectives of the deworming program were to decrease STH and schistosoma mansoni(SM) infections, improve health, and reduce the mortality rate that would eventually improve the social welfare of Kome Island. The focus of the study was to determine whether achieving these health objectives would also influence primary school education, through assessing the effects on school participation as measured by educational attendance and completion rates and on academic achievement as measured by the primary school graduation national exam at both the school and individual levels. In addition, and from a more generalized perspective, the study explored the way in which the donor's intervention influenced public awareness and lead recipients to participate actively in the deworming treatment.

In the remainder of the introduction, I provide brief previews of the analysis and results in the subsequent chapters.

Deworming and Educational Outcomes: School-Level Analysis Using Administration Data

Chapter 2 examines the impact of the deworming program on primary school attendance, completion, and academic achievement at the school-level. The study examined the educational administrative data reported for five years from 10 treatment schools and 168 comparison schools. Although the program increased primary school attendance by 2.5 percentage points and completion rate by 3.2 percentage points in the treatment schools, the impact on academic achievement measured by the national exam pass rate was not statistically significant at the school-level.

Deworming and Educational Achievement: Individual-Level Analysis

One distinctive contribution of this study was the discovery of the impact of the deworming treatment on academic achievement at both school and individual levels. Chapter 3 compares the results of the program impact on academic achievement at an individual-level with the results estimated in Chapter 2 on school-level analysis. The initial examination was on the impact of the program on the primary school national graduation exam, using individual administrative data for a pool of more than 300 students. The results showed that students in treatment schools were more likely to pass the national exam by 21 percent in comparison to comparison students. Because the program treatment involved distributing the deworming drugs, the assumption was that students had more active involvement in the program and a lowered chance for reinfection if they took the deworming drugs on a regular basis. Based on that assumption, I examined the impact of the number of deworming drugs students took for five years against their results on the national pass/fail exam and exam scores of five subjects. Although the impact was small, it was a positive finding because one dose increase in a number of deworming drugs heightened the probability that a student would pass the exam and improve subject scores in Swahili, English, math, and science.

Deworming Intervention and Recipients' Involvement

Chapter 4 addresses whether the donor intervention successfully led recipients to participate in the deworming treatment program. Although the program is organized by a NGO, the Korean government funded it using an ODA budget collected from an antipoverty levy.

Therefore, it was important to note how much the program actually led recipients to participate in the program and receive the treatment. For five years, the goal of the program was to decrease the parasite infection rate and improve health in a targeted area. Of course, the impact would be greater if more people were involved in the program. Also, I believe that ODA policy goals for sustainable development would not be possible without the recipients' awareness and participation. Therefore, this chapter addresses the impact of deworming intervention on recipient's awareness and participation of the program. First, finding noted that persons living in the treatment area were about 25 percent more likely aware of the importance of the deworming treatment. The second step was to determine the effect on recipients taking deworming drugs. The results indicated that people in the treatment group were more likely to take the deworming drugs by 35 percent for adults and 40 percent for primary school students than were those in the comparison group.

1.2 Literature Review

There has been growing recognition of correlations between health and the education of school children. A variety of researchers conducted empirical studies showing that health and nutrition could influence children's success in school. Pollitte (1990), for example, examined the performance of school-aged children infected with intestinal helminths and schistosomiasis and argued that improving their nutrition and health would improve their school participation and result in greater rewards for primary education. Other studies found that poor early childhood nutrition associated with delayed primary school enrollment and reduced academic performance in Ghana (Glewwe and Jacoby, 1995), and iron supplementation improved academic outcomes of anemic children (Nokes, van den Boscj, and Bundy, 1998). Moreover, Druilhe et al. (2005) suggested that deworming could provide an effective means to combat malaria and other life-threatening diseases.

Debates exist on the effects of deworming on growth and cognitive performance in school-age children; however, a series of studies showed positive correlations between deworming and children's physical growth and fitness (Adams et al., 1994; Thein-Hlaing et al., 1991) and cognitive school performance (Nokes et al., 1992; Watkins et al., 1996). In addition, consistent findings noted that serious worm infections produced negative effects on educational achievement (Bundy, 1994; Del Rosso et al., 1996; Drack et al., 1999; Miguel, 2004; Miguel and Kremer, 2004; Stoltzfus et al., 1997). Nokes, van den Bosch, and Bundy (1998) argued that worms induced anemia, which could seriously affect educational outcomes.

Miguel and Kremer (2004) examined the impact of deworming on rural primary school children in a randomized phase-in across schools in Kenya and found that deworming treatment was highly effective increasing school participation, and reducing school absenteeism by one-quarter among young children. In a precursor to Miguel and Kremer's experimental studies, Simeon et al. (1995) found that although there was no significant impact in treating Trichuris trichiura infections on growth, test of reading, spelling and arithmetic, and school attendance, the treatment benefitted school performance and reduced school absenteeism by one-third particularly among children with poor nutrition and children with heavy infections in Jamaica.

Several nonexperimental studies also provided positive and significant effects of deworming on school participation. Geissler et al. (2000) interviewed school children in Kenya and found that worms caused school absence in five percent of those children. Bleakley (2002) studied the Rochefelle-sponsored campaign against hookworm in the US in the 1920s and found that deworming had a large impact on literacy, school attendance, and income among school-aged children. According to Bleakley (2002), research could rule out an omitted variable bias using this nonexperimental approach because the Rochefeller campaign was national, thus, not subject to biases (see also Miguel and Kremer, 2004).

On the other hand, the counter argument to the effectiveness of deworming in improving school performance is that there is insufficient and limited evidence that it increases cognitive performance. Watkin, Cruz, and Pollitt (1996) conducted an experimental study on the effects of deworming on school performance in rural Guatemala. They found that the six-month Ascaris treatment for did not show improvement in reading, vocabulary, or attendance for the treated primary school children. Dickson et al. (2000) systematically reviewed the effects of anthelmintic drug treatment on growth and cognitive performance in children aged 1-16 years. The study included thirty randomized trials in 17 countries on four continents and argued that “the evidence of benefit for mass [anthelmintic 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; Muguel and Kremer, 2004).

Following Dickson et al.’s systematic review in 2000, Taylor-Robinson, Jones and Garner (2009) carried out longer follow-up randomized controlled trials (RCTs) taking into account stratification by worm intensity and prevalence. Their review showed improvement in weight after a single dose of deworming but no significant effect in multiple dose trials. They claimed there was 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, while some researchers found evidence on the benefits of deworming, others did not; however, more research is needed. Taylor-Robinson (2009) argued for longitudinal experimental studies on deworming treatment to evaluate the long-term benefits.

A series of studies indicated that deworming was extraordinarily cost-effective on health, education and future economic outcomes for school-aged children. A review by the Abdul Latif Jameel Poverty Action Lab at Massachusetts Institute of Technology (2005) argued that worm treatment was the most cost-effective way to increase primary school participation (see also Bundy et al., 2009). According to Molyneux, Hotez, and Fenwick (2005), the estimated cost of treating parasitic and infectious diseases, including drugs and delivery, was approximately $204 million for five years to cure the approximately 700 million population of sub-Saharan Africa. Treating schistosomiasis for 200 million targeted school-aged children costs about $80 million;

Praziquantel at $0.25 per treatment and a distribution cost of $0.15 per person. In addition, intestinal helminths treatment for 400 million school-aged children cost about $52 million; for Albendazole at $0.02 per treatment and $0.10 per person delivery (Molyneux et al., 2005).

From an economic perspective, the impact of the deworming would have a long-term effect on the earnings of the children in the future. While the cost of worm treatment was about $0.25 per child per year on average, the gains "of a mere fraction of a percent in income would provide high benefit to cost ratio" (Bundy et al., 2009). Also, Miguel and Kremer (2004) argued that "deworming is likely to increase the net present value of wages by over US$30 per treated individual, creating a benefit to cost ratio of over 100" (Bundy et al., 2009). Kremer (2003) compared school participation in several different programs in a similar environment. His results showed while the deworming intervention cost only $3.50 per additional year of increased school participation, provision of free uniforms and the school feeding program would cost $99 and $36 per additional year of schooling induced. Therefore, school health programs, particularly deworming treatments, might be one of the most cost effective programs to increase school participation (Kremer, 2003).

1.3 Background and Program Design

In 2009, a Korea-based NGO organized a Neglected Tropical Diseases(NTDs) program as one of the Korean government's ODA, public-private partnership programs. NTDs are a pervasive public health challenge in many developing countries and responsible for about 500,000 deaths annually. Although the NTD classification is debatable, the parasite disease is the most common NTD infections in Africa (Molyneux, 2005). WHO (1999) classified 17 NTDs as dengue, rabies, chagas disease, human African trypanosomiasis, leishmaniases, cysticercosis, dracunculiasis, echinococcosis, foodborne trematodiases, lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases, buruli ulcer, leprosy, trachoma and yaws, and reported nearly half of Africa's disease burden was due to infectious and parasitic disease (see also Miguel, 2004) Among parasite related NTDs, soil-transmitted helminths (STH) and schistosomiasis were the most prevalent NTDs in less developed countries, especially in Sub-Saharan Africa. An estimated 166 million schistosomiasis cases exist in Sub-Saharan Africa, and create 89% of the global burden in Africa (Van der Werf et al., 2003).

The three primary STH infections include roundworm (Ascaris lumbricoides), whipworm (Trichuris trichiura), and hookworms (Necator americanus and Ancylostoma duodenale). People living in poverty can easily become infected through contact with parasite eggs that thrive in the soil of tropical and subtropical climates (Bethony 2006). Climates and inadequate water and sanitation facilities are important determinants for parasite larval development in the soil. People living in poor environment that lack adequate water system and sanitation are vulnerable to infection from STH. Although STH infections are primary responsible for disabilities such as iron deficiency, malnutrition, growth and cognitive deficits particularly in children, intense exposure can cause death. Researchers estimate more than 150,000 deaths annually (Crompton 1999; Hotez et al. 2006; Montresor et al. 2002). Schistosoma haematobium, schistosoma intercalatum, schistosoma japonicum, schistosoma mansoni, and schistosoma mekongi represent the five major species of the family schistosomiasis (Hotez et al., 2006). Schistosomiasis infection is from contamination of water by schistosoma eggs, wherein snails in water serve as intermediate hosts. If people have contact with the infected water, they can be infected through skin penetration. WHO estimated approximately 200 million infected people worldwide, and infection rates are higher for children than for adults (Gryseels et al., 2006). Heavy schistosoma infections cause fever and lymphadenopathy with death associated with schistosoma mansoni infection (Hotez et al., 2006). There are no extant vaccines for STH and schistosomiasis infection, and infected people need to take deworming drugs regularly to treat infection.[2]

To understand the effects of deworming treatment on school-aged children, this study evaluated a program in Kome Island, Tanzania where NTDs are a devastating burden for people. Tanzania is endemic with all common NTDs, particularly schistosomiasis and soil-transmitted helminthes found countrywide, and the prevalence of the infection rate is high, creating a major health burden for the country.[3] In the northwest part of Tanzania, Lake Victoria has the highest prevalence of schistosomiasis infection in the world, especially for young school children living in the region (Clements et al., 2006). Kome Island is the second largest island in Tanzania located in Lake Victoria (figure 1). The population of Kome Island use water from Lake Victoria for drinking and washing, and the lake is a playground for young children. Therefore, people living in Kome Island have continual exposure to the causal parasite infections, especially STHs and SM infections from Lake Victoria. There is also high possibility that people are continually re-infected by STH or SM due to the poor living environment. If they have an infection, the chance that they utilize the treatment is low and the symptoms not only detract from their quality of life but also prevent school-aged children from attending school.

[2] Deworming drugs used for treatment are albendazole for STH and praziquantel for schistosomiasis.
[3] Imperial College London reports Schistosomiasis control initiative in Tanzania. An accurate accounting of how many Tanzanians are infected with NTDs does not exist but the estimates are measured that about 80% of residents are infected by STH and Schistosomiasis in some areas.

Figure 1. Location of Kome Island in Lake Victoria, Tanzania

This study evaluates a deworming program implemented in Kome Island in the Sengerema district[4] of Tanzania. The Sengerema district contains 178 primary schools in 34 administratively divided wards, and Kome Island offers 10 primary schools in 2 wards,

[4] Tanzania is divided into 21 administrative regions, which are further divided into 120 districts. Sengerema district is located in the north of Tanzania and it is one of 7 districts in Mwanza bordered by Lake Victoria.

Nyakasasa and Lugata. The population of Kome Island is around 27,000 people.[5] Previous research conducted by the GN's team in 2009 found a high prevalence of schistosoma mansoni and soil-transmitted helminths, particularly hookworms, among residents of the Island. The prevalence of infection among primary school children in Kome Island was 40.6% for the SM and 19.9% for the STH. The primary symptoms of schistosomiasis infection in this area are malnutrition, diarrhea, blood in urine and stool, anaemia, and liver and kidney damage. Children are more vulnerable to such diseases, and the infection can impair their growth and learning ability. Also, a long term infection without treatment can cause death.

Kome Island families engage predominantly in self-employed agriculture and fisheries. The average household annual income in the Island from the household survey in 2013 was approximately 641 US dollars.[6] Their diet consists mainly of maize twice a day mostly. Housing conditions are poor with soil floors and ceilings and without sanitation and water systems. The primary sources of water for drinking, cooking, and washing dishes, clothes, and bodies are traditional wells sparsely located and frequently not functioning due to lack of technique, equipment, or experienced laborers for repairs. Although most Kome residents drink water from wells, they also use water from Lake Victoria for washing dishes and clothes, and bathing. Because the schistosomiasis infection derives from contact with water that contains infected freshwater snails, people living in Kome Island have high exposure to continuous infection by schistosomiasis, from contact with the lake water.

[5] In Kome Island, there are three main tribes, the Wasukuma, Wazinza, and Wajaluo, and Swahili is the common language.

[6] The WB reported that the Tanzanian GDP per capita was approximately 695 dollars in 2013.

Figure 2. Location of primary schools in Kome Island[7]

[7] Good Neighbors NTD report (2014), p.55. The map indicates 10 primary schools and 2 secondary schools that the Good neighbor's NTD program implemented the deworming treatment from 2009 to 2013.

The GN organized the deworming treatment in ten primary schools in Kome Island (figure 2). The treatment consisted of delivering praziquantel for schistosomiasis and albendazole for soil-transmitted helminths every six months for five years, from 2009 to 2013. The program provided deworming treatment to eight villages for both adults and children over two years old from 2009 to 2010 at the community-level, and to ten primary schools from 2011 to 2013 at the school-level. Although the tests were for both children and adults in the schools, the current study estimated and analyzed only the results for the schoolchildren.

The objective of the program was to decrease the STH and SM infection rate in Kome Island. In 2009, five parasite professionals and experts from Korean universities conducted preliminary research to understand the NTD status and the infection rate near Lake Victoria. Based on this research, six highly infected districts were selected in Mwanza and the NTD program tested and treated the STH and SM infections, targeting about 15,000 residents and students annually. The GN's intervention was community-based in the early stage of the program but changed to school-based from 2011 to the end of the program (annex 1, 2). The program comprised the following activities: praziquantel and albendazole distribution once or twice a year, the health education and campaign, and empowerment of health department through training health policy makers, clinic officers, and lab technicians.

For the school-based intervention at ten primary schools in Kome Island, the GN researchers gave plastic cups to the children in attendance and requested they bring stool samples. GN's volunteer doctors checked the stomachs of those students and used abdominal sonography for heavily infected children.[8] The doctors examined the samples for a baseline in 2009, and

[8] Abdominal sonography was done mostly for adults and about 2,877 residents in Kome Island had the sonography examination during 2009-2013.

every six months for five years to determine the parasite status.

In February 2009, before the program initiation, parasite infection rates of Kome children were 40.6% for SM and 19.9% for STH on average. These infection rates showed differences depending on the school location. For instance, the Isenyi primary school located near Lake Victoria showed an SM infection rate of 68.0%, while only 6.8% of students at the Nyamiswi primary school in the center of the island had SM infection. STH infection was present in 33.6% of the Izindabo primary school children, located near the lake, while only 3.0% of the Nyakabanga primary students located in the center of the island showed infection. (figure 2, table 1).

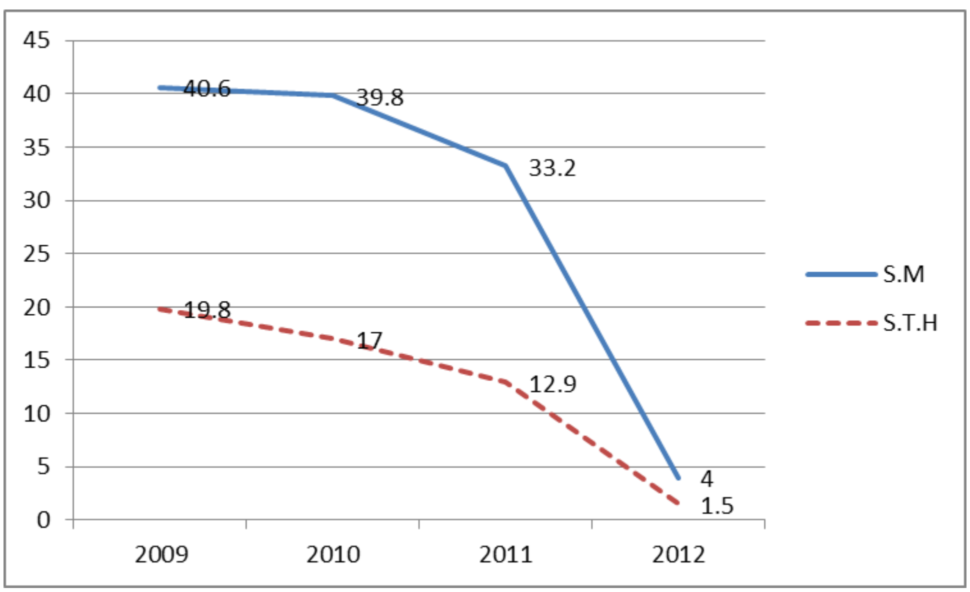
Infected students received praziquantel to treat SM and albendazoles to treat STH in the treatment schools. The program provided praziquantel (40mg/kg in a single dose) and/or albendazole (400mg in a single dose) to all infected primary school children in treatment schools once or twice a year from 2009 to 2013. In January 2013, at the end of the program, the student infection rate had decreased by 9.9% for SM and 4.8% for the STH[9] (figure 3).

[9] The data and results are from Good Neighbor's Neglected Tropical Disease Control Program from 2009 to 2013 collected by Dr. Keeseon S. Eom (Department of Parasitology, Medical Research Institute and Parasite Resource Bank, Chungbuk National University), Dr. Tai-soon Yong (Department of Environmental Medical Biology, Institute of Tropical Medicine and Arthropods of Medical Importance Resource Bank, Yonsei University College of Medicine), Dr. Jong-Yil Chai (Department of Parasitology and Tropical Medicine, Seoul National University College of Medicine), Dr. Duk-Young Min (Department of Immunology and Microbiology, Eulji University School of Medicine), Dr. Han-Jong Rim (Department of Parasitology, Korea University College of Medicine), Su-Young Chang (Good Neighbors Tanzania), Yunsuk Ko (Good Neighbors Tanzania), Charles Kihamia (Muhimbill University College of Health Sciences), Julius Siza, Godfrey Kaatano, Joseph R. Mwanga, and John Changalucha (National Institute of Medical research, Tanzania).

Table 1. STH and SM infection rates of schoolchildren in Kome Island (2009 vs. 2013)[10]

Name of School	STH			SM		
	Num. of Participated Students	Infection Rate (%)		Num. of Participated Students	Infection Rate (%)	
		2009	2013		2009	2013
Buhama	198	33.3	5.0	115	58.0	7.5
Izindabo	196	33.6	8.1	96	48.9	9.9
Isenyi	194	30.9	0.0	132	68.0	26.5
Nyakasasa	100	15.0	4.1	26	26.0	6.2
Nyakabanga	99	3.0	7.5	18	18.1	4.0
Nyamiswi	117	17.9	5.1	8	6.8	2.0
Bugoro	100	12.9	1.2	31	31.0	8.5
Lugata	114	5.2	6.0	39	34.2	5.0
Muungano	98	9.1	4.0	45	45.9	17.5
Kabaganga	112	17.8	7.2	50	44.6	11.4
Kome (Secondary)	118	7.6	-	33	27.9	-
Lugata(Secondary)	115	20.0	-	41	35.6	-
Total	1561	19.9	4.8	634	40.6	9.9

Figure 3. Decrease of SM and STH Infection ratea in Kome Island (2009-2012)[11]



[10] Good Neighbors NTD report (2014), p.56.
[11] Good Neighbors NTD report (2014), p.38.

Chapter 2. Deworming and Educational Outcomes: School-Level Analysis Using Administration Data

2.1 Introduction

This chapter analyzes the impact of the deworming program on schoolchildren's educational outcomes using administrative data at the school-level. The study targeted the primary school children living in Kome Island and around the Lake Victoria region. For the GN's school-based program, all primary schools located in Kome Island were treatment schools and students attending those schools had exmination for parasite infections and received deworming treatment from the GN. On the other hand, comparison schools selected by the educational administrative council among the Sengerema district primary schools were near the lakeshore of Lake Victoria. School participation and school performance estimates derived from the school district administrative data. A detrimental effect on school attendance was one mechanism by which worms adversely affected educational performances (Raj et al., 1997).

Outcome indicators for measuring school participation were school attendance and completion rates, and school performance were measured by the primary school graduation national exam results. I used the difference-in-differences estimations by pooled OLS, panel fixed effects and panel random effects models, and based on the results, I found the deworming program in Kome Island had a statistically significant impact on school attendance and completion, but no significant impact on the educational achievement exam of primary school children. The estimates of the impact of the program on all outcome indicators in Chapter 2 are at the school-level, but the results of academic achievement are at the individual level in Chapter 3.

The next section 2.2 describes the identification strategies and section 2.3 explains the econometric models. Section 2.4 reports the results of the program's impact on school attendance, completion, and academic achievement, respectively. The final section discusses the limitations and implications of the study and concludes.

2.2 Identification strategy

This study used a quesi-experimental design to find the impact of deworming program on educational outcomes at the school-level. The program divided the 178 primary schools under study into a treatment group and a comparison group. All ten primary schools in Kome Island were in a treatment group, while the other 168 primary schools in the Sengerema district created a comparison group.[12] The ten primary and two secondary schools in Kome Island received the GN's treatment. The comparison schools selected by the Sengerema district administration office and located near the lake shore had similar characteristics in terms of school capitation received and teacher to pupil ratios from 2007 to 2012. Kome residents received information about the intervention through the schools and the community and program inputs were easily observable.

The GN and the Sengerema educational district office organized a household survey

[12] Some schools in the comparison group received temporary deworming program implemented by European NGOs; however, there was no GN's intervention in those schools.

towards the end of the program in February 2013. Ten primary schools were designed in each of the treatment and comparison groups and the school headmasters or officers randomly selected approximately 25 to 30 seventh graders in each school to participate in the survey (about 25 students *x* 10 treatment schools = about 250 treatment students, about 25 students *x* 10 comparison schools = about 250 comparison students). Thus, the total observation sample was about 500 students. Ten local volunteers employed for ten days conducted on-site surveys. A parent or caregiver in their family accompanied the students to school on survey days. The adults responded to questions about the deworming treatment experiences, living conditions, education and child care, health and sanitation, and household income and conditions (annex 4).

Table 2. Summary statistics of households and children by the treatment status

	All	Treat. (%)	Comp .(%)	t-value(p)
No. of obs. (Kome / Non-Kome)	501	255(50.9%)	246(49.1%)	
Program Awareness	381(76.7%)	225(88.2%)	156(64.5%)	6.51(0.00)
Taking Deworming Drugs _adults	364(75.1%)	228(92.3%)	136(57.1%)	9.62(0.00)
_children	401(80.0%)	252(98.8%)	149(60.8%)	12.07(0.00)
Average Number of Taking Drugs _adults	1.8 times	2.5	1.2	4.13(0.00)
_children	1.9 times	2.8	1.0	19.25(0.00)
Average age of children	15 years old	15	15	1.39(0.16)
Female	(48.5%)	(51.0%)	(46.1%)	0.99(0.32)
Average num. of total household members	8.6	8.5	8.8	0.81(0.41)
Average num. of siblings	5.4	5.2	5.5	1.33(0.18)
Residence				
Floor-cement	131(28.4%)	67(28.9%)	64(28.0%)	1.02(0.31)
Floor-soil	348(71.6%)	181(73%)	167(70%)	0.70(0.48)
Child wearing shoes	263(55.8%)	122(51.3%)	141(60.3%)	2.06(0.03)
School-aged child not attending school	36 (7.25)	17(6.7%)	19(7.8%)	0.42(0.67)
Average distance to school (minute)	25.9	24.3	27.4	1.49(0.13)
Health and Sanitation				
Average num. of ill in household	1.3	1.2	1.3	0.82(0.40)
Sanitary facility_ pit latrine	469(93.6%)	243(95.3%)	225(91.8%)	1.53(0.12)
Sanitary facility _rubbish pit	421(84.4%)	223(87.5%)	197(81.1%)	1.88(0.06)
Sanitary facility _bath shelter	480(95.8%)	243(95.3%)	236(96.3%)	0.61(0.54)
Sanitary practice _soap after toilet	312(63.2%)	155(61.8%)	157(64.9%)	0.48(0.62)
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%)	0.93(0.34)
Sanitary practice _soap after washing babies	294(59.5%)	148(59.2%)	145(59.7%)	0.17(0.94)
Sanitary practice _washing food ingredient	435(88.1%)	227(90.4%)	208(85.9%)	1.61(0.10)
Sanitary practice _ boiling drinking water	203(41.6%)	118(47.2%)	84(35.4%)	2.61(0.01)
Sanitary practice _separate dwelling for livestock	387(83.8%)	212(91.4%)	174(76%)	4.48(0.00)
Principal source of water for drinking				3.97(0.00)
_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				4.67(0.00)
_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				5.15(0.00)
_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				5.05(0.00)
_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				4.89(0.00)
_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	1.55(0.12)
Average distance to Lake Victoria (minute)	44.8	38.3	52.8	2.98(0.00)
Agricultural Production				
Agricultural activity _crop farming	483(97%)	244(96.1%)	238(98%)	0.16(0.87)
Income & Expenditure				
Main source of income _Self-employment	468(95%)	239(94.5%)	228(95.4%)	0.44(0.65)
Average annual income (US dollar)	837.8	824.9	856.3	0.56(0.57)
Average household debt (US dollar)	136	141.5	129.3	0.27(0.78)
Average medical expenses (US dollar)	15	15.2	14.8	0.08(0.93)
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%)	0.15(0.87)
Average times of full meal a day				4.99(0.00)
_ 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%)	

Because participants traversed an average distance to a school of 25 minutes and the interview took about 2-3 hours including waiting time, many parents of the assigned students had to miss work and their daily earning. When an assigned student was absent or his/her parents or care givers could not make the interview on the survey day, school officers arranged for other students and parents. The data included those students but omitted in the individual-level analysis if their ages were out of the age control group.[13]

To validate the identification strategy, the household survey data confirmed the two groups, treatment and comparison, were similar along a range of characteristics. There were no statistically significant differences between the students in treatment and the comparison groups on most dimensions: age, gender, family background, household facilities, sanitation practice, ill family members, asset ownership, distance to school, health and sanitation status, house income, and expenditure (table 2). However, there were some differences in worm infection behaviors. For the self-reported principal source of water for drinking, cooking and washing, the percentage of people using water from Lake Victoria was much higher in the treatment group. Approximately 20% used the infected lake water for cooking and more than 25% used it for washing clothes, dishes, and bodies in the treatment group, while the comparison groups used the lake water for only 8.6% of their cooking and about 10% of washing. In addition, the average distance from their houses to Lake Victoria was less in the treatment group. From this survey, I can assume that students who use more of the infected water from Lake Victoria and live nearer

[13] Household survey data are focused on students who are in the 7th grade. The average ages of the 7th graders are 14 to 15 years old and it is reasonable considering 7 years of primary school. However, some interviewees answered the age of their children less than 10 (6 or 9 years old) and more than 20 years old. And they were excluded from the study on school performance at individual level in chapter 2.

the lake would have substantially higher rates of schistosomiasis infection.[14]

The study evaluates the impact of deworming treatment on school participation and academic achievement. Three identification outcomes included school attendance rate, completion rate, and the primary school graduation national exam pass rate. The first outcome of interest was school attendance. The attendance rate was measured as the percentage of student-school-days attended over the total enrollment times the number of school days in a given academic year.[15] I used the officially reported data collected by the Sengerema district education council. The data consisted of an average attendance rate for all students in each school as reported to the administration council from 2007 to 2012. The number of those attending was available in the teachers' attendance books reported annually. Teachers note daily attendance for each student on the attendance books, add those days monthly, and report annual records to the educational administrative district council. This means only students counted were actively attending school in a given month. The official attendance record was in distinguishable from enrollment data; thus, it was impossible to determine whether the student's absences were due to health reasons or household conditions or they dropped out of school. Therefore, using the official data offered limitations that could not be circumvented without knowing the number of drop outs or transfers between schools.

The second outcome of interest was the school completion rate. The primary school completion rate was also officially the percentage of students that graduated from 2007 to 2012. In a given year, the completion rate is the percentage of students that successfully graduated in

[14] The schistosomiasis infection rate among school children in the treatment group was 40.6% in 2009. Since my study was not based on a randomized evaluation design, I had limitation that the infection rate in the comparison group could not be collected in this study.

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

that year over the total number of students that enrolled in the school in the standard 1.[16]

Last, the study analyzed the national exam pass rate to estimate the impact of the program on primary school academic performance. All primary school students in Tanzania must take the mandatory primary school graduation exam (the national exam) at the end of standard 7 to be eligible to attend public secondary schools. The exam is in October and students are given only one chance. Students that pass the exam may attend public secondary schools for relatively low tuition; however, if they fail the exam, they have to pay more to attend private secondary schools or begin working at the early age if their family cannot support the high tuition to send them to private schools.[17]

Educational outcomes, such as enrollment, attendance, and exam scores, are influenced by a complex array of determinants: factors like family background, community policies, child health and nutritional conditions, school governance and environment among others (Chaudhury et al., 2006). In this study, I limit those factors to examining the specific correlation between the primary educational outcomes and deworming treatment.

The main analysis in this study used official administrative data from the Sengerema district education council. The panel data of treatment and comparison schools were collected from 2007 to 2012. The number of primary schools in the data included 178 in 33 wards. The working sample included about 1,000 students' average rates in each primary school; the data excluded new schools founded during the period because the records had missing values. The program ran from 2009 to 2013; therefore, the data collected from 2007 to 2008 were before the

[16] The primary school years in Tanzania are 7 years from standard 1 to standard 7.
[17] The average pass rate of the primary school leaving exam in Tanzania is estimated that about 70 to 90 percent of students who took the exam passed in 2009. Out of those passed students, it is reported that 90.4% were attended the public secondary schools in 2010.

treatment and data from 2010 to 2013 were in the treatment period. Analysis excluded 2009 due to ambiguity since it was the beginning year of the program implementation.[18]

The sample included 1,068 school-year observations (178 schools *x* 6 years) for attendance rates and 890 school-year observations (178 schools *x* 5 years) for completion and pass rates. However, the actual sample sizes may vary slightly because the data contains missing school years for a small number of schools newly launched in the lakeshore area across the lake from the island. The study excluded observations for 2009 for sensitive checks, and "*before*" included observations from 2007 to 2008 and "*after*" included observations from 2010 to 2012 for attendance rates and from 2010 to 2011 for completion and pass rates. The final number of observations in the working sample was 1,030 for attendance rates, 834 for completion rates, and 839 for national exam pass rates.

[18] The GN's program was launched in Aug. 2008, but the first year was preliminary research period. The program implementation actually began in the summer of 2009.

2.3 Econometric Modeling

A difference-in-differences model estimated the impact of the deworming program on the attendance rate, the completion rate, and the national exam pass rate of primary school children. The equation of interest is:

$$(1)\ Y_i = \beta_0 + \delta_0 after + \beta_1 Kome + \delta_1 Kome.after$$

where the dependent variable, *y*, in the model is the outcome of interest such as attendance rate, completion rate, and national exam pass rate of students of a school, *i*. The intercept, β_0, is the average rate of interest in schools in a comparison group before the deworming intervention from 2007 to 2008. *After* is a year dummy variable equal to one if the observation comes from 2010 to 2012 and zero if it comes from 2007 to2008, so the parameter, δ_0 , captures changes in comparison schools from after (2010~2012) to before (2007~2008) the intervention. The variable *Kome* is also a dummy variable equal to one if the school belongs to Kome Island and zero otherwise, and the coefficient of Kome, β_1 , measures the location effect that is not due to the deworming intervention.

The estimated outcomes given *Kome* are:

$$(2)\ E(Y) = \beta_0 + \beta_1 dKome + \beta_2 dSEN$$

$$E(Y \mid Kome_{=1}) = \beta_0 + \beta_1 Kome$$

$$E(Y \mid Kome_{=0}) = \beta_0 + \beta_s SEN$$

where SEN indicates the schools without the GN's deworming program located in the Sengerema district.

Finally, $\delta 1$ is the difference-in-differences estimator:

$$(3)\ \delta 1 = (\acute{y}_{a.t} - \acute{y}_{a.c}) - (\acute{y}_{b.t} - \acute{y}_{b.c}),$$

where the $\acute{y}$ denotes the average of interest, the first subscript, *a* and *b*, denotes the year *after* (average rate from 2010 to 2012) and *before* (average rate from 2007 to 2008), and the second subscript, *t* and *c*, denotes treatment schools (with the GN's intervention) and comparison schools (without the GN's intervention). In other words, $\delta 1$, is the difference over time in the average difference of interest in the treatment and comparison groups.

Calculating the difference-in-differences ensured that the study compared like primary schools in the Sengerema district. However, the estimates may have areas of concern about the differing school and environmental conditions between the lakeshore schools in Kome Island and those in other Sengerema district. The assumption was that schools near the lakeshore were easily and more densely infected by schistosomiasis. Thus, the estimate restricted the samples to those schools close to Lake Victoria.

The difference-in-differences estimators showed a sizeable impact of deworming treatment on school attendance and completion rates. I controlled all unobserved time-constant factors that affected the outcome of interest and the result showed statistically significant and positive impact of the program. One problem with using non-experimental administrative data was lack of control over heterogeneity bias, so I assume that the bias is caused by the correlation between the regressors and the unobserved time-invariant factors. Therefore, the study presented a fixed effects model in the results for completeness. Because a fixed effects model controlled the time-invariant variables, the fixed effects model could also control the unobserved omitted variable bias better than the OLS model could. The equation for the fixed effects model is:

$$(4)\ Y_{it} = \beta_0 + \delta_0 after_t + \beta_1 Kome_{it} + \delta_1 Kome.after_{it} + a_i + u_{it},\ \ _{t=1,2}$$

where Y_{it} denotes the outcome rate of a school i during time period t (before and after). a_i contains unobserved effect, which is probably correlated with Y_{it}, such factors as student ability, family poverty level, and school administrative policy, which are roughly constant during the program. u_{it}, is the idiosyncratic error and I assume that the composite error, $a_i + u_{it}$, is uncorrelated with independent variables. By differencing to remove a_i, I simply regressed the changes in the attendance rate, completion rate and national exam pass rate on the change in the *Kome.after* indicator.

2.4 Main results

Tables 3-5 present the changes in the outcome indicators in the Kome treatment schools and the 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- attendance rates, completion rates, and national exam pass rates- showed gains over the years in both the treatment and the comparison groups. However, the improvements were greater in the Kome treatment schools. As a result, the difference-in-differences measures of the program impacted were all positive for each of the outcome measures. These patterns are also visually presented in figures 4-6.

Table 3. Difference-in-differences estimate of the effect on school attendance rate

	Before	After	After-Before
KOME Island attend.(T)	79.13	82.73	3.6
Non-KOME attend.(C)	81.03	82.03	1.00
(T - C)	-1.89	0.70	**2.60**
observations	1030	1030	1030

Notes: before=2007~2008, after=2010~2012. (T) indicates a treatment group and (C) is a comparison group

Table 4. Difference-in-differences estimate of the effect on school completion rate

	Before	After	After-Before
KOME Island completion(T)	90.07	94.10	4.03
Non-KOME completion (C)	91.33	92.19	0.86
(T - C)	-1.26	1.91	**3.17**
observations	834	834	834

Notes: before=2007~2008, after=2010~2011. (T) indicates a treatment group and (C) is a comparison group

Table 5. Difference-in-differences estimate of the effect on national exam pass rate

	Before	After	After-Before
KOME Island pass (T)	58.21	63.25	5.04
Non-KOME pass (C)	45.70	50.08	4.38
(T - C)	12.51	13.17	**0.66**
observations	839	839	839

Notes: before=2007~2008, after=2010~2011. (T) indicates a treatment group and (C) is a comparison group

Figure 4. Attendance rates before and after the program

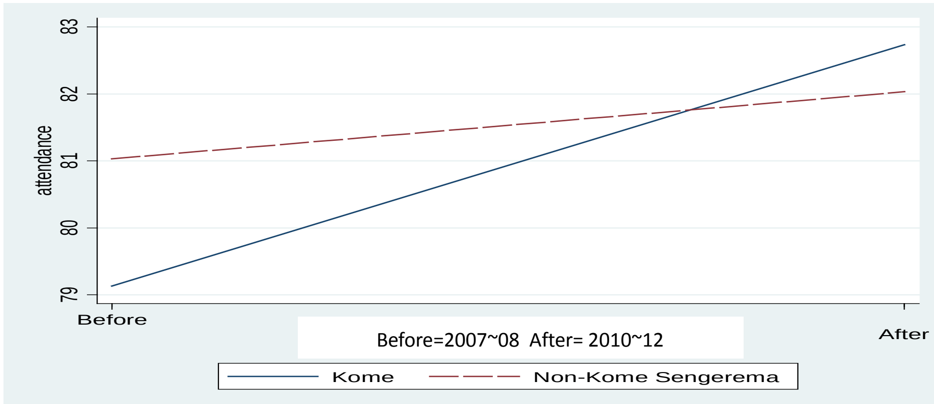


Figure 5. Completion rates before and after the program

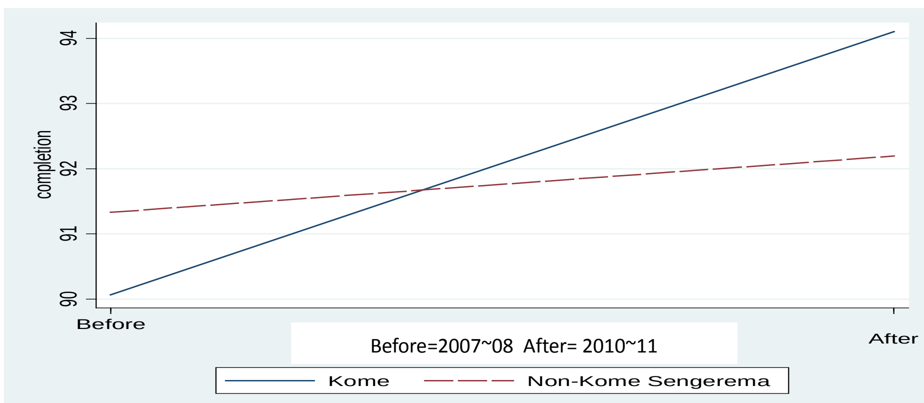
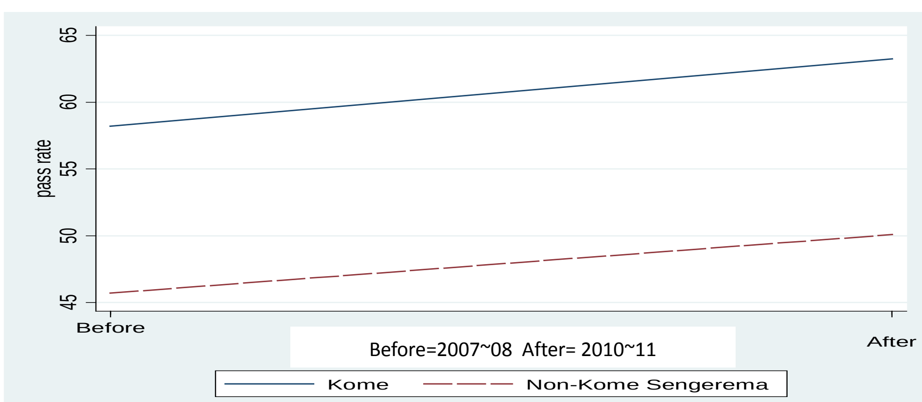


Figure 6. National exam pass rates before and after the program



There was some evidence that the difference measures presented in tables 3-5 might show bias because of imprecision in the data. Ideally, all students that attended and completed the schools would match to before and after the program. In practice, students in a particular school could not match and transfer students were not among those counted. There is a high possibility that incomplete matching could potentially bias the results in this study.

The results implied that the average school attendance rate in the treatment group increased by about 2.6% due to the deworming program. The effect of the program on school completion rate was even greater. The coefficient on the interaction term showed that, because of the deworming program, primary school completion rate increased about 3.2%. The results of the impact of the program on the national exam pass rate showed a limited affect, of only a 0.7% increase due to the program. However, the *t*-statistic of all regressions revealed that the estimates of the difference-in-difference model were statistically insignificant at the 5% level against the two-sided alternative. When adding other variables, such as teacher-pupil ratio and capitation in the control, the results were still not statistically different from zero.

The difference-in-differences by pooled OLS tested whether schools near Lake Victoria were more likely influenced by the deworming treatment each year. Table 6 shows the regression results when considering only the schools at the lakeshore. About two thirds of observed schools were located at the lakeshore, and the results showed these schools were not more likely affected by the program. The results were similar with difference-in-differences estimators of all schools. However, the coefficient estimates for attendance rate, completion rate, and the exam pass rate were not statistically different from zero.

Table 6. Difference-in-differences estimates of the deworming impacts

with lakeshore schools as the control

	Dependent Variables		
	Attendance rate	Completion rate	Passing rate
Kome*after	**2.69**	**3.14**	**0.89**
	(2.38)	(3.53)	(5.04)
After	0.91	0.90	4.14
	(0.70)	(1.05)	(1.47)
Kome	-0.17	0.19	13.09
	(1.69)	(2.24)	(3.25)
Constant	79.3	89.88	45.13
	(0.50)	(0.67)	(0.94)
observations	696	562	565

Notes: The numbers within the parentheses are robust standard errors.

2.4.1 School Attendance

I regressed the effect of the program by using panel fixed and random effects models. The results show that the deworming program increased the school attendance rate in the treatment schools by at least 2.45 percent points (table 7 column 2, 3). The *t* statistic shows that it is statistically significant at the 5 percent level. The fixed effects model omitted the *kome* variable because of collinearity as a time constant variable. Although my interest was in a time-varying explanatory variable, *kome.after*, I also tried the random effects model including the *kome* variable in the regression and assuming the unobserved effect as uncorrelated with all explanatory variables. Then, I tested for statistically significant differences in the coefficients on the *kome.after* by using the Hausman test. The results showed that the Hausman tests rejected (prob>chi2 = 0.70) for the attendance rate, thus, I do not reject the null hypothesis that there is no correlation between the school fixed effect and the regressors, and the random effects was consistent.

The deworming program may have improved students' health and encouraged them to participate in school activities more frequently. From the health impacts, the decreased infection rates of SM and STH by the GN's intervention might have increased the school attendance rate. In addition, the program may have created externalities among students within schools, which likely increased the impact of the program on school attendance. Although the sample in this study consisted of all students from standard 1 to 7 in the schools from 2007 to 2012, the results had limitations because the distinction between drop-outs, transfers, and absences in different years were indistinguishable in the school administration reported data.

Table 7 Deworming impacts on school attendance rate: D-in-D estimates with panel fixed effects and panel random effects

The dependent variable is the average attendance rate in a given school in a given year. The sample consists of schools panel data for 6 years from 2007 to 2012. The results for robust standard errors estimates are similar but not reported in this table. The time invariant variable is not reported in column 2.

	(1) Pooled OLS	(2) Fixed effects	(3) Random effects
Kome*After(t)	2.6	2.44**	2.45**
	(2.43)	(1.18)	(1.18)
Kome	-1.9	-	-1.8
	(1.72)		(2.74)
After	1.0***	1.16***	1.15**
	(0.59)	(0.29)	(0.29)
Constant	81.03*	80.85*	80.94*
	(0.42)	(0.20)	(0.65)
Obs.	1030	1030	1030

Notes: The numbers within the parentheses are robust standard errors. *** p<0.01; ** p<0.05; * p<0.10.

2.4.2 School Completion

School completion rate estimates at the school-level using administration data are presented in table 8. All estimates from the pooled OLS (column 1), the fixed effects (column 2), and random effects (column 3) were similar, showing the deworming program increased the school completion rate by about 3.2 percentage points in the treatment schools compared to the comparison schools. The fixed and random effects estimates were statistically significant at the 5 percent level. From the Hausman specification test, the result (prob>chi2 = 0.99) showed that the random effect as consistent on school completion rates.

The program's health impact may have influenced students' motivation and their ability to concentrate on studies. Among the general population, students are more inclined to attend school and complete their education if they are healthier. Another possibility is that students may continue their education when they are more motivated to participate in school activities. The program may have increased awareness of the importance not only of health but also of education among students in the treatment schools. Added to that, uninfected students could have increased the school completion rate when their classmates were more active in treatment schools. Such effects would influence the effect of deworming program on school completion in this study.

Table 8. Deworming impacts on school completion rate: D-in-D estimates with panel fixed effects and panel random effects

The dependent variable is the average completion rate in a given school in a given year. The sample consists of schools panel data for 5 years from 2007 to 2011. The results for robust standard errors estimates are similar but not reported in this table.

	(1) Pooled OLS	(2) Fixed effects	(3) Random effects
Kome*After(t)	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 robust standard errors. ** p<0.05; * p<0.10.

2.4.3 Educational achievement

The deworming treatment effects on the national exam results for primary school graduation are in table 9. The estimates of the impact of the deworming program on the exam result were positive but the magnitudes of the impact estimates were small. Also, none of these estimates was statistically difference from zero.[19]

A possible explanation for no impact of the deworming program on academic achievement at the school level might omitted variable bias. Although the deworming program might improve exam scores by increasing health and school attendance of students, the relevance was likely weak. Other factors, such as student motivation to concentrate and to continue with studies, and to stretch their learning ability, might closely correlate with improved exam scores. Moreover, exam results might reflect teaching skills, quality of teachers, and the school environment. Although attendance increased, students could perform poorly if teachers were ineffective or absent. Thus, that the deworming program affected the academic performance of primary school children by improving their health may not hold due to complimentary of other effects.

[19] In Chapter 3, an individual-level analysis showed the statistically significant results for the impact of the deworming program on school performance. To make comparison, I selected ten treatment schools and ten comparison schools that were used for the individual-level study and examined the impact at the school-level (obs. 72). The results noted that the impact was positive but the deworming program was still statistically insignificant on school performance at the school-level.

Table 9. Deworming impacts on national exam pass rate: D-in-D estimates with panel fixed effects and panel random effects

The dependent variable is the average national exam pass rate in a given school in a given year. The sample consists of schools panel data for 5 years from 2007 to 2011. The results for robust standard errors estimates are similar but not reported in this table.

	(1) Pooled OLS	(2) Fixed effects	(3) Random effects
Kome*After(t)	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 robust standard errors. * p<0.10.

2.5 Conclusion

The deworming program implemented by a NGO in cooperation with the Korean government in Tanzania had a significant impact on school participation, increasing primary school attendance and completion rate in treatment schools, while it showed no impact on the school performance measured by the national exam pass results.

The school-based deworming treatment showed positive results on school attendance and completion, but the estimated results from this study were at the lower bound. One of the reasons could be that subsequent samples during the study might not resemble the original sample if some groups of students dropped out of the study more often than others did. The composition of the sample students within treatment schools might change from year to year, and such possibility could create sample attrition bias. Second, not every infected student received the treatment in treatment schools if he or she was absent on the treatment day, and it is probable that the heavily infected students were absent because of their illness. If the program kept an individual record for each round check, the treatment effect on attendance could be greater. Third, since my study was based on a quasi-experimental design, I could not control for other deworming interventions in some comparison schools. Although deworming program from other NGOs in comparison schools were only temporary, such interventions could result in the underestimated effects of the GN's program at the school-level. In addition, there was no spillover effect in the treatment schools. Kome Island is geographically isolated from other areas, thus benefits from the GN's deworming treatment might have spilled over to untreated students within the treatment schools but not to students in the untreated neighboring schools. Externalities across schools in Kome Island were less likely to happen in this school-based study.

Therefore, the results could be underestimated effects and the impact of the deworming program on school attendance and completion could be greater.

In the study, the evaluation design using administration data had certain limitations and drawbacks. First, there could be no baseline survey because my evaluation study joined the program in the middle of the GN intervention, not from the beginning of the program design. Therefore, there could be no comparison of the true effectiveness of the program based on the randomized evaluation design. Also, the study could not distinguish the intensity of infection among the students and the schools. The school-level analysis measured the overall treatment effects in the treatment schools but did not separate the direct effects between infected, uninfected, and treated students. In addition, the collected administration data did not differentiate dropouts or transfers during the academic years, therefore the data may have bias from skewed reporting. Bundy and Kremer et al., (2009) argued that "when measuring the educational outcomes, it is critical to verify attendance through independent checks on site rather than relying on reported data, which is often influenced by incentives for teachers to exaggerate enrollment and attendance to increase funding."

Although worm infection affects children's education differently according to various factors, my study confirms that a school based deworming treatment of praziquantel and albendazole is one of effective ways in increasing school participation among primary school students. While large-scale control of schistosomiasis would require holistic treatment, such as building infrastructure for water system, improving sanitation facilities, and controlling the snail population, that would be prohibitively expensive. Therefore, the World Health Organization (WHO) recommends treatment with praziquantel, and my results provide implications on educational effects of this treatment in terms of cost-effectiveness and safeness. On the other hand, one of the critical issues in using praziquantel and albendazole treatment is reinfection. Four years of GN's treatment showed a great impact on the infected school students, yet the reinfection rate might increase without continuous and sustainable management. Children are vulnerable to reinfection under such circumstances without clean water and sanitation facilities. Therefore, future studies should investigate the impact of the program on the continued education of reinfected students. The first objective in such a study would compare the groups between uninfected and infected, treated and reinfected students based on a randomized evaluation design. Moreover, the proposed work could discover the cause of schistosomiasis reinfection of school-age children in Kome Island and effective treatment solutions for them.

Chapter 3. Deworming and Education Achievement: Individual-Level Analysis

3.1 Introduction

The primary question in this chapter is: Can the deworming treatment improve primary educational achievement of primary schoolchildren in Tanzania? The school-level analysis Chapter 2 revealed that no statistically significant impact of deworming program on academic achievement. This chapter analyzed the impact of the program at an individual-level using individual administrative data.

While the STH or SM infections do not affect intelligence directly, they can impair learning ability. For instance, anemia, which is one of common symptoms of STH and SM infections strongly relates to impaired cognitive function and can create susceptibility to mental fatigue in schoolchildren (Lozoff 1990; Nokes et al. 1999; Pollitt et al. 1990; Simeon et al. 1990). Stunting , also consequences of the worm infection, associates with poor performance on tests of cognitive function (McGarvey et al. 1993). Researchers have explored the correlation between worm infection and cognitive performance, but their findings are inconsistent.

Satki's study (1999) showed a significant adverse impact of hookworm infection on test scores among Indonesian schoolchildren. He showed an association between hookworm infection and lower scores in 6, out of 14 cognitive tests in a multiple-regression model. Also, Nokes et al. (1992) reported significant improvement in helminth treatment on cognitive function of Jamaican schoolchildren. On the other hand, Simeon (1995) noted no significant impact of the STH infection on school performance except that the children with heavy infections showed some improvement in spelling test scores in Jamaica. Kvalsvig et al. (1991) and Sternberg et al. (1997) also found no impact of worm infection on cognitive function.

A possible explanation for the inconsistent results of deworming treatment on school performance could be the different types of study designs such as small samples, short-term results or no control groups. For instance, Watkins et al.'s results (1996) showed no effect on the Guatemalan children's school performance in tests of reading and vocabulary but the period that students were free of Ascars was only six weeks. In addition, Taylor-Robinson (2012) raised a question of omitted variable biases in Satki's study (1999) that noted a significant impact of hookworm infection on low academic achievement in Indonesia.

Several studies found some benefits of schistosomiasis treatment in metal ability and test scores of schoolchildren (Bell et al. 1973; Castle et al. 1974, Kimura et al. 1992; Jordan and Randall 1962; Nokes et al. 1999). Castle et al. (1974) found that, among schoolchildren in Zimbabwe, those treated for schistosomiasis had statistically significant improvement on some tests like space relations. Nokes et al. (1999) conducted a randomized control trial in China to study the effects of schistosomiasis treatment on primary schoolchildren's cognitive function, and they found a significant improvement in cognitive function tests (fluency, free recall and picture search) with praziquantel treatment for schistosomiasis infection among the young age group (5 to 7 years old).

Previous prominent studies on the effect of worm treatment on academic performance showed small or lack of consistent results. The effects may depend on the species of worm and the intensity of infection. My study focused on schistosomiasis treatment; however, the data did not clearly define the intensity of infection. This chapter shows the STH and SM treatment associated with educational achievement measured by the primary school graduation national exam scores of schoolchildren at an individual-level. This chapter analyzes the impact of the deworming treatment on the national exam pass results as well as five different subject scores of individual students using individual administrative data.

3.2 Study Design and Methods

The primary school years in Tanzania are seven years. At the end of seventh year, every primary student takes the national exam about three months before graduation. The national exam consists of five subjects: Swahili, English, math, history and science. If students pass the exam, they can enroll in public secondary schools. If students fail the exam, they either have to go to private secondary schools that are more expensive or discontinue their education. This study focused on students who were scheduled to take the exam in October 2013. The analysis of educational achievement in this study was the 2013 primary school national exam pass/fail results and scores of individual students in five subjects.

From the 501 students that participated in the household surveys in February 2013, the Mwanza educational administration office supplied the individual national exam test results and subject scores for 339 students.[20] Although it was impossible to distinguish children infected by the STH or/and SM, all children in the treatment group knew about deworming, tested for worm infection, and received the deworming treatment by GN from 2009 to 2013, while children in the

[20] All students who participated in the household survey were supposed to be the 7th graders, but when there was no show on the survey day, some lower graders were included. Those students who were not in the 7th grade did not take the national exam in 2013. Also, some students' individual school ID numbers were not matched between the survey data and administrative reported data. Therefore, the observation numbers on this study at individual level are smaller than the original survey sample numbers, 501.

comparison schools did not. Of the 339 students, there were 140 students in the treatment group and 199 students in the comparison group. Each was in the last year, the seventh grade, of primary school education and took the national exam in October 2013. This study also used the 2013 household survey data. One of the survey questions asked the number of times a student took deworming drugs from 2009 to 2013. These data measure the impact of the number taking deworming drugs before the national exam.

This study described educational achievement using a linear relationship with deworming intervention in Kome Island and included other variables describing student characteristics and family background, such as age, gender, family size and siblings, household income and living conditions, which might directly affect student performance. This diverse set of house and family environment characteristics created from the household survey data offers other independent variables that might relate to the student national exam scores. The treatment independent variable, whether a student attended the treatment schools, is a proxy for deworming program intervention and activities.

There were no significant differences among students between the treatment and comparison groups in terms of their age, gender, family size, number of siblings, and household income (table 10). Only students in the treatment group received the GN's deworming program, and treatment with albendazole, which reduced the student infection rate of the STH from 19.9% in 2009 to 4.8% in 2013. The reduction rate was even higher for the SM, from 40.6% in 2009 to 9.9% in 2013 with the praziquantel treatment. The Mwanza educational administration office estimated that the exam take-up rate is above 90% on average in Mwanza district. The school-level study in Chapter 2 also showed that the school completion rate were similar, above 90%, between the treatment and comparison schools;[21] therefore, I assumed that almost all students who completed primary schools took the national primary school graduation exam and the exam take-up rates were similar between the treatment and comparison groups.

In this individual-level analysis, the study examines the impact on national exam results (pass or fail) by deworming intervention and the number taking deworming drugs, respectively. Following that analysis, the study explores the impact of the deworming program and the number taking deworming drugs on the national exam scores in five different subjects using individual students' administration national exam result data.

[21] In Chapter 2, table 4 showed that the school completion rate were 90% before the program and 94% after the program in the treatment schools and 91% before the program and 92% after the program in the comparison schools.

Table 10. Comparison of student characteristics by treatment status

There were no significant differences between the treatment and comparison groups ($p > 0.05$). Observation numbers are 139 for treatment students and 197 for comparison students. The age groups who participated in the survey were from 6 to 20 years old. Since the study measures the effects on the primary school graduates who were in the 7th grade in 2013, the age groups were controlled from 10 to 18 years old, and 2 students who were less than 10 years old and 9 students who were more than 18 years old were dropped. For gender variable, gender equals 0 if a student is a boy and 1 if a student is a girl.

	(A) Treatment Students		(B) Comparison Students		(A)-(B) T test	
	Mean	se	Mean	se	t value	p value
Age	14.67	0.09	14.87	0.11	1.39	0.16
Gender	1.51	0.03	1.46	0.03	0.99	0.32
Family size (no.)	8.51	0.21	8.76	0.21	0.81	0.41
Num. of siblings	5.23	0.16	5.56	0.18	1.34	0.18
Household income (USD)	826.16	171.18	958.00	156.08	0.56	0.57
Num. of full meal (a day)	2.08	0.02	2.26	0.03	4.99	0.00
Obs.	251		247			

For the five exam subjects of Swahili, English, math, history and science, the total average score for both the treatment and comparison students was about 22 points out of 100 points (23.2 points for treatment students and 21.4 points for comparison students). Students failed the national exam when the total average score was below 20 points, below a grade C. The mean scores for each subject were 28.09 points for Swahili, 19.69 points for English, 23.84 points for math, 18.66 points for history and 22.08 points for science, and z-scores mostly occurred close to the mean between -2 and 2 standard deviations for both comparison and treatment groups (table 11). In 2013, the administration data reported that about 61% of students who took the exam passed the national exam.[22]

Table 11. Average test scores in the national exam

The minimum score that students received for a subject was 0 and maximum score was 47. For each subject, min. is 0 and max. is 47 for Swahili, min. is 3 and max. is 45 for English, min. is 8 and max. is 41 for math, min. is 5 and max. 46 for history, and min. is 2 and max. is 44 for science.

	(A) Treatment		(B) Comparison		(A)-(B) T test	
	Mean (points)	se	Mean (points)	se	t value	p value
Swahili	29.48	0.54	17.11	0.54	3.01	0.00
English	20.52	0.62	19.10	0.51	1.77	0.07
Math	25.39	0.56	22.75	0.48	3.59	0.00
History	19.38	0.62	18.15	0.59	1.41	0.16
Science	23.31	0.62	21.22	0.49	2.67	0.01
Obs.	141		200			

[22] 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.

To measure the impact of the deworming program on national exam results at the individual-level, the study compared the possibility of passing the national exam for individual students in treatment schools to comparison students using the logit and probit model. The basic OLS equation for this model is:

$$(1)\ Y_i = \beta KOME_i + \varepsilon_i$$

where Y_i is the outcome variables for individual student *i* whether the student passes or fails the national exam, and $KOME_i$ is the dummy independent variable whether the student *i* is attending a primary school in Kome Island ($KOME_i = 1$) or attending the comparison schools ($KOME_i = 0$) near Lake Victoria in the Sengerema district.

The dependent variable Y_i is a binary response, so it indicates 0 if a student fails the national exam and 1 if a student passes the exam.

$$(2)\ Yi = \begin{Bmatrix} 0 & if\ fail \\ 1 & if\ pass \end{Bmatrix}$$

Because the dependent variable is dichotomous, I used the logit and probit models. The binary outcome Y_i estimates the probability that Y_i equals one as a function of the independent variable, $KOME_i$:

$$(3)\ P = Pr\,[Y_i = 1 \mid KOME\,] = f\ (\beta KOME_i')$$

Two different types of models depend on the functional form of $f\ (\beta KOME_i')$.

$$(4)\ f(\beta KOMEi) = \frac{e^{\beta KOMEi}}{1+e^{\beta KOMEi}} = \frac{\exp(\beta KOMEi)}{1+\exp(\beta KOMEi)} \quad \text{[logit model]}$$

$$(5)\ f(\beta KOMEi) = \int_{-\infty}^{\beta KOMEi} \Phi\ (z)dz \qquad \text{[probit model]}$$

These two models have advantages for estimating the predicted probabilities between 0 and 1 (0 for fail and 1 for pass), and the maximum likelihood method can compare the results between two models.

Then, as estimates of the logit and probit models tell signs, the marginal effects can explain the magnitudes of the effects, calculated as:

$$\frac{\partial p}{\partial KOMEi} = F'(\beta KOMEi')\ \beta i$$

The marginal effects depend on $KOMEi$. Estimating the marginal effects at a value of $KOMEi$ and coefficients of the logit and probit models and marginal effects have positive signs because $F'(\beta KOMEi') > 0$.

Since this study did not use experimental data and students' national exam data was available only for students who took the exam in 2013, the results that students passed the national exam may result from other factors. As the results of the school-level analysis on the national exam pass rate from the previous chapter showed, primary school students attending schools in Kome Island passed the national exam more often than students in comparison schools and scores were higher in treatment schools regardless of deworming intervention. When a previous study examined the changes in the national exam pass rate in the treatment and the comparison groups before and after the deworming intervention, the pass rate in Kome Island was already higher than those in the comparison groups before the program intervention (58.2% pass rate in treatment schools and 45.7% pass rate in comparison schools), and the results were similar after the program.

Thus, to evaluate a direct effect of deworming treatment on academic performance at the individual-level, this chapter examined the effect of the dosage among students taking the deworming drugs. The assumption was that students who took more of the deworming drugs are freer from STH or SM infections. Thus, to derive a true comparison, a longitudinal study might be best to see whether the treatment from STH and SM infections affected on national exam results. The model uses the same OLS equation except revising the independent variable as numbers of dosages of deworming drugs:

$$(6)\ Pass_i = \beta NumDrugs_i + \varepsilon_i$$

where $Pass_i$ the binary dependent variable for $Pass_i$ equals 1 if a student i passes the national exam and $Pass_i$ equals 0 if a student i fails the exam. $NumDrugs_i$ represents the number of times that a student i takes deworming drugs and ε_i is the error term. Using the logit and probit models, the marginal effects reflect the change in the probability of a student passes the national exam given a one dose increase of deworming drugs in an independent variable, $NumDrugs_i$.

Then, I estimated the predicted probability for each student that he or she passes the exam and the percent of correctly predicted values that are the proportion of correct predictions to the total number of predictions. The percent correctly predicted values have four cases:

	Actual y = 1 (pass)	Actual y = 0 (fail)
Predicted $\hat{y} = 1$ (pass)	Correct	False
Predicted $\hat{y} = 0$ (fail)	False	Correct

where y is the actual national exam result of a student and $\hat{y}$ is the predicted results. y=1 if a student passes the exam and y=0 if a student fails it. Two columns that actual values and predicted values are the same, $y = \hat{y}$, represent correct predictions and other two columns are wrong predictions.

Next, I examined the effect of the deworming treatment on five subjects, Swahili, English, math, history and science, separately. The assumption was that all students in treatment schools had some effect from the deworming intervention and the national exam scores for students in the treatment groups depended on deworming treatment as well as other factors. The ordinary least squares model at an individual-level estimated the outcome scores for each subject.

The basic OLS regression equation is:

$$(7)\ Score_{ij} = \beta KOME_{ij} + \gamma X_{ij} + v_{ij}.,$$

where $Score_{ij}$ captures the national exam scores of a student *i* in subject *j* depending on independent variables. *KOME* is a dummy variable; *KOME* equals 1 if a student *i* taking subject *j* attends a primary school in Kome Island (treatment schools) and *KOME* equals 0 if a student *i* taking subject *j* attends a school in another district (comparison schools). *X* is a set of other factors such as student characteristics and family background and *v* is the error term.

I also compared the estimates of $KOME_{ij}$ on Y_{ij} ($Scores_{ij}$) with the estimates of

$NumDrugs_{ij}$ on $Score_{ij}$ using the OLS model. Instead of using a dummy independent variable, the study employed the number of times a student took the deworming drugs to evaluate the effects on each separate subject score as well. Therefore, the model used the same OLS equation with the number of times a student took the deworming drugs, *NumDrugs*, for a student *i* in taking subject *j* as the independent variable:

$$(8) \qquad Score_{ij} = \beta_0 + \beta_1 NumDrugs_{ij} + \beta_2 X_{ij} + v_{ij.,}$$

However, the OLS estimation can show inconsistency when there are omitted variables. One could measure the explanatory variable, *NumDrugs*, with error terms, $v_{ij,}$ and the unobserved variables could correlate with both the dependent and independent variables. Therefore, the instrument variable estimation (IV) determined the impact on each subject score of the number of times a student took the deworming drugs. The variable $KOME_{ij}$ was used as the instrumental variable because a) $KOME_{ij}$ is correlated with the regressor $NumDrugs_{ij,}$ $E[KOME_{ij}, NumDrugs_{ij}] \neq 0$; b) $KOME_{ij}$ has no correlation with the error term $v_{ij,}$ $E[KOME_{ij}, v_{ij}] = 0$; and c) $KOME_{ij}$ is not a direct cause of the dependent variable $Scores_{ij,}$ $cov[Scores_{ij}, KOME_{ij} \mid NumDrugs_{ij}] = 0$. The two stage least squares (2SLS) estimation is:

$$(9) \qquad NumDrugs_{ij} = \gamma_0 + \gamma_1 X_{ij} + \gamma_2 KOME_{ij} + eij_{.,} \quad (First\ Stage)$$

$$Score_{ij} = \beta_0 + \beta_1 \widehat{NumDrugs}_{ij} + \beta_2 X_{ij} + vij_{.,} \quad (Second\ Stage)$$

where I first estimated the first stage equation with only exogenous regressors X_{ij} , and then I calculated the predicted values $\widehat{NumDrugs}_{ij}$ and substitute them in the structural equation model. $NumDrugs_{ij}$ is an endogenous variable representing a number dosages of the deworming drugs taken by a student *i*, and X_{ij} is a set of exogenous variables. $KOME_{ij}$ is the instrumental variable representing *KOME* equals 1 if a student is in the treatment group and 0 of a student is in the comparison group.

3.3 Results

3.3.1 National Exam Results

In 2013, the average national exam pass rate was 52.2% in comparison schools and 73.5% in treatment schools. Table 12 presents the estimated results of the impact of deworming intervention on the national exam pass/fail results and shows that students in treatment schools were more likely to pass the national exam in comparison to comparison students due to the deworming intervention. The results were statistically significant at the 1 percent level for the OLS, logit and probit models. The average marginal effects are almost identical for the logit and probit models as well. Treatment students were 26% more likely to pass the national exam in comparison to comparison students (table 13). The effect was smaller for female students with about 30% less likely to pass the exam in comparison to male students, and the difference was statistically significant at the 1 percent level.

The advantage of using the logit and probit models is that the predicted probabilities are limited between 0 and 1. This study predicted the probability that $Y_i = 1$ for each observation. The average of the predicted probability for students in the treatment schools was about 63% which is similar to the actual frequency, 61%. The estimates of the logit and probit models correctly predicted only 61% of the values and the rest are miscalculated.

Table 12. The estimates of the effects of deworming intervention on national exam pass results: logit and probit results

The dependent variable is the national exam result that is a dummy variable that takes 1 for students in treatment group and 0 for students in comparison groups. The administrative results are collected in 2013 and the sample consists of students who are in the 7^{th} grade and were in the relevant age group, age 11-18 in 2013 (two students who are less than 10 years old and nine students more than 18 years old are dropped). Three different types of models are compared but the ordinary least square model include the predicted probability less than 0 and more than 1, so the logit and probit models are used. Constants are included in the regressions, but estimates are not reported. Age controls are included but not reported. For gender variable, boy equals 0 and girl equals 1. The independent variables of numbers of bike, cow, goat, and bird are included to see the effect of household asset.

	(1) OLS	(2) Logit	(3) Probit
Kome (treatment)	0.22***	1.12***	0.68***
	(0.05)	(0.27)	(0.16)
student age	-0.01	-0.04	-0.03
	(0.02)	(0.08)	(0.05)
student gender	-0.29***	-1.37***	-0.84***
	(0.05)	(0.27)	(0.16)
caregiver age	0.00	0.00	0.00
	(0.00)	(0.01)	(0.01)
num. of sibling	-0.00	-0.02	-0.01
	(0.01)	(0.05)	(0.03)
annual income (log)	-0.00	-0.02	-0.01
	(0.02)	(0.09)	(0.05)
num. of bike	0.02	0.07	0.04
	(0.04)	(0.19)	(0.11)
num. of cow	-0.00	-0.02	-0.01
	(0.00)	(0.02)	(0.01)
num. of goat	0.00	0.02	0.01
	(0.01)	(0.04)	(0.02)
num. of bird	0.01**	0.07**	0.04**
	(0.00)	(0.03)	(0.02)
Constant	1.03***	2.66	1.63
	(0.36)	(1.78)	(1.06)
Observations	310	310	310

Notes: the number within the parentheses are robust standard errors. *** p<0.01, ** p<0.05, * p<0.10

Table 13. Marginal effects deworming intervention on national exam pass results:

logit and probit results

This table reports the marginal effects of the logit and probit models at means and average. The marginal effects at the mean are estimated for the average students in the sample and the average marginal are estimated as the average of the individual student marginal effects. The marginal effects are almost identical and the results from column (1) and (3) are used in this paper. For gender variable, boy=0 and girl=1. The independent variables of numbers of bike, cow, goat, and bird are included to see the effect of household asset.

	(1) Logit Average marginal effects	(2) Logit Marginal effects at mean	(3) Probit Average Marginal effects	(4) Probit Marginal effects at mean
Kome	0.26***	0.26***	0.23***	0.26***
(treatment)	(0.06)	(0.06)	(0.05)	(0.06)
student age	-0.01	-0.01	-0.01	-0.01
	(0.02)	(0.02)	(0.02)	(0.02)
student gender	-0.32***	-0.31***	-0.28***	-0.31***
	(0.06)	(0.06)	(0.05)	(0.06)
caregiver age	0.00	0.01	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
num. of siblings	-0.00	-0.00	-0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
annualincome	-0.01	-0.01	-0.01	-0.01
(log)	(0.02)	(0.02)	(0.02)	(0.02)
num. of bike	0.01	0.02	0.01	0.01
	(0.04)	(0.04)	(0.04)	(0.04)
num. of cow	-0.01	-0.01	-0.00	-0.01
	(0.00)	(0.00)	(0.00)	(0.00)
num. of goat	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
num. bird	0.01**	0.01**	0.01**	0.01**
	(0.01)	(0.01)	(0.01)	(0.01)
observation	310	310	310	310

Notes: the number within the parentheses are robust standard errors. *** p-value<.01 ** p-value<0.05

Then, I examined the effect of the number of dosages of deworming drugs on the national exam results to compare with the previous estimates. The estimate results are in Table 14 and 15. An increase in the number of dosages of deworming drugs increased the probability that a student would pass the exam and the results were statistically significant at the 1 percent level. It is statistically significant at the 1 percent level that a student with a one dose increase in deworming drugs was about 8% more likely to pass the national exam in 2013 (table 15). Other factors, except number of birds, had no impact on the national exam results[23] but girls were less likely to pass the exam than boys by about 30% and statistically significant at the 1 percent level.

The mean for passing the national exam was higher for students who took more deworming drugs (figure 7). The sample size included all 310 students who had individual exam results in the treatment and comparison schools. Among those students, the ones that took the deworming drugs for six times from 2009 to 2013 passed the national exam. On the other hand, students that never took the deworming drugs had the lowest mean of passing the national exam, less than 0.5. As the numbers of taking deworming drugs increased from 0 to 6 times, the mean on passing the national exam also increased to 1. The effects were similar for both girls and boys. Girls taking more deworming drugs were about 8% more likely to pass the national exam while boys taking more deworming drugs were about 7% more likely to pass. The difference was statistically significant at the 1 percent level. The average of the predicted probability is about 63%, and the probit model correctly predicted 63.5% of the values, and the rest were miscalculated.

[23] Among household asset related variables, only number of birds was statistically significant at the 5 percent level. A student with one bird increase in household was 1% more likely to pass the exam.

Figure 7. The means of the national exam results by the number of deworming drugs taken

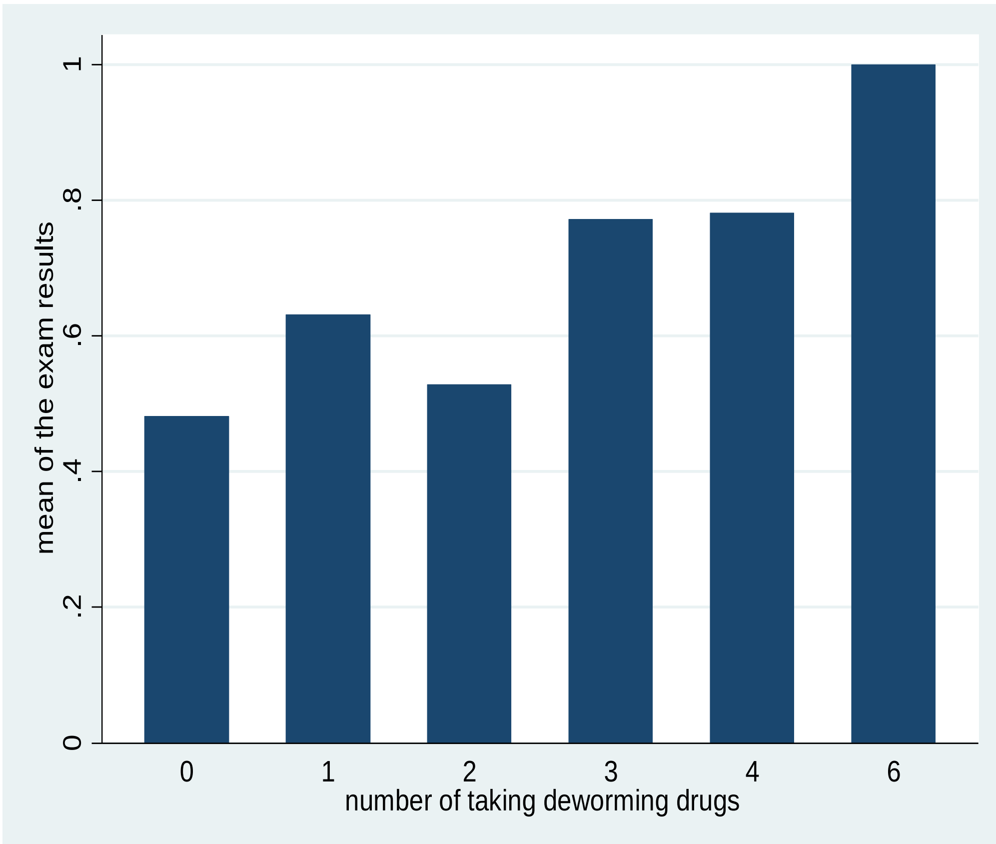


Table 14. The effects of the number of deworming drugs taken on national exam pass results

The dependent variable is the national exam pass/fail results. The independent variable, the number of taking deworming drugs, consists of six categories from zero time to six times. The students in treatment groups take higher number of deworming drugs. The mean of number of taking deworming drugs is 2.8 times for treatment group and 0.9 for comparison group. The column (1) is reported to compare with the logit and probit models but the predicted probability is not limited between 0 and 1. For gender variable, boy=0 and girl=1. The independent variables of numbers of bike, cow, goat, and bird are included to see the effect of household asset.

	(1) OLS	(2) Logit	(3) Probit
Num. drugs	0.07***	0.37***	0.23***
	(0.02)	(0.10)	(0.05)
student age	-0.00	-0.0	-0.01
	(0.02)	(0.08)	(0.04)
student gender	-0.29***	-1.39***	-0.84***
	(0.05)	(0.26)	(0.15)
caregiver age	0.00	0.00	0.00
	(0.00)	(0.01)	(0.01)
num. sibling	-0.01	-0.03	-0.02
	(0.01)	(0.05)	(0.02)
annual income (log)	0.01	0.03	0.02
	(0.02)	(0.09)	(0.05)
num. of bike	0.01	0.05	0.02
	(0.04)	(0.19)	(0.11)
num. of cow	-0.0	-0.02	-0.01
	(0.00)	(0.02)	(0.01)
num. of goat	0.00	0.02	0.011
	(0.01)	(0.04)	(0.02)
num. of bird	0.01**	0.05**	0.03**
	(0.00)	(0.03)	(0.02)
Constant	0.80**	1.34	0.82
	(0.38)	(1.83)	(1.08)
Observations	310	310	310

Notes: the number within the parentheses are robust standard errors. *** p<0.01, ** p<0.05, * p<0.10

Table 15. Marginal effects the number of deworming drugs taken on national exam pass results: logit and probit results

The dependent variable is the national exam pass/fail results. The number of taking deworming drugs is higher for treatment group. The mean of number of taking deworming drugs is 2.8 times for treatment group and 0.9 for comparison group. The marginal effects of covariates were separately estimated for treatment and comparison groups but I find that none of the effect estimates except gender are statistically distinguishable from 0. For gender variable, boy=0 and girl=1.

	(1) Logit Average marginal effects	(2) Logit Marginal effects at mean	(3) Probit Average Marginal effects	(4) Probit Marginal effects at mean
Num. Drugs	0.07***	0.08***	0.08***	0.09***
	(0.02)	(0.02)	(0.02)	(0.02)
student age	-0.00	-0.00	-0.00	-0.00
	(0.02)	(0.02)	(0.02)	(0.02)
student gender	-0.28***	-0.32***	-0.28***	-0.31***
	(0.04)	(0.06)	(0.05)	(0.06)
caregiver age	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)
num. of siblings	-0.01	-0.01	-0.01	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
annual income (log)	0.01	0.01	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)
num. of bike	0.01	0.01	0.01	0.01
	(0.04)	(0.04)	(0.04)	(0.04)
num. of cow	-0.00	-0.00	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)
num. of goat	0.00	0.00	0.00	0.00
	(0.01)	(0.01)	(0.01)	(0.01)
num. of bird	0.01**	0.01**	0.01**	0.01**
	(0.01)	(0.01)	(0.01)	(0.01)
observation	310	310	310	310

Notes: the number within the parentheses are robust standard errors. *** p<0.01, ** p<0.05, * p<0.10

3.3.2 Individual Subject Scores

In this section, I estimated the impact of the deworming program on the national exam scores (raw scores and z-scores) of five subjects using the OLS and IV models. First, the OLS estimates of the impact of the program are in table 16 and 17, showing the impact as positive and statistically significant for all five subjects. The treatment students increased their national exam scores by 2.4 points for Swahili, 1.4 points for English, 2.7 points for math, 1.4 points for history, and 2.2 points for science (table 16), and the program increased 0.33 standard deviation (SD) above the mean for Swahili, 0.18 SD above the mean for English, 0.40 SD above the mean for math, 0.29 SD above the mean for science in treatment students and, except in history, the results were significant (table 17). The impact was smaller particularly for English and history and greater in subjects that had higher mean scores, such as Swahili, math, and science.[24] The subject teachers' ability or quality of the exam could also influence the students' exam results. Therefore, there was possibility of omitted variable bias that the impact was underestimated for some subjects.

The OLS and IV estimations analyzed the impact of larger dosages of deworming drugs taken on the raw scores (table 18) and z-scores (table 19). Although the impact was small, it was statistically significant that an increase in the number of deworming drugs increased the national exam subject scores except in history (For history, there was no effect).

[24] The mean scores for Swahili, math and science are above 20 points while the mean scores of English and history are below 20 points (table 11).

Table 16. Effects of the deworming treatment on national exam scores: OLS estimates

The dependent variable is the national exam rawscores of 5 subjects. The column (1) to (5) are coefficient estimates of each subject. The sample consists of students who took the national exam in 2013 among those who were participated in the household survey in 2012. Age controls are included (two students under 10 years old are dropped). For other independent variables, only gender showed a statistically significant impact, and girls (girl=1) had lower scores in every five subject than boys (boy=0). The other independent variable, such as number of bike, cow, goat, and bird, were included but not reported in this table.

	(1) Swahili (points)	(2) English (points)	(3) Math (points)	(4) History (points)	(5) Science (points)
Kome	2.44***	1.39*	2.68***	1.37*	2.15***
(treatment)	(0.76)	(0.83)	(0.69)	(0.83)	(0.75)
student age	-0.24	-0.17	0.26	0.07	0.23
	(0.26)	(0.25)	(0.23)	(0.25)	(0.26)
student gender	-3.30***	-1.71**	-5.42***	-5.57***	-4.54***
	(0.79)	(0.84)	(0.71)	(0.83)	(0.72)
num.of sibling	0.18	0.28**	0.18	0.10	0.24*
	(0.14)	(0.15)	(0.12)	(0.14)	(0.14)
household	-0.02	-0.04	0.14	-0.17	-0.12
income (log)	(0.27)	(0.27)	(0.22)	(0.25)	(0.24)
Obs.	315	315	315	315	314

Notes: the numbers within the parentheses are robust standard errors. *** p-value<.01 ** p-value<0.05 * p-value<0.10

Table 17. Effects of the deworming treatment on national exam z-scores: OLS estimates

The dependent variable is the national exam z-scores of 5 subjects of the national exam. For gender variable, boy=0 and girl=1.

	(1) Swahili (sd)	(2) English (sd)	(3) Math (sd)	(4) History (sd)	(5) Science (sd)
Kome (treatment)	0.33*** (0.11)	0.18* (0.11)	0.40*** (0.10)	0.16 (0.10)	0.29*** (0.11)
student age	-0.03 (0.04)	-0.02 (0.03)	0.04 (0.03)	0.01 (0.03)	0.03 (0.04)
student gender	-0.47*** (0.11)	-0.24** (0.11)	-0.80*** (0.10)	-0.71*** (0.10)	-0.65*** (0.10)
num.of sibling	0.03 (0.02)	0.04** (0.02)	0.03 (0.02)	0.02 (0.02)	0.04** (0.02)
household income (log)	-0.01 (0.04)	-0.01 (0.04)	0.01 (0.03)	-0.02 (0.03)	-0.02 (0.03)
Obs.	315	315	315	315	314

Notes: the number within the parentheses are robust standard errors. *** p-value<.01 ** p-value<0.05 * p-value<0.10

To test the endogeneity problem of the independent variable in this IV model, the number of dosages of deworming drugs taken, I tested Durbin-Wu-Hausman test of endogeneity in each five subjects, and the results were significant ($p < 0.10$), which means that there was an endogenous problem. Also, after running the weak instrument variable test, the result showed robust F was greater than 200 in every subject, which meant that *Kome* was a strong instrumental variable. Therefore, the results from IV estimates, represented in table 18 and 19, are reliable. From the GN's deworming treatment, the results by using z-scores showed that a one dose increase of deworming drugs increased 0.17 SD above the mean for Swahili (table 19 column 6), 0.09 SD above the mean for English (table 19 column 7), 0.21 SD above the mean for math (table 19 column 8), and 0.15 SD above the mean for science (table 19 column 10). For history, the result was not statistically distinguishable from zero.

Table 18. The OLS and IV estimates of national exam scores for deworming drugs taken

The dependent variables are raw scores of five national exam subjects. For IV estimation, the number of taking deworming drug is the endogenous variable and a binary variable, Kome (Kome equals 1 if students are in a treatment group and 0 if students are in a comparison group) is used as an instrumental variable. For gender variable, boy equals 0 and girl equals 1.

	OLS					IV				
	(1) Swahili (points)	(2) English (points)	(3) Math (points)	(4) History (points)	(5) Science (points)	(6) Swahili (points)	(7) English (points)	(8) Math (points)	(9) History (points)	(10) Science (points)
Num. Drugs	0.74*** (0.28)	0.67** (0.29)	1.07*** (0.24)	0.34 (0.29)	0.56** (0.25)	1.24*** (0.42)	0.71* (0.43)	1.4*** (0.36)	0.67 (0.44)	1.08*** (0.39)
student age	-0.18 (0.26)	-0.11 (0.25)	0.36 (0.24)	0.09 (0.25)	0.28 (0.26)	-0.13 (0.26)	-0.11 (0.27)	0.39* (0.22)	0.12 (0.27)	0.33 (0.24)
Student gender	-3.43*** (0.79)	-1.79** (0.83)	5.50*** (0.69)	- 5.70*** (0.83)	-4.67*** (0.72)	-3.43*** (0.81)	-1.80** (0.84)	-5.50*** (0.69)	- 5.69*** (0.86)	-4.66*** (0.77)
num.of sibling	0.17 (0.14)	0.28* (0.15)	0.15 (0.12)	0.11 (0.14)	0.24* (0.14)	0.16 (0.14)	0.28* (0.15)	0.14 (0.12)	0.11 (0.15)	0.23* (0.13)
household income (log)	0.05 (0.27)	0.02 (0.26)	0.12 (0.22)	-0.15 (0.26)	-0.07 (0.24)	0.09 (0.26)	0.02 (0.27)	0.15 (0.22)	-0.12 (0.28)	-0.03 (0.25)
Obs.	315	315	315	315	314	315	315	315	315	314

Notes: the number within the parentheses are robust standard errors. *** p-value<.01 ** p-value<0.05 * p-value<0.10

Table 19. The OLS and IV estimates of z-scores for deworming drugs taken

The dependent variables are z-scores of five national exam scores. The mean scores are represented in table 11. For IV estimation, the independent variable, a number of taking deworming drugs, is an endogenous variable, and Kome variable (Kome equals 1 if students are in a treatment group and 0 if students are in a comparison group) is used as an instrumental variable. For gender variable, boy equals 0 and girl equals 1.

	OLS					IV				
	(1) Swahili (sd)	(2) English (sd)	(3) Math (sd)	(4) History (sd)	(5) Science (sd)	(6) Swahili (sd)	(7) English (sd)	(8) Math (sd)	(9) History (sd)	(10) Science (sd)
Num. Drugs	0.10*** (0.04)	0.09** (0.04)	0.16*** (0.04)	0.04 (0.04)	0.08** (0.04)	0.17*** (0.06)	0.09* (0.06)	0.21*** (0.05)	0.08 (0.06)	0.15*** (0.05)
student age	-0.02 (0.04)	-0.02 (0.03)	0.05 (0.03)	0.01 (0.03)	0.04 (0.04)	-0.02 (0.04)	-0.01 (0.04)	0.06* (0.03)	0.02 (0.03)	0.05 (0.03)
student gender	-0.47*** (0.11)	-0.24** (0.11)	-0.81*** (0.10)	-0.71*** (0.10)	-0.65*** (0.10)	-0.47*** (0.11)	-0.24** (0.11)	-0.81*** (0.10)	-0.71*** (0.11)	-0.65*** (0.11)
num.of sibling	0.02 (0.02)	0.04* (0.02)	0.02 (0.02)	0.01 (0.02)	0.03* (0.02)	0.02 (0.02)	0.04* (0.02)	0.02 (0.02)	0.01 (0.02)	0.03 (0.02)
household income (log)	0.01 (0.04)	0.01 (0.04)	0.02 (0.03)	-0.02 (0.03)	-0.01 (0.03)	0.01 (0.04)	0.01 (0.04)	0.02 (0.03)	-0.02 (0.03)	-0.01 (0.03)
Obs.	315	315	315	315	314	315	315	315	315	314

Notes: the number within the parentheses are robust standard errors. *** p-value<.01 ** p-value<0.05 * p-value<0.10

3.4 Conclusion

In the school-level analysis in Chapter 2, the results showed that the deworming treatment had no impact on educational achievement; however, in this chapter, the individual-level study showed small but positive impact of the deworming treatment on students' academic performance. There can be several reasons that the results are different between the school and individual level analyses.

First, in the comparison group, there were a few short-term deworming interventions from other NGOs in the past; therefore, it could be possible that the effects in the school-level analysis were underestimated and biased. In the individual-level study, there could be chances that the ten selected comparison schools were not influenced by any kinds of deworming activities, and the individual-level evaluation could show the greater and significant impact of the deworming program. If this evaluation study had joined from the program design and schools were randomly selected, for both school- and individual-level evaluations, among schools that did not have any deworming interventions in the comparison group, the study could have better comparative analyses for accessing the impact of the deworming activity on primary school performance.

Second, academic performance is influenced by a complex array of many factors including parasite infection, such as family background, educational expectation and motivation, nutritional conditions, school governance, and cross-linkage across factors. Karande and Kulkarni (2005) reports that "there are many reasons for children to underperform at school, such as, medical problems, below average intelligence, specific learning disability, attention deficit hyperactivity disorder, emotional problems, poor socio-cultural home environment, psychiatric disorders and even environmental causes" (p.961). My study limited those factors to exam specific correlation between educational achievement and parasite infection at the school-level analysis using panel data. Also, although I used instrumental variable estimation (for one endogenous variable) in the individual-level analysis using cross-sectional data, there could remain other endogenous variables problems.

In addition, not only my study but also the previous studies in many other countries showed inconsistent results for the impact of the deworming programs on school performance. One of factors that influence on academic achievement could be the types or intensity of parasite infections. Kome Island was the heavily infected area by STH and SM in Tanzania and the intensive or slight treatment intervention could influence on not only school participation but also academic performance. For instance, Guatemala where Watkins' study showed no impact of deworming on children's school performance was less intensively infected by parasites than Kome Island, therefore, the impact of the deworming program could be less affective in Guatemala and the impact was significant in Kome Island. Therefore, the different intensity of parasite infections among participated students could result the different outcomes between school- and individual-level analyses.

To overcome such problems, I examined the impact of number of dosages of the deworming drugs taken on academic performance by assuming that students who took more number of deworming drugs were more actively involved in the GN's program. Since there were no infrastructural changes for water and sanitation facilities or snail control, the possibility that students were re-infected were high and similar for all students. So, students taking more number of deworming drugs are freer from parasite infections. The results showed that one dose increase in deworming drugs taken increased the national exam pass rate by about 8 percent and improved the exam scores in four out of five subjects. Even though the impact was small, the results implied that deworming drugs treating the STH and SM infection were beneficial to increase academic performance for primary school students in Kome Island.

For my further research, it may provide better comparative analyses between school and individual levels to measure the impact of the deworming program on school performance if I design that the treatment and comparison schools are randomly selected in the Sengerema district, instead of including all schools in Kome Island in the treatment group and non-Kome schools in the comparison group. Also, data needs to be collected at baseline, follow-up and end-point with individual infection status. The extended socioeconomic, educational, and anthropometric data and randomized evaluation designs may improve further study.

Chapter 4. Deworming Intervention and Recipients' Involvement

4.1 Introduction

This chapter discusses the effect of the deworming intervention on recipients' awareness and participation in the program, evaluating a direct relationship between the goal of donor's intervention and its achievement. The ODA government funding collected from taxes needs to be spent wisely for both donors and recipients. For sustainable development, it is important that the intervention awakes the recipients to be aware and understand the importance of aid activities. The fundamental objective of the deworming activities, such as organizing campaigns, training staffs and providing deworming treatment, is to improve the health of all adults and children and decrease the mortality rate in the long-run. For short-term outcomes, the program aims to decrease the deworming infection rate by encouraging more people to participate in the program. The participating professors and specialists on parasites and the GN successfully decreased the STH and SM infection rates in Kome Island, but they worried about sustainability at the end of the program. One of program's participating professors said the reinfection rate might rise about 40% in less than five years after program termination in Kome Island. When donors leave, recipients should take more active roles and attitudes.

Awareness is the fundamental agent for change. It is important that recipients are aware of the program goals and understand the importance of deworming activities in order to sustain such activities after the donors depart. It is also important that people learn about parasites and deworming education. Infected people may not take any action and make their health and situation worse without knowing that they are infected with STH or SM. For instance, GN interviewed infected people in Kome Island prior to the intervention. A 39-year-old male, Treviata, had a parasite infection. Without knowing he had the infection and how he should be treated, he "was chased out from [his] parents after they consulted with the witchcraft."[25] Another interviewee, a parasite infected boy, said that he "has suffered since early childhood and [he] could not attend school at all."[26]

Many people in Kome Island do not know they are infected by parasitic disease or how to treat the infection. WHO reported that more than 200 million people in Africa received preventive chemotherapy, more than for one of parasitic disease[27] (annex 3). Because there was insufficient information on how many people suffered from infection without being aware of the problem, the number of parasite infected people could be greater. Therefore, it is important that people are aware of parasites and the treatment. Therefore, this chapter examines the direct effects of the GN's program on recipients' awareness and participation in deworming activities. First, the study estimates the impact of GN's intervention on deworming awareness of adults living in Kome Island by using the logit and probit models. Then, the study analyzes the participation in the program measured by the number of dosages of deworming drugs taken among adults and schoolchildren.

[25, 23] Good neighbors' report on NTDs Control Program (2014), p12.

[27] Good neighbors' report on NTDs Control Program (2014), p7. WHO published the first report on neglected tropical diseases in 2010, "Working to overcome the global impact of neglected tropical diseases."

4.2 Background and study design

In 2008, a Korea based development NGO, Good Neighbors, launched the NTDs control program in Mwanza, Tanzania in cooperation with the Korea International Cooperation Agency (KOICA).[28] The program targeted primary schoolchildren and residents in Kome Island, where schistosomiasis infection was high. The program consisted of three projects: operating a NTD control center in Mwanza city, implementing deworming control program in Kome Island and analyzing the program results. In addition to such projects, the GN organized campaigns and training programs to increase awareness and awake knowledge of the importance of the deworming treatment.

One of the merits of NGO's intervention is that the program is relatively small, compared to the government ODA, but able to provide aid to specific target groups in specific places, even remote areas. The GN's deworming program also targets residents and schoolchildren living in a small island where a high prevalence of STH and SM infections exists. As mentioned in Chapter 1, the GN's program was first a community-based intervention, with many adults involved in the program. In the middle of the intervention periods, the program changed to a school-based intervention to allow more schoolchildren and adults to participate in the deworming treatment. The targeted groups included all residents (older than two years old) but mainly adults in the community-based intervention from 2009 to 2011. From 2011 to 2013, the intervention was school-based and the treated targets were mostly primary and secondary schoolchildren

[28] This program was the second round program that was funded from KOICA. The first round program was "Korea-Tanzania collaborative project on health promotion through parasite control among school children" from 2005 to 2009. The KOICA funded approximately 2,400,000 US dollars from Aug. 2008 to Sept. 2013 for this NTDs program and beget was from the levy designated as the poverty eradication contribution in Korea. Korea Foundation for International Healthcare (KOFIH) was also a partnership agency of this program supporting vehicles and building wells and schools, and five parasite specialized professors from Korea were involved in cooperation with Good Neighbors Tanzania (GNTZ West) and National Institute for Medical Research (NIMR) in Tanzania.

(appendix 1, 2).

Household survey data aided the estimation of the impact of the donor’s intervention on deworming awareness and deworming drugs taken. All residents and students, older than two-year-old, were eligible to participate in the GN’s deworming program, including campaigns, examinations and treatment in Kome Island. All ten primary schools were treatment schools with another 169 serving as comparison schools that had similar characteristics and locations near the infected lake. The district educational administration council selected the comparison schools. After approval of the program and evaluation study by the council, headmasters of all participating schools received information about the deworming treatment in the treatment schools and the household survey in both the treatment and comparison schools. The household survey was conducted as a single follow-up at the end of the program in 2012. About 500 residents and students, including approximately 250 headmaster-selected seventh graders in each treatment and comparison group, participated in the survey with caregivers accompanying all selected students. Local interviewers translated the survey questions into Swahili or English and each caregiver offered information about the deworming treatment; including their awareness of the deworming treatment and how many times they and their children took the deworming drugs, albendazole or/and praziquantel from 2009 to 2012.

This study used only the survey data. Collection of individual STH or SM infection data was prior to the survey, and the data of those who are infected, uninfected, or treated could not match with survey participants due to the ID number mismatch. Since the evaluation study did not join the program from the beginning of the GN's intervention, the problem of matching individuals' ID was unsolved. Thus, this study could not compare the relationship between infection and drugs taken or reinfection and the amount of drugs taken, but it is a valid assumption that people who are more actively involved in the deworming treatment would have taken greater amounts of the deworming drugs. It is possible that those infected by STH or SM can be easily reinfected due to the lack of safe water system, poor sanitation and household conditions. Thus, infected people have greater exposure to reinfection and need to take the deworming drugs multiple times. Another assumption is there may be similarity in infections between the treatment and comparison groups. The GN's research found that people living in Kome Island were highly infected by STH and SM because of the proximity to Lake Victoria. The residents and students in the comparison schools may also have a high infection rate since they are also exposed to the infected lake.

At the end of program survey, higher percentage of adults were aware of the importance of the deworming treatment, and more adults and schoolchildren had taken a higher number of deworming drugs in the treatment group (table 20, 21). In the treatment groups, about 88 percent of adults were aware of the deworming treatment and more than 90 percent of adults and children took the deworming drugs. In the comparison group, approximately 60 percent of adults were aware of the deworming but only rate 57 percent of adults and 60 percent of school children had taken the drugs. In the treatment group, more than half of the adults responded they learned about the importance of deworming at a school-based intervention and most of adults and students took the drugs at schools. In the comparison group, about half of adults, 47 percent, learned about deworming and took the drugs at nearby health centers. Quite a high percentage, about 60 percent, of people in the comparison group answered that they took deworming drugs, and it is possible they took the drugs at least once through other NGOs' deworming intervention. Therefore, the percentage of people taking the deworming drugs was sufficiently higher and the percentage of people taking fewer deworming drugs was lower in the treatment group. The average number of drugs taken was approximately three times in the treatment group and two times in the comparison group for adults and three times in the treatment group and one time in the comparison group for students, respectively. The number of times between the treatment and comparison groups is presented in figure 8. Both adults and schoolchildren in the treatment group took the drugs two to three times, while most of adults and children in the comparison group reported zero to one time. The results are similar for females and males separately in every group.

Table 20. Awareness and participation of adults, 2009-2012

The summary statistics include only adults who participated in the survey. For awareness and taken variables, awareness is equal to 1 if an adult answered he/she is aware of importance of deworming treatment and 0 if he/she is not aware of the program. Taken is equal to 1 if he/she has taken a deworming medicine from 2009 to 2012 and 1 otherwise. For the survey participants who answered aware=1, they answered the following questions how and where they were able to learn about the deworming treatment. Community and school based education is operated by the GN. For minimum number of taking deworming medicines is 1 for both treatment and comparison groups and maximum number is 8 for treatment and 6 for comparison. These numbers are included in the summary but not reported in this table. The numbers are percentage and the numbers in parenthesis are total observation numbers. The mean value of number for taking deworming medicine is the number of times.

	Treatment %	Comparison %	Mean in Treatment (no.) (±s.e)	Mean in comparison (no.) (±s.e)
Awareness	88.45	64.46		
	(251)	(241)		
Aware from community based education	21.50	12.58		
	(214)	(159)		
Aware from school based education	50.47	25.16		
	(214)	(159)		
Aware from health centers	19.16	46.54		
	(214)	(159)		
Taken	92.18	57.14		
	(243)	(238)		
Taken=1	12.07	41.84		
	(232)	(141)		
Taken=2	34.48	31.21	2.69	2.14
	(232)	(141)	(± 1.14)	(±1.41)
Taken=3	34.91	12.77		
	(232)	(141)		
Taken=4	13.79	5.67		
	(232)	(141)		

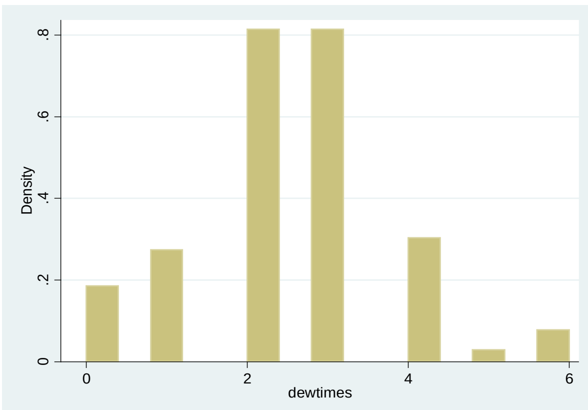
Table 21. Awareness and participation of students, 2009-2012

The age groups of students who participated in this survey are from 6 to 20. Taken is 1 if a student has taken the deworming drugs and 0 if a student has not. For number of taking deworming medicine, zero time is included, so there is no difference for the sample size between awareness and taken variables for a comparison group. For taken at school variable, it is a cumulative percentage of students who answered to have taken the medicine at their schools from 2011 to 2012, and other choice of places to receive the medicine is at their communities from 2009 to 2010. The numbers are percentage and the numbers in parenthesis are total observation numbers. The mean value of number for taking deworming medicine is the number of times.

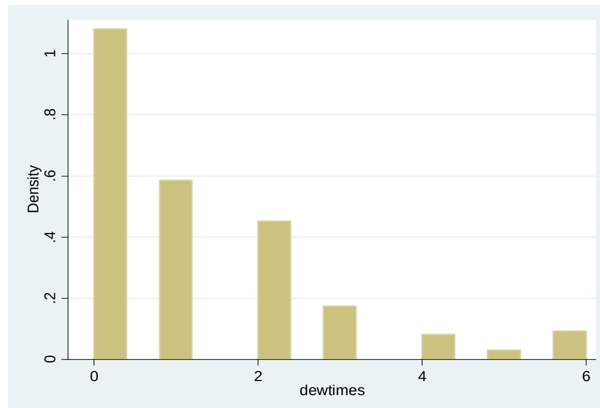
	Treatment %	Comparison %	Mean in Treatment (no.) (±s.e)	Mean in comparison (no.) (±s.e)
Taken	98.80	60.82		
	(251)	(246)		
Taken=0	-	38.62		
		(246)		
Taken=1	8.06	32.52	2.8	1.0
	(248)	(246)	(± 1.03)	(±1.05)
Taken=2	32.26	22.76		
	(248)	(246)		
Taken=3	36.29	4.88		
	(248)	(246)		
Taken at school	99.17	69.12		
	(240)	(136)		

Figure 8. The number of deworming drugs taken by the treatment status:

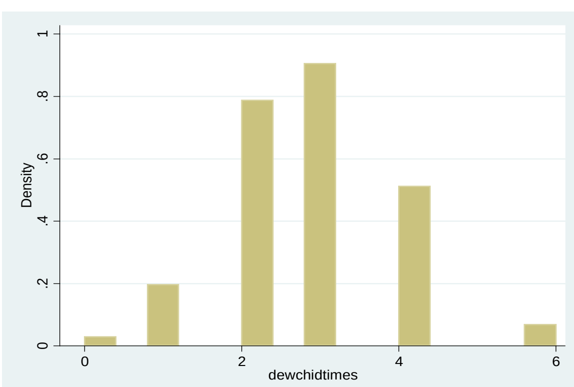
adults and schoolchildren



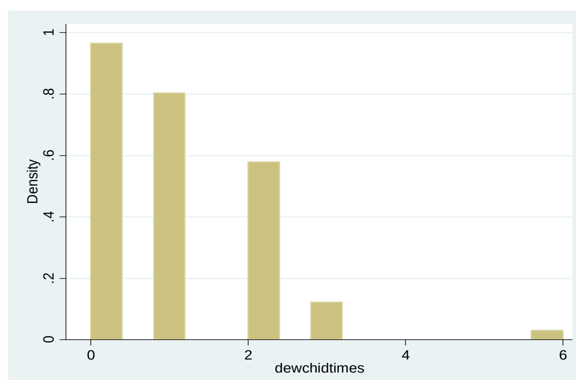
Adults in the treatment group



Adults in the comparison group



Schoolchildren in the treatment group



Schoolchildren in the comparison group

4.3 Econometric modeling and results

4.3.1 Awareness of deworming

Using the household survey data, this section estimates the impact of GN's program on awareness of deworming in Kome Island. The simple ordinary least squares model of this analysis is:

$$(1)\ Y_i = \beta_0 + \beta_1\, Kome_i + \beta_2 X_i + v_i$$

where Y_i is a dependent dummy variable for awareness of deworming of an individual *i*,and $Kome_i$ is a dummy variable equal to 1 if an individual, *i*, is in the treatment group in Kome Island and 0 if the individual is in the comparison group. X_i is a vector of a series of other independent factors such as gender, age, number of family members and children, annual income and number of ill people in households and v_i is an error term.

Since the dependent variable, Y_i, is dichotomous, I used the logit and probit models to estimate whether an individual was aware of the importance of deworming treatment and it measured the impact of the GN's intervention. The probability equation that an individual was aware of the deworming is:

$$(2)\ P = Pr\,[Y_i = 1 \mid Kome\,] = f\ (\beta Kome_i')$$

the binary outcome Y_i estimates the probability that Y_i equals 1 as a function of the independent variable *Kome*. Using the logit and probit model limits the predicted probabilities between 0 and 1, 0 if an individual was not aware of the deworming and 1 if an individual was aware of the deworming treatment. The hypothesis is that adults and students were more aware of the importance of deworming activities, $\beta=1$, due to the GN's intervention.

Tables 22 and 23 present the coefficient estimates of the logit and probit models (column 2,3) and the OLS estimates (column 1) as comparison. The results show the estimates are positive, suggesting that both adults and students living in Kome Island were more likely aware of the importance of deworming treatment in comparison to comparison groups due to GN's program. The impact estimates are statistically significant at the 1 percent level. Table 23 offers the average marginal effects and shows that adults living in Kome Island, in comparison to adults living in other areas near the infected Lake Victoria, were about 25% more likely aware of the deworming treatment due to the GN's intervention.[29] The result was statistically significant at the 1 percent level (table 23 column 1, 2). For the other independent variables, none of the estimates was statistically different from zero. The average of predicted probability for being aware of deworming treatment was about 76% which is similar to the actual frequency, about 77%. The logit and probit models correctly predicted about 76% of values and the rest are misclassified.

[29] The marginal effects at mean are also estimated and the results show the similar effects with the average marginal effects: the GN's intervention increases the probability that y_i =1 by 25% at the 1 percent level.

Table 22. The logit and probit estimates of the GN's program impact on awareness: adults

The dependent variable is awareness of deworming treatment of an individual. The total sample size in the survey is 499 but the actual observation is 454 as the data contains some missing values for annual income and number of family members. Ages of survey participants consists of adults aged from 18 to 89 years old. Age controls are included in the models and two 18-year-old adults are dropped as the student age control groups include 18 years old students. The independent variable, Kome(t) is one if an adult is included in a treatment group. For gender variable, boy=0 and girl=1.

Independent variables	(1) OLS	(2) logit	(3) probit
Kome(treatment)	0.25***	1.49***	0.86***
	(0.04)	(0.25)	(0.14)
gender	-0.02	-0.12	-0.08
	(0.04)	(0.24)	(0.14)
age	0.00	0.01	0.00
	(0.00)	(0.01)	(0.01)
no. of family members	0.01	0.05	0.03
	(0.01)	(0.05)	(0.03)
no. of children	-0.01	-0.01	-0.01
	(0.01)	(0.06)	(0.04)
no. of ill	0.04	0.27	0.15
	(0.03)	(0.19)	(0.11)
annual income(log)	-0.01	-0.08	-0.05
	(0.01)	(0.08)	(0.05)
Constant	0.72***	1.02	0.68
	(0.21)	(1.27)	(0.74)
Observations	454	454	454
R-squared	0.09		

Notes: the numbers within the parentheses are robust standard errors. ***p-value<0.01

Table 23. The average marginal effects on awareness: adults

The dependent variable is the awareness of deworming treatment. The marginal effects at mean are also calculated but only average marginal effects are reported since the results are the same. For gender variable, boy=0 and girl=1.

Independent variables	(1) Logit marginal effects	(2) Probit marginal effects
Kome(treatment)	0.25***	0.24***
	(0.04)	(0.04)
gender	-0.02	-0.02
	(0.04)	(0.04)
age	0.00	0.00
	(0.00)	(0.00)
no. of family members	0.01	0.01
	(0.01)	(0.01)
no. of children	-0.01	-0.01
	(0.01)	(0.01)
no. of ill	0.04	0.04
	(0.03)	(0.03)
annual income(log)	-0.01	-0.01
	(0.01)	(0.01)
Observations	454	454

Notes: the numbers within the parentheses are robust standard errors. ***p-value<0.01

4.3.2 Participation of deworming drugs taken

This section measures the impact of the GN's intervention on deworming drugs taken by adults and students. The logit and probit models are:

$$(3)\ Y_i = \beta KOME_j + \gamma X_j + v_i$$

where Y_i is a dummy dependent variable capturing whether an individual *i* has taken deworming drugs or not. Y_i equals 1 of an individual answers having taken deworming drugs and 0 if one has never taken the drug during 2009 to 2012. The independent variable, *KOME,* is a dummy variable for representing *KOME* equals 1 if an individual *i* lives in Kome Island (a treatment group) and *KOME* equals 0 if an individual lives in other areas (a comparison group). *X* is a set of other factors such as age, gender, number of family members and children, number of ill persons in a household and household annual income, and *v* is the error term.

The hypothesis is that more people have taken deworming drugs due to the GN's intervention. The previous section shows that adults are more aware of deworming due to the GN's intervention. If they are more aware of the importance of deworming, they may have more involvement in treatment activities. In addition, if adults in households are aware of deworming and treated, their children can undergo treatment by their caregivers. On the other hand, if adults in a household have STH and SM infection, their children are more likely infected as well.

First, this section estimates the impact of the GN's intervention on deworming drugs taken. The results from the logit and probit models show that the GN's intervention had a significant and positive impact on deworming drugs taken by adults and students (table 24, 25). Due to the GN's intervention, adults and schoolchildren living in Kome Island were about 35%

and 40% more likely to take deworming drugs, respectively in comparison to schoolchildren living in the comparison areas, which was statistically significant at the 1 percent level. The marginal effects were greater for schoolchildren than for adults. Since the GN's intervention was school-based for the last three years, schoolchildren could have mandatory involvement in the treatment activities without parental involvement. The average of predicted probability for taking deworming drugs for schoolchildren was about 81% which is similar to the actual frequency, 80%. Also, the logit and probit models correctly predicted 85% of the values and the rests are misclassified.

The marginal effects percentage for deworming drugs taken is about 10% higher than that of awareness. Although people are not aware of the STH or SM infections and the deworming treatment, they may be treated due to the GN’s intervention. Also, it may be possible that there may be treatment externalities for taking deworming drugs among adults within the community, particularly at the community-based intervention. Those who were not aware of or educated about parasite infection and importance of deworming might be involved in community activities along with their neighbors. The estimates of other factors are not statistically significant from zero for adults. The average of predicted probability for deworming drugs taken by adults is about 73% and the actual frequency is about 75%. The logit and probit models correctly predicted 75% of values and the rests are misclassified.

Table 24. The logit and probit estimates of the GN's program impact on deworming drugs taken: adults

The dependent variable is a dummy variable equaled to 1 if an adult or student has taken deworming drugs from 2009 to 2012 and 0 if he/she has never taken one. Age control is included from 19 to 89 years old for adult group. The independent variable Kome equals 1 if an adult has taken deworming drug and 0 if one has never taken it. For gender variable, boy=0 and girl=1.

Independent variables	(1) OLS	(2) Logit	(3) Probit
Kome(treatment)	0.36***	2.20***	1.26***
	(0.04)	(0.28)	(0.15)
gender	-0.02	-0.12	-0.09
	(0.04)	(0.26)	(0.15)
age	0.00	0.00	0.00
	(0.00)	(0.01)	(0.01)
no. of family members	-0.00	-0.02	-0.01
	(0.01)	(0.05)	(0.03)
no. of children	0.01	0.04	0.02
	(0.01)	(0.06)	(0.03)
no. of ill	0.01	0.08	0.05
	(0.03)	(0.17)	(0.10)
annual income(log)	-0.02	-0.12	-0.07
	(0.01)	(0.09)	(0.05)
Constant	0.81	1.75	0.94
	(0.22)	(1.35)	(0.79)
Observations	445	445	445
R-squared	0.18		

Notes: the numbers within the parentheses are robust standard errors. ***p-value<0.01

Table 25. The logit and probit estimates on the GN's program impact on deworming drugs taken: students

The dependent variable is the deworming drugs taking of students. Age control is included from 10 to 18 years old. The student group is supposed to be 7th graders but the grades can be vary because other students were substituted as a survey participant if a designated student was absent on the survey day. The independent variable, deworming drugs taking of care givers, may not be parents but can be any care givers who accompanied with students to participate in the survey. The independent variable Kome equals 1 if an adult has taken deworming drug and 0 if one has never taken it. For gender variable, boy=0 and girl=1.

Independent variables	(1) OLS	(2) Logit	(3) Probit
Kome(treatment)	0.30***	3.96***	1.96***
	(0.03)	(0.74)	(0.31)
gender	0.01	0.02	0.04
	(0.03)	(0.31)	(0.18)
age	-0.02*	-0.16	-0.09*
	(0.01)	(0.11)	(0.06)
deworming dugs taking of care giver	0.22***	1.29***	0.77***
	(0.05)	(0.32)	(0.18)
no. of siblings	0.00	0.04	0.02
	(0.01)	(0.06)	(0.03)
annual income(log)	-0.02**	-0.22**	-0.11*
	(0.01)	(0.11)	(0.06)
distance to school	0.00	0.01	0.01
	(0.00)	(0.01)	(0.00)
Constant	1.01***	4.42**	2.34*
	(0.22)	(2.14)	(1.23)
Observations	407	407	407
R-squared	0.30		

Notes: the numbers within the parentheses are robust standard errors. ***p-value<0.01 **p-value<0.05 *p-value<0.10

Table 26. The average marginal effects on deworming drugs taken: adults and students

The dependent variable is the deworming drugs taking of adults and students. The independent variable Kome equals 1 if an adult has taken deworming drug and 0 if one has never taken it. For gender variable, boy=0 and girl=1.

Independent variables	(1) Logit marginal effects adults	(2) Probit marginal effects adults	(3) Logit marginal effects students	(4) Probit marginal effects students
Kome(treatment)	0.35***	0.34***	0.40***	0.38***
	(0.34)	(0.03)	(0.07)	(0.05)
gender	-0.02	-0.02	0.00	0.01
	(0.04)	(0.04)	(0.03)	(0.03)
age	0.00	0.00	-0.02	-0.02*
	(0.00)	(0.00)	(0.01)	(0.01)
no. of family members	-0.01	-0.01	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)
no. of children	0.01	0.01	0.00	-0.00
	(0.01)	(0.01)	(0.01)	(0.01)
no. of ill	0.01	0.01	-0.01	-0.01
	(0.03)	(0.03)	(0.02)	(0.02)
annual income(log)	-0.02	-0.02	-0.02**	-0.02*
	(0.01)	(0.01)	(0.01)	(0.01)
deworming drugs taking of			0.13***	0.13***
care giver			(0.03)	(0.03)
distance to school			0.01	0.01
			(0.00)	(0.01)
Observations	445	445	407	407

Notes: the numbers within the parentheses are robust standard errors. ***p-value<0.01 **p-value<0.05 *p-value<0.10

For schoolchildren's deworming drugs taken, the estimates of other factors, like age, household annual income, and caregivers taking the drugs are also statistically significant at the 10 percent level for age and annual income and the 1 percent level for deworming drugs taken by caregivers, respectively. The probit model result (table 26 column 4) shows that a one year increase in age of students decreased the likelihood that the student received a deworming drug by 2%. Students that participated in the survey were from 6 to 20 years old. Supposedly, the student group in the survey were seventh graders in 2013; however, there were some students who were absent on the survey day. About 500 students participated in the survey but only 314 students matched with seventh graders. Hence, I can assume that age correlates with grade variances: younger ages may represent lower grades and older students are in the higher grade. The results show that older students, assumed to be in the higher grade, were less likely to take deworming drugs. It may be possible that younger students were more obedient and highly participated in school activities, or attendance rates in the higher grade might be lower than that in the lower grade. If students in the higher grade are absent more often, the chances that they participated in the program would decrease. Since the treatment program took place at school, students' attendance may closely relate to treatment. If more students attended on a treatment day, more infected students have received the deworming drugs. The attendance rate by grades is in table 27: the attendance rate decreases as the grade is higher and the decrease of attendance rate is greater in the treatment group. There were no gender differences between boys and girls.

Table 27. The average attendance rate of each standard: 2007-2012

The number is the average attendance rate of schools in each standard from 2007 to 2012, so the average attendance rate in standard 1 is mean of standard 1 for 6 years. The number of observation is reported with doubled number as gender is included separately. For treatment schools, the number of observation is 10 schools* 6 years =60 and for comparison schools 168 schools* 6 years=1,008. Newly founded schools that did not report attendance rate for a certain year are considered as missing values.

	Total (%)	No. of obs.	Treatment (%)	No. of obs.	Comparison (%)	No. of obs.
Standard 1	67.1	2105	69.5	120	66.9	1985
Standard 2	65.2	2101	65.6	120	65.2	1981
Standard 3	63.4	2093	59.3	120	63.7	1973
Standard 4	63.5	2083	57.8	120	63.9	1963
Standard 5	60.7	2077	50.9	120	61.2	1957
Standard 6	60.6	2067	51.2	119	61.1	1948
Standard 7	61.0	2057	46.7	117	61.8	1940

In table 26 column 3 and 4, the marginal effects show that an increase in household annual income decreased the likelihood that y_i=1, a school child took deworming drugs by about 2% and it is statistically significant at the 5 percent level for logit marginal effects (column 3) and the 10 percent level for probit marginal effects (column 4). The average annual income in the survey was about USD 641 and the main source of income was from self-employed agricultural or fishery activities. For questions asking about home environments, such as living in a soil or cement house, wearing shoes, and number of meals a day, about 28% of survey participants answered living in a cement-built house, 56% of children wore shoes and 19% ate meals three times a day (78% of people answered two meals a day). The STH and SM infections related to living conditions. If children had greater exposure to soil and malnutrition, they were more likely to be infected. Therefore, it is possible that students growing up in households with higher annual income may be less likely to be infected by SM or STH and less likely to take deworming drugs because their living conditions are better. However, unfortunately, using quasi-experimental data in this study made the infection rate data of individuals by household annual income limited.

The caregiver's taking deworming drugs had a significant impact on their children taking the drugs. Children living with caregivers who had taken deworming drugs were more likely to take the deworming drugs in comparison to those living with caregivers who did not take the deworming drugs. Table 25 shows that the estimates for the impact of caregivers were all positive and statistically significant at the 1 percent level. Children whose parents or care givers took deworming drugs were 13% more likely to take the drugs in comparison to children whose caregivers were not taking deworming drugs (table 26, column 3&4). Thus, it is a valid assumption that taking the drugs for children closely correlates with their parents' behavior. In the household survey, the percentage of taking deworming drugs is 92% for adult caregivers and 98% for schoolchildren. Also, the drug taking of one child may correlate with number of children in a household. Caregivers involved in the deworming treatment activities may bring their children who are not in school for treatment. In addition, if a household has many children, the probability that at least one child takes deworming drugs may be sufficiently large; however, the estimates of other variables like number of siblings, gender difference and distance to schools were not statistically distinguishable from zero for schoolchildren.

In Chapter 3 (table 18, 19), the first stage of IV regression, using the number of deworming drugs taken by school children as the endogenous variable and a binary z variable of treatment or comparison groups as the instrumental variable, showed that treatment children took about 1.9 times ($p<0.01$) more of deworming drugs due to the GN's program. This chapter notes the robustness of the results using ordered logit and probit models for deworming drugs taken by defining seven categories of outcomes: zero time, 1 time, 2 times, 3 times, 4 times, 5 times, and 6 times taking the deworming drugs. The probability that an individual *i* (adult or student) takes *j* times of deworming drugs is:

$$(4)\ P_{ij} = p(y_i=j) = p(\alpha_{j-1} < y_i^* \leq \alpha_j) = F(\alpha_j - x'_i\beta) - F(\alpha_{j-1} - x'_i\beta)$$

where y* is a single latent variable falling between α_{j-1} and α_j. For the ordered logit, F is the logistic cumulative distribution function, and for the ordered probit, F is the standard normal cumulative distribution function. $_{j-1}$ represents a cutoff point.

The results are in table 28. The number of times taking deworming drugs is higher (from 0 time to 6 times) in the treatment groups and statistically significant at the 1 percent level for both adults and students. Both adults and students in a treatment group were less likely to take deworming drugs for 0 or 1 time; however, in taking the drugs 3 and 4 times, the impact was much higher for the treatment group. Adults were 20% more likely (raw 1 column 4) and students were 34% more likely (raw 2 column 4) to take the drugs 3 times, and 10% of adults (raw 1 column 5) and 18% of students (raw 2 column 5) were more likely to take the drugs 4 times in the treatment group. For 5 and 6 times, the effects were smaller than for 3 to 4 times, but the GN's intervention had a positive impact on taking deworming drugs for adults and schoolchildren in the treatment group. There were no differences in results between females and males for adults and girls and boys for students.

Table 28. Marginal effects on deworming drugs taken: ordered logit results

Two independent variables are reported in this table: KOME (1) reports the marginal effects of an adult individual and KOME(2) reports that of a student in a treatment group. Other independent variables such as age, gender, number of children, and household income(log) are included but none of the estimates are statistically distinguishable from zero. The ordered logit and probit models with 7 alternative times have one set of coefficients with 6 intercepts; they are included but not reported. The marginal effects for the probit model are similar of the logit model and only the estimates of the logit model are reported. For adult sample, one who responded to have taken deworming drugs more than 6 times is dropped. For student sample, the column (6) is not included because no one answered to take it for 5 times. Cutoffs are included in the regressions but the coefficients are not reported.

	(1) Ordered logit marginal effects for 0 time	(2) Ordered logit marginal effects for 1 time	(3) Ordered logit marginal effects for 2 times	(4) Ordered logit marginal effects for 3 times	(5) Ordered logit marginal effects for 4 times	(6) Ordered logit marginal effects for 5 times	(7) Ordered logit marginal effects for 6 times
KOME (1)	-0.33***	-0.11***	0.07***	0.20***	0.10***	0.02***	0.04***
Adults	(0.03)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)
Obs.	456	456	456	456	456	456	456
KOME (2)	-0.35***	-0.29***	0.09***	0.34***	0.18***	-	0.03***
Students	(0.03)	(0.03)	(0.03)	(0.03)	(0.02)		(0.01)
Obs.	460	460	460	460	460	460	460

Notes: the numbers within the parentheses are robust standard errors. *** p-value<0.01

4.4 Conclusion

This chapter analyzed the impact of the deworming intervention on recipients' awareness and participation in reducing the STH and SM infections in Kome Island. The GN's intervention aimed to treat and lower the STH and SM infection rates by providing deworming drugs during five years. The results showed that adults and schoolchildren were more likely aware of the importance of deworming and involved in deworming treatment activities due to the GN's program. Adults were more aware of parasitic infection and educated about the importance of deworming treatment, and a larger percentage of adults and children took greater numbers of deworming drugs in comparison to people living in other areas, where there was no GN's intervention. Although the GN's intervention increased deworming awareness by about 25% and participation by about 35% in Kome Island, there still has a room to increase recipients' involvement in greater percentage with the same budget.

Since the program was implemented at the school-level and the examination of this study used individual data, the effects of the program may be underestimated. The possibility of spillover effects among students across schools is less likely since the treatment schools included all existing primary schools in Kome Island; however, there is a possibility of externality benefits across untreated adults at community-based program and students within treatment schools. Adults who live near the treated community and children who may not attend schools but live near the treated schools may have exposure to deworming activities. Unfortunately, this study could not obtain the individual data for infected, treated, or untreated of people living near treatment schools. The study used quasi-experimental data, hence could not examine whether adults and children had positive externality benefits due to the GN's program.

The five years of donor intervention ended and the short-term impact of the GN's program was positive improving living conditions with lower burden of worm infection in Kome Island. However, the possibility for reinfection is high and the problem of sustainability still exits. Without recipients' motivation and active roles that learned through understanding and participation of donor's intervention and activities, the infection rates of STH and SM may rise again in a few years. In order to guarantee the long-term outcomes, establishing a management system of deworming among recipients is necessary and achievable if recipients are fully aware of and actively participated in donor's activities during the intervention periods. It is possible that the changes in recipients may lead to sustainable changes for a better environment. For instance, people in Kome Island will be more cautious about using the infected lake water from Lake Victoria for not only drinking but also washing, and they will be more involved in treatment when they are aware of parasite infection symptoms. These changes may retain a low parasite infection rate in Kome Island in the long-run.

5. Concluding Remarks

My empirical evaluation study showed that the Korea's deworming program had impact on primary school outcomes in Kome Island, Tanzania. It was statistically significant that the deworming program increased school participation by about 3 percentage points, and one dose increase in deworming drugs taken improved school performance increasing the national exam scores about 0.15 standard deviation on average above the mean. However, the further research needs to examine the long-term outcomes of the deworming intervention because reinfection rate is still high.

Even with the high risk of reinfection, the deworming treatment at a minimal cost contributes to subsequent improvement in health and educational development, particularly in school-aged children. Deworming can be the initial health activity in developing countries because it is “simple, effective, safe, and cheap” compared to other health programs (The Lancet, 2004, p.1994). In 2005, WHO aimed to achieve deworming treatment by 2010 for at least 75% of school-aged children at risk of schistosomiasis and soil-transmitted helminths infections (Kobayashi et al., 2006; WHO, 2005), and UNDP in 2005 claimed the global expansion of deworming treatment was crucial to benefit school-aged children, particularly in sub-Saharan Africa (Kpbayashi et al., 2006; UNDP, 2005). The treatment for worms has a low cost, of less than one dollar per person a year, but the reinfection rate is high due to the poor environmental sanitation and inadequate access to safe and clean water.

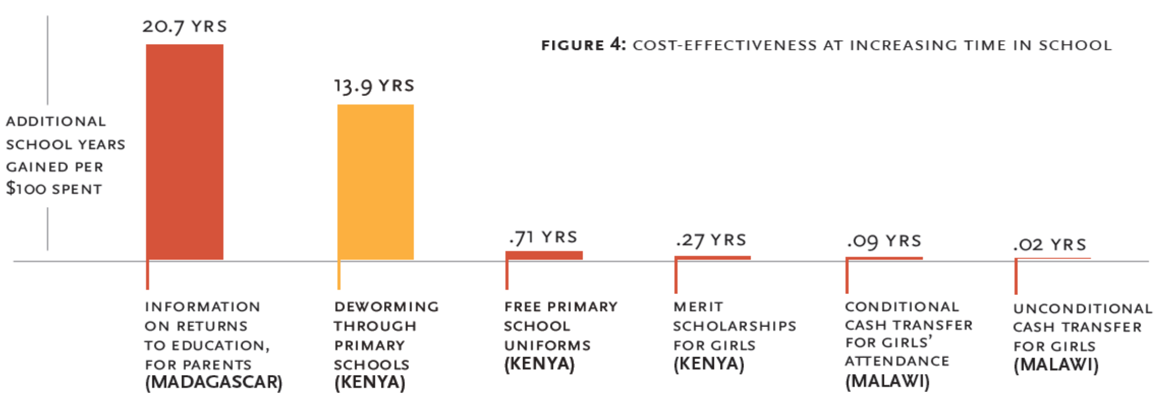
As many deworming studies showed, the deworming treatment is cost-effective in comparison to other aid programs. It costs less than a dollar for a single dose for albendazole and praziquantel.[30] Although the NTD program as a whole is more expensive, the GN's deworming program cost approximately USD 10,000 per year including drugs, delivery, and other extras, such as providing a simple meal before drug administration for children. The *J-Pall Bulletin* (2012) reported the cost-effectiveness comparison for different programs implemented to increase school attending years, and the results showed that deworming intervention in primary schools increased 13.9 additional school years per USD 100 spent. The program was considerably more cost-effective than other interventions, such as free uniform, merit scholarships, and conditional and unconditional cash transfer programs.[31]

Calculations for this study involved a back-of-the envelope type cost-effectiveness. In order to calculate, I needed to know the estimated effect of the GN's deworming program in Kome Island. In Chapter 2, panel random effects estimation assessed an approximate 2.45 percentage points increase in school attendance due to the GN's deworming program (table 7, column 3). The number of official school days in Tanzania is about 200 days per year, with

---

[30] WHO estimates that the cost of a single 600mg praziquantel is about US$0,08 and the treatment costs about US$0.20-0.30 on average. A single 400mg albendazole is sold in about US$0.77 in developed countries, and these drugs are free of charge in highly prevalent countries like sub-Saharan Africa.

[31] Figure: Cost-effectiveness comparison for various interventions designed to promote school attendance



Source: March 2012 issue of the J-PAL Bulletin approximately 1,000 primary students attending primary school in Kome Island. Since there are ten primary schools in Kome, there are approximately 10,000 primary schoolchildren. Therefore, calculating extra child-school days per year due to the program, with an approximate 2.45% increase in school attendance equals roughly 49,000 additional school days (2.45% *x* 200 days *x* 10,000 students = 49,000).

The GN's deworming program cost about USD 10,000 per year, so the average cost for two years of implementing the deworming program in Kome Island was approximately USD 20,000 and spending USD 100 for the program gives offers about 245 additional school days. To compare this number with the *J-Pall Bulletin* (2012) report on the cost-effectiveness comparison for various interventions designed to promote school attendance, I divided the 245 additional school days by 200 school days per year, which equals about 1.2 additional school years gained per USD 100. This result showed that the GN's program was more cost-effective than merely providing free uniforms, scholarships for girls, and conditional and unconditional cash transfers noted in the *J-Pall Bulletin* diagram.

On the other hand, in comparison to Kenya, offering 13.9 additional years per USD 100 spending for the deworming program, the impact was lower. Several reasons could account for the lower impact on additional year increases in this program. One of the reasons would be that the true impact of the GN's intervention was underestimated. Since the target area, Kome Island, is isolated area, it was difficult to expect spillover effect and positive externalities. Moreover, there could be sample attrition bias because this study could not collect the data for school dropouts or transfers and each student's infection data was not available. In addition, the impact could be bigger if there was no deworming intervention at all in comparison group. Therefore, the impact for attendance rate could be greater than 2.45 percentage points in this program, which could offer more than 1.2 additional school years gained per USD 100. In addition, the rigorous cost-effectiveness comparison could not be possible for the GN's program because it was on smaller scale than the program in Kenya and the GN's program changed the implementation design from community-based to school-based intervention during the program years.

My empirical study showed that Korea's ODA spending on the deworming drug distribution program was cost-effective to improve social welfare in Kome; however, there is still the need for complementary activities in water and sanitation and snail control in the lake for the sustainable development. A short-term program based intervention needs to be expanded to a long-term program in order to sustain development in recipient countries. For instance, the deworming intervention can be expanded in a form of health institutional programs, which are more costly but the effectiveness is greater in cooperation with public, private and individual partnership and with bilateral and multilateral donors' mutual efforts. Also, the intervention should be more focused on increasing recipients' awareness and participation of the activities, so recipients can have ownership. By increasing partnership between donors and recipients based on enough understanding and communication can improve the quality of aid and development with limited budget.

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

		Eligible population			Treated						
	Village	**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	

Notes: *: 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 to 2012

		2011 School Treatment			2012 School Treatment		
NO	**Primary School**	**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

<Annex 3> NTD infection and number of people treated in the world

WHO region	No. of countries reporting to WHO	No. of people treated for				No. of people reached for preventive chemotherapy for at least one disease
		Lymphatic filariasis	Soil-transmitted helminthiases	Schistosomiasis	Onchocerciasis	
Africa	34	69,131,743	103,186,098	14,735,638	65,408,388	200,788,299
Americas	17	3,364,031	39,160,613	30,418	314,444	40,934,175
Eastern Mediterranean	7	25,000	2,513,093	2,551,316	3,011,429	5,699,204
Europe	2		789,413			789,413
South-East Asia	7	395,934,743	154,139,343			428,623,308
Western Pacific	10	16,774,365	14,304,492	2,642,207		28,250,061
Global	77	485,229,882	314,093,053	19,959,579	68,734,261	705,084,460

Reference: WHO report on NTDs 2010

<Annex 4> Questionnaire for the 2013 survey

Survey Number	(for identification)
Interviewer Name	**(Position)**

Interview Date	MM-DD-YYYY	**Community name**	
School Name		**Student Name**	(Given name) ( ) * (Family name) ( )
Student gender	1 Male □ 2 Female□	**Student Age**	Age ( ) Birth Year( ) Month( )

Name of the respondent	(Given name) (Family name)		
Age of the respondent		**Gender of the respondent**	1. Male □ 2. Female □
Household Composition	Does the student live with the following member of the household ? Father ( ) Mother ( ) Grandfather ( ) Grandmother ( ) The total number of household members is ( ). Of these, the number of siblings of the child * is ( ).		

1. Deworming Treatment	
1-1. Are you aware of deworming treatment?	1. Yes 2. No
1-2. If yes, how did you come to know about deworming treatment?	1. Education by government 2. Education by NGOs at community 3. Education by NGOs at schools 4. Education at health centers 5. From neighbors, relatives, friends 6. Other ____________________
1-3. Have you taken deworming drugs?	1. Yes 2. No
1-4. If yes, how many times have you taken?	1. once 2. twice 3. three times 4. four times 5. five times 6. more than five times
1-5. When did you take drugs? (Multiple answers are allowed)	1. 2012 (the second half year) at school

	2. 2012 (the first half year) at school 3. 2011 (the second half year) at school 4. 2011 (the first half year) at school 5. 2010 (the second half year) at community 6. 2010 (the first half year) at community 7. 2009 (the second half year) at community 8. 2009 (the first half year) at community
1-6. Has the child (whose name is given as * above) taken deworming drug?	1. Yes 2. No
1-7. If yes, how many times did the child take drugs?	1. once 2. twice 3. three times 4. four times 5. five times 6. more than five times
1-8. When did the child take drugs? (Multiple answers are allowed)	1. 2012 (the second half year) at school 2. 2012 (the first half year) at school 3. 2011 (the second half year) at school 4. 2011 (the first half year) at school 5. 2010 (the second half year) at community 6. 2010 (the first half year) at community 7. 2009 (the second half year) at community 8. 2009 (the first half year) at community
2. Living Conditions	
2-1. Residence	1. Rented from Government 2. Rented from Another Private Citizen 3. Owned Privately 4.. Other (specify)____________________
2-2. The floor of house is made of cement	1.Yes 2.No
2-3. The floor of house is made of soil or mud	1.Yes 2.No
2-4. The child * wears shoes most of the time.	1.Yes 2.No

3. Education and Child Care	
3-1. If the household has any school-aged child other than (***) or children, do they all attend school?,	1. Yes 2. No
3-2. If no, what are the reasons? *(Multiple answers are allowed.)*	1. Long distance 2. Illness/disability 3. Low income 4. Early marriage 5. No interest by child 6. No interest by parents 7. Other (specify) ______________________ 8. Not applicable
3-3. How far is the primary school from your house?	1. ------------ Km 2. ------------ minutes (on foot)
3-4. Who is the main care giver for the child (*)	1. Parent(s) 2. Grandparent(s) 3. Sister / brother 4. Other relatives 5. Other (specify) _____________________
3-5. What is the education level of the main care giver?	
3-6. What level of education do you expect the child * to accomplish?	
4. Health & Sanitation	
4-1. Total number of chronically ill in this household	_______________ persons
4-2. What are the most common diseases/conditions among children? *(Multiple answers are allowed.)*	1. Malnutrition 2.Malaria 3. Diarrhea 4. Dysentery 5. Skin diseases 6. Abdominal Discomfort 7. Fever 8. Common Cold(Flu) 9. Cough 10. TB 11. Measles 12. Cholera 13. Pneumonia

	14. HIV/AIDS 15. Others (specify) ________		
4-3. What are the most common diseases among adults? *(Multiple answers are allowed.)*	1. Malnutrition 2.Malaria 3. Diarrhea 4. Dysentery 5. Skin diseases 6. Digestive disorder 7. Non malaria fever 8. Flu 9. TB 10. Measles 11. Cholera 12. Pneumonia 13. HIV/AIDS 14. Others (specify) ________		
4-4. Does the household have the following sanitary facilities?		Pit latrine	1=yes 2=no
		Rubbish pit	1=yes 2=no
		Bath shelter	1=yes 2=no
		Other (specify)	1=yes 2=no
4-5. Do you practice the following sanitation practices?		Wash hands with soap after visiting toilet(Latrine)	1=yes 2=no
		Wash hands with soap before eating food	1=yes 2=no
		Wash hands with soap before preparing food	1=yes 2=no
		Wash hands with soap after washing babies bottoms	1=yes 2=no
		Wash food stuffs before eating	1=yes 2=no
		Boil drinking water	1=yes 2=no
		Provide separate dwelling for livestock	1=yes 2=no
		Other (specify)	1=yes 2=no
4-6 What is the principal source of the water for drinking ( ), cooking ( ), and washing ( )?			

1. Traditional Well 2. Pump Well 3. Improved Well without pump 4. Rain 5. River/Stream 6. Lake (Lake Victoria)	
4-7 If you use water from a well, how far is the well from your house?	1. ________________ Km 2. ------------ minutes (on foot)
4-8 how far is schools that children are attending from your house?	1. ________________ Km 2. ------------ minutes (on foot)
5 Agricultural Production	
5-1 Major agricultural activities *(Multiple answers are allowed.)*	1. Crop farming 2. Livestock farming 3. Fish farming 4. Forestry & horticulture (including floriculture, fruit tree, mushroom, tobacco, etc.) 5. Bee keeping 6. Other (Specify) ____________________
5-2 If 1) and 4), do you practice agricultural techniques?	Irrigation: 1=yes 2=no Chemical Fertilizer: 1=yes 2=no Manure: 1=yes 2=no Improved seed: 1=yes 2=no Farming machine: 1=yes 2=no
6.Income & Expenditure	
6-1 What is the main source of income?	1. Regular employment (gov't employees, office worker, etc) 2. Non-regular employment (daily laborer, seasonal worker, etc.) 3. Self-employment (farmer, vendor etc.) 4. Aid (government, NGOs) 5. Other sources (specify)____________________
6-2 Annual income	Amount: ______________ (answered in local currency) USD ____________ (calculated by local staff)

6-3 Household Assets	Item	Yes(1)/ No(2)	Number	Monetary value

	Car			
	Boat			
	Canoe			
	Dhow			
	Motorcycle			
	Bicycle			
	Television			
	Radio			
	Foam Mattress			
	Cotton Mattress			
	Plough			
	Tractor			
	Cows			
	Sheep/Goats			
	Birds(Chicken/Ducks)			
	Nile perch Fishing Net			
	Sardines Fishing Gear			
	Coach/Sofa Set			
	Cupboard			
	Other(specify)			
	TOTAL			(Local currency)

6-4 Expenditure

1. Household Debt (total): _________ (Local currency)/________(USD)
2. Medical expenses (monthly) : _____ (Local currency) / _____(USD)
3. Main cause of medical expenses: Disability□ Chronic diseases□ Care of vulnerable group(children, the aged)□ Accidents□ Others__
4. Main food of this family: Rice□ Wheat□ Potato□ Bean□ Maize□ Others__
5. Full meals with staple food are consumed: None□ Once□ Twice□ Three times□
6. Other (Specify)_______________

BIBLIOGRAPHY

Abdul Latif Jameel Poverty Action Lab. "Education: meeting the Millennium Development goals." Fighting poverty: what works? Issue 1. available: http://www.porvertyactionlab.org/research/ education%20MDGs.pdf. Accessed 20 October 2012.

Beasley, N.M, Tomkins, A.M., Kihamia C.M., Lorri, W. Nduma, B., Issae, W., Nokes, C. and Bundy, D.A.P. (1999) "The impact of population level deworming on the haemoglobin levels of schoolchildren in Tanga, Tanzania." *Trop. Med. And Int. Health* 4(11):744-750.

Bell R., Daly J,. Kanengoni E and Jones J. (1973) "The effects of endemic Schistosomiasis and of hycanthone on the mental ability of African school children." *Tans. Roy. Soc. Trop.Med. Hyg*. 67:694-701.

Bethony, Jeffrey, Simon Brooker, Marco Albonico, Stefan M Geiger, Alex Loukas, David Diemert, Peter J Hotez (2006) " Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm" *The Lancet* 367(9521):1521-1532.

Bleakley, H. (2007) "Disease and development: evidence from hookworm eradication in the American South." *QJ Econ* 122:73-117.

Bundy, D. Kremer M. Bleakley H. Jukes M. and Miguel E. (2009) "Deworming and development: asking the right questions, asking the questions right." *PLoS Neglected Tropical Diseases* 3(1):e362.

Castle, W., De Clarke V., and Hendrikz E. (1974) " The effects of subclinical Bilharziasis on mental ability in school children." *S. Afr. Med. J.* 48:2035-2038.

Clements ACA, Lwambo NJ, Blair L, Nyandindi U, Kaatano G, Kinung'hi S, Webster JP, Fenwick A, and Brooker S (2006) "Bayesian spatial analysis and disease mapping: tools to enhance planning and implementation of a schistosomiasis control programme in Tanzania." *Trop Med Int Health* 11:490-503.

Crompton D.W. (1999) "How Much Helminthiasis Is There in the World?" *Journal of Parasitology* 85:397-403.

Danso-Appiah, A., Utzinger J, Liu J, Olliaro P. (2008) "Drugs for treating urinary schistosomiasis." *Cochrane Database Syst Rev* 16(3);CD000053.

Dickson R, Awasthi S, Williamson P, Demellweek C, and Garner P. (2003) "Effects of treatment for intestinal helminth infection on growth and cognitive performance in children: systematic review of randomized trials." *BMJ* 320:1697-701.

Fenwick, A., Molyneux, D., and Nantulya, V. (2005) "Achieving the millennium development goals." *Lancet* 365:1029-1030.

Gryseels, Bruno, Katja Polman, Jan Clerinx, and Luc Kestens (2006) "Human schistosomiasis" *The Lancet* 368(9541):1106-1118.

Hotez, Peter J., Donald A.P. Bundy, Kathleen Beegle, Simon Brooker, Lesley Drake, Nilanthi de Silva, Antonio Montresor, Dirk Engels, Mathew Jukes, Lester Chitsulo, Jeffery Chow, Ramanan Laxminarayan, Catherine Michaud, Jeff Bethony, Rodrigo Correa-Oliveira, Xiao Shuhua, Alan Fenwick, and Lorenzo Savioli (2006) "Helminth infections: soil-transmitted helminths infections and schistosomiasis." *Disease control priorities in developing countries. 2nd edition,* World Bank, Washington DC.

Jordan, P. and Randall K. (1962) "Bilharziasis in Tanganyika: observation on its effects and the effects of treatment in school children." *J. Trop. Med. Hyg.* 65:1-6.

Krande, Sunil and Madhuri Kulkani (2005) “Poor school performance.” *Indian Journal of Pediatrics*, 72(11):961-967.

Kimura, E., Moji K., Uga S., Migwi DK, Mutua WR, Muhoho ND and Aoki Y. (1992) “Effects of Schistosoma haematobium infection on mental test scores of Kenyan school children.” *Tropical Medicine and Parasotology* 43(3):155-158.

Kremer, Michael. (2003) “Randomized evaluations of educational programs in developing countries: some lessons.” *The American Economic Review*, 93(2): 102-106.

Kvalsvig, JD, Coopan RM, and Connolly KJ (1991) “The effects of parasitic infection on cognitive processes in children.” *Ann Trop. Med. Parasitol* 85:551-568.

Lozoff, B. (1990) “Has iron deficiency been shown to cause altered behavior in infants?” Dobbing J. ed. “Brain, Behavior and Iron in the infant” London: Springer-Verlag, 107-131.

McGarvey, ST., Wu G, Zhang S, Wang Y, Peters P, Olds GR and Weist PM (1993) “Child growth, nutritional status, and Schistosomiasis japonica in Jiangxi, People’s Republic of China.” *Am J Trop Med Hyg* 48:547-553.

Miguel, E. and Kremer M. (2004) “Worms: identifying impacts on education and health in the presence of treatment externalities.” *Econometrica* 72(1):159-217.

Molyneux, D., Hotex P. and Fenwick A. (2005) ““Rapid-impact interventions”: How a policy of integrated control for Africa’s neglected tropical diseases could benefit the poor.” *PLoS Medicine* 2(11):e366.

Montresor, A., D.W.T. Crompton, T.W. Gyorkos, and L. Savioli (2002) *Helminth Control in School-Age Children: A Guide for Managers of Control Programmes.* World Heath Organization, Geneva.

Nokes, C., McGarvey S., Shiue L., Wu G., Wu H., Bundy D.A.P. and Olds G. (1999) “Evidence for an improvement in cognitive function following treatment of *schistosoma japonicum* infection in Chinese primary schoolchildren.” *Am. J. Trop. Hyg.* 60(4):556-565.

Nokes, C., Grantham-McGregor SM., Sawyer AW., Cooper ES., Robinson BA. and Bundy D.A.P. (1992) “Parasitic helminth infection and cognitive function in school children.” *Proc. R. Soc. Lond*. 247:77-81.

Pollittt, E. (1990) “Malnutrition and infection in the classroom.” Paris: UNESCO.

Raj, S.M., Sein K.T., Anuar K. and Mustaffa B.E. (1997) “Effects of intestinal helminthiasis on school attendance by early primary schoolchildren.” *Trans R Soc Trop Med Hyg* 91:131-132.

Sakti, H., Nokes C., Hertanto WS, Hendratno S., Hall A., Bundy DA, and Satoto (1999) “Evidence for an association between hookworm infection and cognitive function in Indonesian school children.” *Trop. Med. Int. Health* 4(5):322-334.

Simeon, DT, Grantham-McGregor, SM., Callender, JE., and Wong, MS. (1995) “Treatment of trichuris trichiura infections improves growth, spelling scores and school attendance in some children.” *J Nutr* 125:1875-83.

Sternberg, RJ, Powell, C., McGrane, P. and Granham-McGregor, SM. (1997) “Effects of a parasitic infection on cognitive functioning,” *J Exper Psychol Appl* 3: 67-76.

Taylor-Robinson, D., Jones A, and Garner P. (2003) “Does deworming improve growth and school performance in children?” *PLoS Neglected Tropical Disease* 3(1):e358.

The Lancet (2004) “Thinking beyond deworming.” *The Lancet* 364(9450):1993-1994.

Van der Werf MF, de Vlas SJ, Brooker S, Looman CW, Nagelkerke NJ et al. (2003)

“Quantification of clinical morbidity associated with schistosome infection in suv-Saharan Africa.” *Acta Trop* 86;125-139.

Watkins, WE., Cruz, JR., Pollitt, E. (1996) “The effects of deworming on indicators of school performance in Guatemala.” *Trans R Soc Trop Med Hyg* 90: 156-161.

World Bank (1993) “Investing in health.” World Bank development report, Washington DC: the World Bank.