# Impact of a Local Government Unit Supported School-based Initiative for Control of Intestinal Helminth Infections

Vicente Y. Belizario, Jr.,[1,2] Andrew O. Plan,[1] Winifreda U. de Leon,[1]
Francis Isidore G. Totañes[1] and Raezelle Nadine T. Ciro[1]

[1]*National Institutes of Health, University of the Philippines Manila*
[2]*Department of Parasitology, College of Public Health, University of the Philippines Manila*

**ABSTRACT**

Objectives. This study aimed to describe baseline and follow-up prevalence and intensity of soil-transmitted helminth (STH) infections, nutritional status and school performance of school-age children in Cebu City. By measuring these parameters, it also aimed to monitor the progress of a local government unit-led, school-based, schoolteacher-assisted deworming initiative.

Methods. Grade three and grade four pupils from two selected school districts in Cebu City were chosen as participants. Kato-Katz technique was used to assess helminth infections. All positive slides and 10% of all negative slides were re-examined blindly by a reference microscopist for quality control. Secondary anthropometric and school performance data were also obtained from the Department of Education.

Results. Baseline results showed cumulative prevalence and prevalence of heavy intensity infection of 73.1% and 44.3%, respectively, which were significantly lower during follow-up at 56.5% ($p < 0.0001$) and 26.5% ($p < 0.0001$), respectively. School performance improved in District B, with an 8.8% increase in mean percentage score from baseline to follow-up. There was no marked difference between baseline and follow-up proportions of pupils with below normal weight-for-age and height-for-age.

Conclusions. The positive results merit continuation of the school-based STH control initiative in Cebu City. Improvements in water supply and sanitation, promotion of good hygiene and health education are important in minimizing risks of infection and re-infection.

*Key Words: neglected tropical diseases (NTDs), soil-transmitted helminths (STH), mass drug administration (MDA)*

Corresponding author: Francis Isidore G. Totanes, MD, MA
National Institutes of Health
University of the Philippines Manila
623 Pedro Gil St., Ermita, Manila 1000 Philippines
Telephone: +632 5264266
Email: doydoytotanes@yahoo.com

## Introduction

Soil-transmitted helminth (STH) infections are among the most prevalent afflictions of humans who live in areas of poverty in the developing world.[1] Recent data showed that ascariasis, trichuriasis, and hookworm infections ranked as the three most prevalent neglected tropical diseases (NTD) in the world.[2] Studies have shown that the prevalence and intensity of STH infections caused by *Ascaris* and *Trichuris* are highest among children 5-14 years old, implying that this age group is at greatest risk for infection.[3] STH infections in children may result in reduced cognitive development, hampered concentration and increased school absenteeism.[4]

Previous parasitological surveys of communities in Cebu City have shown moderate to high prevalence of STH infections. Biomedical surveys done by the U.S. Naval Medical Research Unit No. 2 in Cebu City in 1984 showed prevalence rates of 50.0%, 53.0% and 22.0% for *Ascaris*, *Trichuris*, and hookworms, respectively.[5] In a study done in 2002, 75.3% of the pupils examined in Cebu City were infected with STH and 10.0% had heavy infection. Individual prevalence rates for *A. lumbricoides, T. trichiura,* and hookworms were 56.6%, 56.0%, and 8.7%, respectively.[6] The relatively high prevalence rates in Cebu City despite the 18 years separating the two surveys imply that STH infections will remain a public health concern in the area in the absence of a more directed approach to disease control and prevention.

The World Health Organization (WHO) recommends preventive chemotherapy as a means to control STH infections and its subsequent morbidities. This strategy is done through periodic mass drug administration (MDA) in endemic communities given at least two times a year.[7] Although interventions through national helminth control program are being implemented, poor treatment coverage, limited sanitation facilities and lack of health education strategies may be major challenges in program implementation as evidenced by the continuing high prevalence of STH infections in many areas reported by a nationwide survey conducted in 2004.[8] In 2006, the local government of Cebu City addressed the issue of treatment coverage by embarking on a school-based division-wide helminth control initiative.

This study monitored the baseline and follow-up parasitologic, nutritional status and school performance parameters of elementary students in order to describe the impact of the local government-initiated school-based helminth control initiative in Cebu City.

## Methods

### Study Site and Population

Cebu City is the capital city of the province of Cebu and is located on the eastern shore of the province. The school division is composed of 10 school districts.[9] Two school districts of Cebu City, denoted in this study as Districts A and B, were selected as the sentinel or study sites. Approximately 250 grades three and four elementary school pupils were targeted from each of the selected sentinel school districts based on the recommended WHO guidelines.[7] There were 50 students targeted for each of the five elementary schools from each district for the baseline and follow-up assessments.

### Parasitologic Assessment

Stool cups were given to pupils who were oriented with appropriate collection instructions. Stool samples were sent to the field laboratory (set up in the City Health Office) for processing and examination using the Kato-Katz method as described in the WHO Bench Aids for the Diagnosis of Intestinal Parasites.[10] The accuracy and reliability of the parasitologic assessment were maintained through quality assurance measures. Slides positive for STH were referred to an expert microscopist for cross-checking and validation. Ten percent of all negative slides were re-examined blindly by a reference microscopist to ensure accuracy of microscopic readings.

Data gathered were used to derive the cumulative and individual prevalence and intensities of STH infections. Intensities of infection were reported using the calculated geometric mean egg count (GMEC) in eggs per gram (epg) and were classified as light, moderate or heavy according to the WHO classification.[11] For the purposes of this study, moderate to heavy intensities of infections were considered heavy for the calculation of the prevalence of heavy intensity infections.

Parasitologic assessments were performed at baseline (July 2006) and follow-up (March 2007), each before a round of MDA. All data were double-encoded, collated and analyzed using EpiInfo (version 6) software. Chi-square test ($\chi^2$) was used to identify significant differences between values obtained for each survey period. The level of significance was set at 5%.

### Nutritional Status Assessment

In this study, secondary district-wide anthropometric data, taken and collated by Department of Education (DepEd) school nurses during the beginning of the academic year (School Years 2005-2006 and 2006-2007), were requested from the DepEd Division Office of Cebu City.[12,13] Nutritional status indicators such as weight-for-age and height-for-age are classified by the DepEd using the International Reference Standards (IRS).

### School Performance Assessment

The National Achievement Test (NAT) results of the selected schools were requested and obtained from the DepEd Division Office to measure the learning outcomes of students in the elementary level as recommended by the Congressional Commission on Education. The mean percentage score (MPS) is the percentage of all correctly answered items in the NAT and is computed as the ratio between the numbers of correctly answered items and the total number of test questions. The competence level is set at a MPS of 75%.[14]

### Mass Drug Administration

MDA involved the administration of chewable albendazole (Benzol) 400 mg tablets, given single dose to all elementary school children in Cebu City in September 2006. The tablets used for the mass treatment were purchased by the local government unit (LGU) of Cebu City. Tablets were administered by school teachers under the supervision of school nurses trained by the project team. MDA coverage rates were reported according to grade level, school, and district.

### Ethical considerations

During the development of the protocol for this study in early 2006, national guidelines on the ethical review of studies involving human subjects were still being finalized. However, this study conformed to important ethical guidelines for the protection of human subjects. The interventions for the control of STH infections are in line with the Integrated Helminth Control Program (IHCP) of the DOH. These minimal risk interventions include the provision of standard monitoring (stool examination) and treatment recommended by the national program guidelines. Confidentiality was maintained through replacement of study participant identifiers with codes. Only authorized personnel from the research team were allowed to access the results. With regard to treatment of identified cases, all school children with parental consent received albendazole during the regular MDA.

Study results together with the appropriate recommendations were conveyed to the DOH–National Center for Disease Prevention and Control (NCDPC), DepEd - School Health and Nutrition Center and to the Cebu City local government unit (LGU).

## Results

### Parasitologic Assessment

At baseline, 403 out of 551 pupils were found to be infected with at least one STH, giving an overall cumulative prevalence of 73.1%. The overall prevalence of heavy intensity infections was 44.3%. During follow-up, a total of 536 pupils submitted samples for assessment. Cumulative STH prevalence during this period was 56.5%, a reduction of 22.7%, while prevalence of heavy intensity infections was 26.5%, a reduction of 40.2%. Both parameters were found to be significantly lower than the baseline findings ($p < 0.0001$). District A consistently had higher STH prevalence during the two survey periods.

Ascariasis was the most common STH infection observed in both survey periods. During baseline, *Ascaris* infections were seen in 58.3% of the pupils examined. Most of the pupils with *Ascaris* (69.8%) had heavy intensity infection. The overall GMEC for *Ascaris* was 226.6 epg at baseline. The follow-up assessment showed that 44.0% of the pupils examined were infected with *Ascaris*, 56.4% of which had heavy intensity infection. Reduction rates for *Ascaris* prevalence and proportion of heavy intensity infection were 24.5% and 19.2%, respectively. Both the *Ascaris* prevalence and proportion of heavy intensity infections during follow-up were significantly lower than baseline ($p < 0.0001$). The overall GMEC for *Ascaris* was 39.9 epg at follow-up, a reduction of 82.4%.

The baseline assessment showed a 54.8% prevalence of *Trichuris* infections. Heavy intensity infection was observed in 35.8% of the pupils infected. The overall GMEC for *Trichuris* was 30.8 epg at baseline. During follow-up, *Trichuris* infections were seen in 38.2% of the pupils examined, showing a 30.3% reduction. Of those with trichuriasis, 38.5% had heavy intensity infection, a 7.0% reduction from baseline. Both *Trichuris* prevalence and proportion of heavy intensity infections were found to be significantly lower than baseline ($p < 0.0001$). The overall GMEC for *Trichuris* was 6.9 epg at follow-up, a reduction of 77.6%. Cumulative prevalence of STH infections and prevalence of *Ascaris* and *Trichuris* infections are summarized in Table 1.

Only a single case of light intensity hookworm infection was seen in District A during baseline. Overall GMEC for hookworm was 0.01 epg.

**Table 1.** Prevalence of Soil-Transmitted Helminth Infections and Heavy Intensity Infections in School-Age Children in Districts A and B, Cebu City from Baseline (July 2006) to Follow-Up (March 2007)

| | Overall | | | District A | | | District B | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline No. (%) | Follow-up No. (%) | Reduction rate % | Baseline No. (%) | Follow-up No. (%) | Reduction rate % | Baseline No. (%) | Follow-up No. (%) | Reduction rate % |
| Number of pupils examined | 551 | 536 | n/a | 273 | 285 | n/a | 278 | 251 | n/a |
| Prevalence of STH infection | 403 (73.1) | 303 (56.5)* | 22.7 | 202 (74.0) | 186 (65.3)* | 11.8 | 201 (72.3) | 117 (46.6)* | 35.5 |
| Prevalence of heavy intensity STH infections | 244 (44.3) | 142 (26.5)* | 40.2 | 117 (42.9) | 93 (32.6)* | 24.0 | 127 (45.7) | 49 (19.5)* | 57.3 |
| Prevalence of *Ascaris* infection | 321 (58.3) | 236 (44.0)* | 24.5 | 160 (58.6) | 152 (53.3) | 9.0 | 161 (57.9) | 84 (33.5)* | 42.1 |
| *Ascaris* GMEC (epg) | 226.6 | 39.9 | 82.4 | 210.9 | 92.5 | 56.1 | 243.1 | 15 | 93.8 |
| Proportion of heavy intensity *Ascaris* infection | 224 (69.8) | 133 (56.4)* | 19.2 | 103 (64.4) | 87 (57.2) | 11.2 | 121 (75.2) | 46 (54.8)* | 27.1 |
| Prevalence of *Trichuris* infection | 302 (54.8) | 205 (38.2)* | 30.3 | 164 (60.1) | 129 (45.3)* | 9.0 | 138 (49.6) | 76 (30.3)* | 42.1 |
| *Trichuris* GMEC (epg) | 30.8 | 6.9 | 77.6 | 46.1 | 11.2 | 75.7 | 20.6 | 3.9 | 81.1 |
| Proportion of heavy intensity *Trichuris* infection | 108 (35.8) | 24 (11.7)* | 67.3 | 65 (39.6) | 19 (14.7)* | 62.9 | 43 (31.2) | 5 (6.6)* | 78.9 |

** Significantly lower than baseline ($p < 0.05$)*

**Table 2.** Below Normal Weight-for-Age and Height-for-Age School-Age Children in Districts A and B, Cebu City at Baseline (Sy 2005-2006) and Follow-Up (Sy 2006-2007)[12,13]

| | Overall | | | District A | | | District B | | |
|---|---|---|---|---|---|---|---|---|---|
| | Baseline No. (%) | Follow-up No. (%) | Reduction rate* % | Baseline No. (%) | Follow-up No. (%) | Reduction rate % | Baseline No. (%) | Follow-up No. (%) | Reduction rate* % |
| Number of pupils weighed | 18,620 | 18,247 | n/a | 8,966 | 9,204 | n/a | 9,654 | 9,043 | n/a |
| Proportion of below normal weight-for-age | 3,210 (17.2) | 3,225 (17.7) | -2.9 | 1,602 (17.9) | 1,597 (17.4) | 2.8 | 1,608 (16.7) | 1,628 (18.0)** | -7.8 |
| Number of pupils whose heights were taken | 11,818 | 10,619 | n/a | 5,588 | 5,274 | n/a | 6,230 | 5,345 | n/a |
| Proportion of below normal height-for-age | 2,215 (18.7) | 1,925 (18.1) | 3.2 | 1,163 (20.8) | 1,007 (19.1)** | 8.2 | 1,052 (16.9) | 918 (17.2) | -1.8 |

** Reduction rates with a negative sign actually mean rates of increase*

*** Significantly different from baseline ($p < 0.05$)*

**Nutritional Status and School Performance Assessment**

During the baseline period, 17.2% and 18.7% of the pupils had below normal weight-for-age and height-for-age, respectively.[12] During the follow-up period, 17.7% of the pupils were found to be underweight while 18.1% were found to be stunted (Table 2).[13]

All the elementary schools included in the study had overall MPS below the competence level of 75% during both survey periods (Table 3).[15,16] The MPS in District B had improved by 8.8%, while District A had a lower MPS during follow-up compared to baseline.

**Mass Drug Administration Coverage**

Among 19,010 pupils enrolled, 90.4% had parental consent for treatment, 99.0% of whom were treated during the mass treatment. This translated to an overall MDA coverage rate of 89.5% for the two school districts. District B had a higher coverage rate of treatment at 92.8% compared with the District A at 86.2% (Table 4).[17]

**Table 3.** National Achievement Test Results in Districts A and B, Cebu City at Baseline (Sy 2005-2006) and Follow-Up (Sy 2006-2007)[15,16]

| School districts | Baseline % | Follow-up % |
|---|---|---|
| District A | 61.64 | 50.64 |
| District B | 45.21 | 49.20 |
| **OVERALL** | **53.42** | **49.92** |

**Table 4.** Department of Education School-Based Mass Drug Administration Coverage Rates in Districts A and B, Cebu City, September 2006[17]

| School district | Enrolees No. | Pupils with consent No. (%) | Pupils treated No. (%) | Mass treatment coverage % |
|---|---|---|---|---|
| District A | 9,574 | 8,388 (87.6) | 8,255 (98.4) | 86.2 |
| District B | 9,436 | 8,798 (93.2) | 8,763 (99.6) | 92.9 |
| **OVERALL** | **19,010** | **17,186 (90.4)** | **17,018 (99.0)** | **89.5** |

## Discussion

This study consisted of baseline and follow-up parasitologic surveys which were conducted to describe the prevalence, intensity and reduction rate of STH infections among public elementary school children in two school districts in Cebu City after a round of a local government unit-led, school-based, schoolteacher-assisted MDA initiative. This study also reviewed data on nutritional status and school performance of school children in the selected study sites.

Results of this study showed a 22.7% reduction in the overall cumulative STH prevalence and 40.2% reduction in the prevalence of heavy intensity infections following a round of MDA. District B had greater reductions in overall cumulative prevalence (35.5%) and prevalence of heavy intensity (57.3%) compared with District A (11.8% reduction in cumulative prevalence and a 24.0% reduction in the prevalence of heavy intensity infections). These results may be related to the generally high coverage of MDA in the two school districts.

Treatment coverage is an important factor to be considered during MDA. Although a coverage rate of 75% of all school-age children at risk was recommended during the 54th World Health Assembly and a coverage rate of 85% of children 1-12 years of age was set as the target of the Integrated Helminth Control Program of the DOH, a higher coverage rate may translate to higher reduction in worm burden and thereby resulting in a higher reduction in morbidity.[18]

Another important factor to consider is the frequency of MDA. In areas with high intensities of infections, it is recommended to conduct mass treatment two to three times a year.[19] A study done in Kenya suggested that high coverage deworming programs may also have a positive spillover effect to the community, resulting in positive health benefits even among students that did not receive treatment.[20] MDA decreases the number of children with STH infections, thereby decreasing chances of environmental contamination with helminth ova, which leads to reduced STH transmission as well as reduced risks for infection and re-infection.

Reductions in *Ascaris* and *Trichuris* prevalence and proportions of heavy intensity infections were observed in this study. These reductions may partly be attributed to the effect of MDA carried out in the city. No hookworm infection was observed in the follow-up study. The low hookworm infection rate in most of the provinces may indicate that urbanization and health education, focusing on the use of footwear, may have made an impact.[21] The observed low infection rate, however, could also be attributed to the limitations of the Kato-Katz method used in the study. Kato-Katz smears may rapidly deteriorate in dry climates, affecting slide quality and reading when re-examined after prolonged storage.[22] Hookworm eggs also tend to clear up within hours after the preparation of the slide smears.[23]

Studies from different countries showed that malnutrition occurs in areas where there are STH infections. Poor nutritional status may lead to impaired cognitive function, absenteeism and increased school drop-out.[24,25,26] The effects of undernutrition on the school performance of children, among other factors, may have contributed to the low NAT scores of the 10 selected public elementary schools.

The percentage of underweight and/or stunted children from the ten selected sentinel public elementary schools during both survey periods were found to be lower than the national figures reported in the 2005 update of the National Nutrition Survey conducted by the Food and Nutrition Research Institute (FNRI), which were 22.8% and 32.0%,

respectively.[27] Compared with baseline figures, improvements in the weight- and height-for-age were noted in children from District A, while the proportion of school-age children with below normal weight- and height-for-age increased in District B during follow-up. Various factors may account for the undernutrition observed in school-age children; STH infections especially have been shown to contribute considerably to malnutrition.[28,29] It is important to note that secondary data on the nutritional status of school children used in this study may be subject to inter-observer and instrument-to-instrument variability since collection of primary data, i.e. weight and height measurements, was done by several school nurses in various areas.

Based on the results of this study, school-based helminth control strategies which have high MDA coverage rates should be sustained in Cebu City to address the continuing burden of STH infections. The LGU of Cebu City with the cooperation of the community may consider efforts to improve environmental sanitation conditions, while the DepEd may spearhead efforts to improve delivery of MDA to students as well as incorporate health education in the school curriculum. The complementary roles played by the LGU of Cebu City, the DepEd and the community will be crucial in the successful implementation of the school-based helminth control program.

School-based helminth control programs in Cebu City may focus on intensifying health education and promotion, and emphasizing submission to mass treatment even without the benefit of stool examination. Health education accompanying deworming can create positive changes in the knowledge and behavior of school-age children regarding hygienic practices effective for STH control, such as proper hand-washing and use of sanitary toilets. Cost-effectiveness and sustainability of program strategies should also be considered. In recent years, various disease control programs in Japan and Kenya have addressed these issues by putting the development and implementation of health education into the hands of school teachers and their students.[30]

The DepEd may need to consider developing a supplementary program to train school teachers on how to develop their own health education curriculum and teaching aids, using materials they already have. Such a program would allow for the minimization of the costs associated with health education and allow schools to customize the education to the unique profile of their students. Involving students in the implementation of health education may also be an effective method of reaching out to non-enrolled school children, as enrolled school age children can encourage their peers to come to school during deworming days.[31] Health education along with efforts towards improvement in water, sanitation and regular deworming comprise the WASHED (Water, Sanitation, Hygiene Education and Deworming) Framework for the control of STH. These strategies are important in achieving sustained reductions in helminth infection in the community.[32]

It is also important to consider the inclusion of preschool-age children in the division-wide helminth control project of the local government of Cebu City. Compared with any other age group, school-age and preschool-age children tend to harbor the greatest numbers of intestinal worms.[33] Periodic anthelminthic treatment has been found to have a positive effect on preschool-age children's motor and language development,[34] and growth deficits may be reversible following proper treatment,[35] making them vital targets in sustained worm control programs. Facility-based MDA through day care centers and pre-elementary schools, which can be performed by day care workers and teachers, may be considered as the strategy to treat preschool-age children. Other high risk groups, including out-of-school youths, adolescent females and pregnant women may also be considered for MDA.

High cumulative prevalence of STH infections as well as prevalence of heavy intensity infections reported in the baseline study established the need for regular treatment of STH infections in school-age children in Cebu City. The results of the follow-up study confirmed the effectiveness of the Cebu City STH control program in reducing both prevalence and intensity of infection of *Ascaris* and *Trichuris* in school-age children. These reductions lead to the control of morbidities associated with helminth infection. Measures for monitoring nutritional status and cognitive performance should be refined in future studies to establish more definitive links between treatment and these outcomes.

The positive results merit the need to sustain school-based STH control programs in Cebu City as a morbidity control strategy. Potential expansion of these strategies to other communities with high prevalence of infection should be considered by the DepEd and the respective LGUs of the communities. Further baseline studies should also be carried out to assess the potential benefit of including other groups at risk for STH infection in helminth control strategies, including high school students, pregnant women and women of childbearing age.[36]

**Acknowledgments**

This project would not have been successful without the invaluable support and assistance of the officials and staff of the Cebu City Local Government, the City Planning and Development Office, the City Health Office and the DepEd for Region VII-Central Visayas. The research team would also like to acknowledge the efforts of the principals/school heads, school nurses and school teachers of the participating schools in Cebu City to facilitate the conduct of the field work. The authors also wish to express their appreciation for the assistance of Dr. John Manuel Flores, Ms. Cyndi Mae Tai and Mr. Terence Eday in the data collection and processing for this study.

**References**


1. Hotez PJ, Bundy DAP, Beegle K, et al. Helminth infections: soil-transmitted helminth infection and schistosomiasis. In: Jamison DT, Breman JG, Measham AR, et al, eds. Disease Control Priorities in Developing Countries, 2nd ed. Washington: World Bank; 2006. pp. 467-78.
2. U.S. Global Health Policy. Neglected tropical diseases: Fact Sheet. 2009; Publication # 7938.
3. Xu LQ, Yu SH, Jiang ZX, et al. Soil-transmitted helminthiasis: nationwide survey in China. Bull World Health Organ. 1995; 73(4):507-13.
4. World Health Organization (WHO). Guidelines for the Evaluation of Soil-transmitted Helminthiasis and Schistosomiasis at Community Level. Geneva. 1998.
5. Cross JH, Basaca-Sevilla V. Biomedical Surveys in the Philippines. Manila, Philippines: U. S. Naval Medical Research Unit No. 2. 1984.
6. Belizario VY, *et al*. Baseline assessment for school-based control of common intestinal helminthiasis in public elementary school children in Cebu City. National Institutes of Health – Philippines. 2006
7. World Health Organization. Preventive Chemotherapy in Human Helminthiasis. Geneva, Switzerland: World Health Organization press. 2006.
8. de Leon W, Lumampao Y. Nationwide Survey of Intestinal Parasitosis in Pre-School Children. Final report submitted to UNICEF. 2005.
9. Department of Education. Basic Education Information System. Masterlist of government elementary schools SY 2007-2008, Region VII – Central Visayas [Online]. 2008 [cited 2010 April]. Available from http://deped.gov.ph/pubic/public.excel.asp.
10. World Health Organization (WHO). Bench Aids for the diagnosis of intestinal parasites. 1994.
11. World Health Organization (WHO). Helminth control in school-age children. Geneva. 2002.
12. Department of Education. Division Office of Cebu City. Nutritional Status of Public Elementary School Children in Cebu City (SY 2005-2006). 2006.
13. Department of Education. Division Office of Cebu City. Nutritional Status of Public Elementary School Children in Cebu City (SY 2006-2007). 2007.
14. National Educational Testing and Research Center. National Achievement Test. [Online]. 2008 [cited 2009 December]. Available from http://netrc.sysportal.net/homepage.aspx.
15. National Educational Testing and Research Center. National Achievement Test – Grade VI (SY 2005-2006), Central Visayas Region. 2006.
16. National Educational Testing and Research Center. National Achievement Test – Grade VI (SY 2006-2007), Central Visayas Region. 2007.
17. Department of Education. Division Office of Cebu City. Deworming Accomplishment. 2006.
18. World Health Organization (WHO). Helminth control in school-age children. Geneva, Switzerland. 2002.
19. World Health Organization (WHO). WHO Tech Rep Ser No 912. Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis: Report of a WHO Expert Committee. 2002
20. Kremer M, Miguel E. Worms: Identifying impacts on education and health in the presence of treatment externalities. Econometrica. 2004; 72(1): 159–217.
21. World Health Organization (WHO). Report of the WHO Informal Consulation on the Use of Chemotherapy for the Control of Morbidity Due to Soil-Transmitted Nematodes in Humans. WHO/CTD/SIP/96.2. Geneva, Switzerland. 1996.
22. Cline BL, Habib M, Gamil F, Abdel-Aziz F, Little MD. Quality control for parasitologic data. Am J Trop Med Hyg. 2000; 62(2):14-6.
23. Raso G, Luginbühl A, Adjoua CA, et al. Multiple parasite infections and their relationship to self-reported morbidity in a community of rural Côte d'Ivoire. Int J Epidemiol. 2004; 33(5):1092-102.
24. Stephenson LS, Latham MC, Adams EJ, Kinoti SN, Pertet A. Weight gain of Kenyan school children infected with hookworm, *Trichuris trichiura* and *Ascaris lumbricoides* is improved following once- or twice-yearly treatment with Albendazole. J Nutr. 1993; 123(4): 656-65.
25. Nokes C, Grantham-McGregor SM, Sawyer AW, Cooper ES, Bundy DA. Parasitic helminth infection and cognitive function in school children. Proc Biol Sci. 1992; 247(1319):77–81.
26. Ezeamama AE, Friedman JF, Acosta LP, et al. Helminth infection and cognitive impairment among Filipino children. Am J Trop Med Hyg. 2005; 72(5): 540–8.
27. Food and Nutrition Research Institute. Department of Science and Technology. Update on the 6th National Nutrition Survey Report. 2005.
28. Pullan R, Brooker S. The health impact of polyparasitism in humans: are we underestimating the burden of parasitic diseases? Parasitology. 2008; 135(7):783-94.
29. Zulkifli A, Khairul Anuar A, Atiya AS, Yano A. Malnutrition and helminth infections among pre-school children in Orang Asli resettlement villages in Kelantan. JUMMEC. 1999; 2:99-103.
30. Montresor A, Ramsan M, Chwaya HM, et al. Extending anthelminthic coverage to non-enrolled school-age children using a simple and low-cost method. Trop Med Int Health. 2001; 6(7):535-7.
31. Kirwan P, Asaolu SO, Molloy SF, Abiona TC, Jackson AL, Holland CV. Patterns of soil-transmitted helminth infection and impact of four-monthly albendazole treatments in preschool children from semi-urban communities in Nigeria: a double-blind placebo-controlled randomised trial. BMC Infect Dis. 2009; 9:20.
32. Children Without Worms (CWW). A Comprehensive Strategy for STH Control [Online]. 2010 [cited 2010 August]. Available from www.childrenwithoutworms.org.
33. Crompton DW, Nesheim MC. Nutritional impact of intestinal helminthiasis during the human life cycle. Annu Rev Nutr. 2002; 22:35–59.
34. World Health Organization (WHO). Deworming for Health and Development. Geneva, Switzerland. 2005.
35. Stephenson LS, Latham MC, Ottesen EA. Malnutrition and parasitic helminth infections. Parasitology. 2000; 121:S23–38.
36. World Health Organization. Report of the WHO Informal Consultation on Hookworm Infection and Anaemia in Girls and Women. WHO/CTD/SIP/96.1. Geneva, Switzerland. 1994.