Abstract:

A third of the world's population most commonly in developing countries like Ethiopia, are infected with intestinal parasites. School age children are the most affected segment of the population. WHO recommends periodic "deworming" to all at-risk people living in endemic areas.

In 2009, the Ben Gurion University associated NALA foundation in collaboration with an Ethiopian NGO (OSSA) and the Tigray Regional Health Bureau (TRHB) launched a deworming project for school children in Mekele city, Ethiopia. During the four years of its implementation (2009-2012), the efficacy of this intervention in controlling helminthic infection in the participating schools, were evaluated. The program consisted of intensive health education combined with mass drug administration (MDA) with pre and post intervention stool surveys, during each year of the intervention,

The results of the sequential stool surveys demonstrated a significant and consistent decrease in the prevalence of both Schistosomiasis and STH infection in all the school children that participated in the project, and was sustained throughout the intervention period, decreasing from 54.6% at the beginning to 6.4% at the end.

These results suggest that a comprehensive program, which combines MDA with health education can lead to sustained control of helminthic infections in school children living in highly endemic areas for these infections. Though continued evaluation of this program is warranted in order to determine how long and permanent can such a control last, it is highly likely that such programs of deworming can be
applied widely in Ethiopia and in other developing countries where these infections are so common and where their long lasting control is so much needed.

**Suggested Reviewers:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Email</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael French</td>
<td>Imperial College London School of Public Health</td>
<td><a href="mailto:michael.french05@imperial.ac.uk">michael.french05@imperial.ac.uk</a></td>
</tr>
<tr>
<td>Sten Vermund</td>
<td>Vanderbilt University School of Medicine</td>
<td><a href="mailto:sten.vermund@vanderbilt.edu">sten.vermund@vanderbilt.edu</a></td>
</tr>
<tr>
<td>Thomas Nutman</td>
<td>National Institute of Allergy and Infectious Diseases</td>
<td><a href="mailto:tnutman@mail.nih.gov">tnutman@mail.nih.gov</a></td>
</tr>
<tr>
<td>David Taylor-Robinson</td>
<td>University of Liverpool</td>
<td><a href="mailto:David.Taylor-Robinson@liverpool.ac.uk">David.Taylor-Robinson@liverpool.ac.uk</a></td>
</tr>
</tbody>
</table>

**Opposed Reviewers:**

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alison Elliott</td>
<td>MRC/UVRI Uganda Research Unit On Aids</td>
</tr>
</tbody>
</table>

**Additional Information:**

**Question**

Do the authors confirm that all data underlying the findings described in their manuscript are fully available without restriction?

**Response**

Yes - all data are fully available without restriction

Your answers to the following constitute your statement about data availability and will be included with the article in the event of publication. **Please note that simply stating ‘data available on request from the author’ is not acceptable. If, however, your data are only available upon request from the author(s), you must answer "No" to the first question below, and explain your exceptional situation in the text box provided.**

Do the authors confirm that all data underlying the findings described in their manuscript are fully available without restriction?

Please describe where your data may be found, writing in full sentences. **Your answers should be entered into the box below and will be published in the form you provide them, if your manuscript is accepted.** If you are copying our sample text below, please ensure you replace any instances of **XXX** with the appropriate details.

All data are included in the submitted article.
If your data are all contained within the paper and/or Supporting Information files, please state this in your answer below. For example, “All relevant data are within the paper and its Supporting Information files.”

If your data are held or will be held in a public repository, include URLs, accession numbers or DOIs. For example, “All XXX files are available from the XXX database (accession number(s) XXX, XXX).” If this information will only be available after acceptance, please indicate this by ticking the box below. If neither of these applies but you are able to provide details of access elsewhere, with or without limitations, please do so in the box below. For example:

“Data are available from the XXX Institutional Data Access / Ethics Committee for researchers who meet the criteria for access to confidential data.”

“Data are from the XXX study whose authors may be contacted at XXX.”

<table>
<thead>
<tr>
<th>Additional data availability information:</th>
<th>Tick here if your circumstances are not covered by the questions above and you need the journal's help to make your data available.</th>
</tr>
</thead>
</table>
Dr Peter Hotez,
Editor in Chief
PLoS NTD

Dear Dr Hotez,

Re: Deworming school children in Ethiopia: The importance of Health Education

Attached please find our article for your consideration for publication in the Journal. This study describes a collaborative deworming intervention program developed by the Ben-Gurion University's Center for Emerging Tropical Diseases and AIDS (CEMTA) and NALA Foundation, from Israel, and implemented in Ethiopia together with the local health bureaus and local NGOs in Tigray regional state of Ethiopia.

The main objective of the study was to assess the efficacy of a comprehensive multi-stage deworming intervention based on the combination of mass drug administration together with intensive health education, on the control of Schistosomiasis and soil-transmitted helminth (STH) infections in an endemic area in Ethiopia. The results of the study demonstrate an impressive sustained decrease in the prevalence of these infections during the four years of the intervention program. These results lend support to our original hypothesis that health education is a crucial element in control of neglected tropical diseases. While a major effort is made currently in various countries around the globe to control and eradicate neglected tropical diseases (NTD) based on mass drug administration alone, we believe that the results of our study, reinforce the notion that MDA alone is not enough and that health education is essential for the control of these diseases. Since this message is of wide application we believe it will be of general interest to the audience of this Journal.

Sincerely,

Zvi Bentwich
Professor and Head
Introduction

Helminths infect approximately one-third of the world's population, most commonly in developing countries (1, 2). Over 400 million school-aged children are infected with parasitic worms (3). Risk factors for these infections include poor hygiene, lack of sanitation and low socioeconomic status. In many countries of sub-Saharan Africa and Southern Asia, sanitation coverage is below 50% (4). Our study took place in the city of Mekele, the capital of Tigray Regional State in Ethiopia. According to the most recent census in 2007 carried out in Mekele city, about 72% housing units did not have bathing facility and nearly half did not have proper toilet facilities (5). Most elementary and junior school compounds in Mekele city did not have properly functioning latrines and running water facilities. With these known risk factors for the helminthic infections in mind, we chose to perform our intervention program and study in Mekele.

Although intestinal parasites are often asymptomatic, they may cause gastrointestinal symptoms such as abdominal cramps, indigestion, vomiting and diarrhea. They can also result in additional morbidities such as malnutrition, growth retardation and anemia. In fact, hookworm has been found to account for up to 73% of severe iron-deficiency anemia in various areas of Africa (6, 7). Furthermore, helminthic infections are often co-morbid with other significant infectious diseases such as malaria, tuberculosis and HIV (8-12). The impact of helminthic infections extends far beyond these obvious health effects and includes economic and social effects due to lost school attendance and effective work time. Treatment of these infections by mass drug administration (MDA),
at a cost of $0.03 to $0.50 US dollars per individual, is an extremely cost-effective and attractive way for controlling these infections.

The World Health Organization (WHO) recommends treating all school children at regular intervals with deworming drugs in areas where helminth infection is common. The WHO states this will improve nutritional status, hemoglobin, and cognition and thus will improve health, intellect, and school attendance (13). For worm infections, many studies have clearly shown that morbidity can be significantly reduced through repeated and regular treatment with single-dose MDA delivered through school health programs. The drugs are safe, inexpensive and simple to administer, and thus ideally suited for mass administration (14). However, the rates of reinfection in countries where the infrastructure, sanitation and hygiene have not been changed are extremely high which raises serious questions regarding the efficacy of MDA alone.

On this background, we have developed a comprehensive program, which combines intensive health education with MDA, so as to achieve a longer lasting control of the infections and decrease the rate of reinfection by changing the behavior of the school children. A pilot project to implement this approach was first initiated in three sites by us in collaboration with the Federal Ministry of Health (FMoH) of Ethiopia (15). This was then followed by the Mekele project targeting school children after a baseline stool survey that determined the prevalence of schistosomiasis and soil-transmitted helminthiasis. This was followed by comprehensive deworming program, which included: capacity building, training of health care workers, drug distribution, health education, and improvement of water supply and sanitation. The protocol used on the
deworming campaign was based on the WHO guidelines for deworming school children (16) and modified according to resource availability.

**Materials and Methods**

Mekele City covers an area of 109 square kilometers and is the capital city of the Tigray Regional State of Northern Ethiopia, with an estimated population of 215,000 according to the 2007 CSA data (5), which has by now grown significantly. During the time of the program there were 68 governmental and private elementary and junior schools in the city, with a total of 45,307 students. A total of 38 schools were involved in the multi-stage survey and deworming program.

In October 2008, the first seminar on NTDs, with sensitization and mobilization of the school community was organized and conducted in collaboration with the Health and Education bureaus of the regional, zonal and city administration. In a joint effort with Mashav (Israel's Agency for International Development & Cooperation) the Center for Emerging Tropical disease and AIDS/ NALA foundation and the city administration, 30 pit latrines as well as water sanitation facilities were constructed in 30 school compounds in Mekele and Health education materials in local language [“Tigrigna”] were prepared.

From its outset this intervention was planned as a multi-stage deworming program. In February 2009, the first stage began with a random sampling of stool specimens for a baseline assessment of prevalence of Schistosomiasis and STH infection followed by the first MDA. During this stage, the health education program was also initiated, consisting of training health care workers, school teachers and community volunteers, and
distributing health education materials. This was followed by sequential deworming campaigns and follow up stool surveys, with intensive continuous health education sessions during the four years deworming program (Figure 1).

Students who were randomly selected for sampling were asked to have a bowel movement in the school latrines and collect their stool in leak proof clean stool cups. The stool samples were coded with a number to identify student data. Stool samples were then analyzed by direct wet-mount preparation and Kato-Katz smear technique (17), performed at the department of Microbiology and Parasitology, Ayder teaching hospital, in Mekele. All students who were present at school on the days of drug administration were given antihelminthic treatment, which consisted of Albendazole and Praziquantel. Dosing of Praziquantel was based on height scales while a stat dose of 400 mg was applied for Albendazole. Drug distribution was conducted by city health bureau and delivered by trained volunteers and teachers, and attended by health professionals. Adverse effects of the MDA were observed and attended to by nurses during the deworming campaign. Data were collected on a standard record format prepared for the deworming program registration. Data were first entered in excel format for clearance and transformed into SPSS version 16 statistical package. The prevalence of the parasitic infection was compared between groups at all stages.

**Results**

A total of 1871 students participated in the multi-stage stool survey from 38 schools. Prior to the baseline survey and in between the multistage surveys, comprehensive
training on prevention of NTDs, particularly on prevention of helminth infection (STH infection and schistosomiasis) was given to health care workers, school teachers and community volunteers. Health education materials on prevention of helminth infection were printed in local language [“Tigrigna”] and distributed to all the schools after the baseline survey.

At baseline and in all the stages of the survey, different parasite species were found. *Schistosoma mansoni* was the leading prevalent parasitic infection during all the surveys and *Ascaris lumbricoides* was the leading STH infection (Table 1). Among the other intestinal parasite species *Hyminolypis nana* and *Enterovius vermicularis* were the most frequently recovered infections.

A deworming campaign was conducted biannually in all the schools involved on each survey of the multi-stage deworming program. A total of 23,214 (51.2%) of the estimated 45,307 students in Mekele city were dewormed. Target age group was 5-15 years of age and all students present at school during the mass drug administration (MDA) took the deworming tablets. Albendazol stat dose was given in the first week, and Praziquantel dosed by height scale, a week later. The over all prevalence of Schistosomiasis and STH infection at baseline was 54.6%, after the biannual deworming decreased to 13.5%, 12.9% and 6.4%, on the subsequent stages, respectively.

The prevalence of Schistosomiasis at baseline was very high in some of the schools-100% in FelegDaero, 83.1% in Lachi, 81.2% in Gembela and 43% in Aynalem. The highest prevalence of STH infection was in Quiha elementary and junior school (34.2%). Overall the prevalence of schistosomiasis was 44.6%, STH infection 8.1%. As depicted in Figures 2 and 3, the high baseline prevalence of the helminth infections decreased for
both Schistosomiasis and STH gradually, but very significantly. Follow up was not possible in all schools surveyed at baseline and so we followed those schools with the highest prevalence that participated in the first stage of the deworming campaign. The cumulative results of all the stool surveys are depicted in Figure 4, which clearly shows the dramatic decrease and its persistence at that stage.

**Discussion**

The results reported here, clearly demonstrate the significant and sustained decrease in the prevalence of both schistosomiasis and STH in Mekele city, following our deworming program implemented there between 2009 and 2012. The continued follow up of the prevalence of these infections carried out by the Federal Ministry of Health in 2014 revealed that the decreased prevalence of both schistosomiasis and STH in Mekele persisted long time after the conclusion of our intervention. This success, that in some of the locations was truly dramatic, is most probably accounted by the comprehensive approach used in this program, which combined MDA with intensive health education and also addressed the water and sanitation issues.

The success of the initial pilot was key in setting the stage to extend the program to the multi-stage deworming plan in Mekele city for school children (age 5-15 years), grades 1-8, in 38 elementary and junior schools. Furthermore, the intensive health education program was continuously improved during the progress of the intervention, involving several additional elements such as community workers, volunteers and "womens' army" members. The growing awareness and involvement of the community as well as that of
the city administration at all levels, also developed with time and became significant in its influence on the results of the program. During the primary stages of the deworming campaign in Mekele city, we tried to address the water and sanitation situation as well. Thus, six-hole pit-latrines were built separately for boys and girls in 30 schools, and installation of water taps for hand washing took place in all these schools, in collaboration and support of the city administration. Sensitization seminars, comprehensive training on prevention of NTDs, particularly on prevention of helminth infection (STH infection and schistosomiasis) and mobilization of the community were conducted prior to each subsequent survey and health education sessions were held in all the schools under the program.

During the deworming campaign at all stages, the program reached only 50% of school age children in Mekele city, who received the chemotherapy at least once a year in the biannual deworming program. The sequential stool surveys carried out during the project were preformed only in the treated population. Thus, we don’t have information on the untreated population of school children or the rest of the population of Mekele. Such information would have been very valuable, as it would possibly demonstrate the effect of the "limited" intervention on the population at large. Furthermore, it could possibly reflect the influence of health education as well as the decrease of infection prevalence outside of the treatment group. It would therefore be highly informative to collect such data in future interventions of this kind.

In all the surveys, *Schistosoma mansoni* remained the most frequent parasite recovered from the school children. The foci with the highest burden of schistosomiasis were FelegDa’ero, Lachi, Gembela and Aynalem, which are adjacent to the river Elala or
Gereb Giba. River Elala and the down steam is a likely environmental reservoir for *Schistosoma mansoni* because of the known presence of the snail intermediate host, *Biomphalaria pfeifferi* (18). Eradication of the intermediate host, while effective in prevention of schistosomiasis, would be costly, both financially and environmentally. Another environmental source of *Schistosoma mansoni* infections are newly constructed dams and reservoirs. A 2010 study found that *Schistosoma mansoni* infection was higher in areas with irrigation dams and reservoirs than in areas without irrigation (19).

The overall prevalence of parasitic infection at base line (63%) was comparable with a study in Adwa (20), but higher as compared to a study conducted near Mekele city (19). It was still lower than the prevalence found in studies conducted in Zarima (82.4%) and Azezo (72.9%), in Amhara Regional State (21, 22).

The very significant decrease in the prevalence of parasitic infections in this study does demonstrate the effective impact of mass drug administration (MDA) “deworming”. However, as originally perceived, we believe that the sustained decreased prevalence of the infections would not have occurred if children did not change their behavior and retained the information they received about prevention. It is highly likely that if that would not have happened, they would have been re-exposed and re-infected. Regretfully, we were not able to perform a full evaluation of the outcome of the health education program, and its efficacy in changing the behavior of the school children that participated in this program, during this intervention. Such evaluation has been previously performed by us in a small-scale study in a different area in Ethiopia and has indeed showed the successful and significant effect it had on the knowledge attitudes and
practices of the school children (   ). Thus, future studies are needed to evaluate the educational component of the intervention to determine its short and long-term effects. Taken together, this study has clearly demonstrated a dramatic and sustained decrease in the prevalence of both schistosomiasis and STH infections in school children living in a highly endemic area for these infections. The comprehensive approach that combined MDA with intensive health education and addressed also the water and sanitation issues prevalent in the town, may serve as a model that may be applied in other regions in Ethiopia as well as elsewhere, in areas with high prevalence of these infections.

Acknowledgements
We acknowledge the collaboration work with Ministry of health and the health and education bureau of the Tigray Regional State. We would like to thank the principals of the schools, teachers, community volunteers and health care workers for their unreserved cooperation. We are also grateful for all the students that participated in this program.

References


Health Education material were culturally adopted and translated to local language “Tigrigna”

Training of teachers, volunteers and community engagement

Baseline and annual follow up stool survey

Distribution of health education material to all schools

Initial and biannual deworming campaign

Structured and continuous intensive health education in all schools
Click here to access/download Other Legend_Tables_Figures.doc