Evaluation of a Novel Water Recreation Area as an Effective Tool for the Reduction of Schistosomiasis in Rural Ghana

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Background
Parasitic blood flukes of the genus *Schistosoma* infect approximately 200 million people worldwide and are responsible for over 1.53 million disability-adjusted life years. In Kwabeng, a rural Ghanaian town, adult *Schistosoma haematobium* worms were projected to live within the blood vessels of the bladders of around 40 percent of schoolchildren. In fieldwork conducted between 2005 and 2006, Ms. Charline Han, a former Tufts Graduate student, found that children in Kwabeng typically contract schistosomiasis by playing in and collecting water from perpetual streams that carry the parasite and its intermediate host, snails of the genus *Bulinus*. As a follow-up to work conducted by Ms. Han, I was seeking a new public health tool that would be efficacious at breaking the schistosomiasis transmission cycle and affordable for governments in developing countries. Formulating the problem as one that is within the realm of water resources engineering and public health provides an opportunity to invent new tools and create unique interdisciplinary solutions to a problem that is thousands of years old. My proposal to Tufts Institute of the Environment (TIE) was submitted before the commencement of fieldwork in Ghana and was based on the findings of Ms. Han, as advised by Dr. John Durant and Dr. David Gute (Department of Civil and Environmental Engineering).

Relationship to Mission of Tufts Institute of the Environment
Schistosomiasis is called a ‘disease of development’ because the parasite’s intermediate host, the snail, is found in slow-moving water caused by water development activities. Dams, irrigation projects, and mining impoundments are typical ways in which humans alter natural hydrology, and in doing so, create conditions ideal for the propagation of schistosomiasis. In Kwabeng, a gold mining operation upstream of the community was undertaken in the early 1990s and might have caused a reduction in streamflow and an alteration in the vegetative habitat in the Awusu River. There may have been an increase in the number of *Bulinus* snails in response to changing water velocities, bringing with it an increase in the incidence and severity of schistosomiasis, particularly in Kwabeng’s children.

This project was originally designed to address the TIE area of “Water” by studying the effect on schistosomiasis of providing clean water for recreating and drinking. “Health and Environment” was addressed as I studied the prevention of schistosomiasis where the disease was expected to be endemic due to human alteration of the natural environment. It was my hope that if the water recreation area described above was found to prevent disease, it would become part of government policy aimed at reducing waterborne disease in rural areas of developing countries.

Summary
Prior to beginning project work in 2007 in Kwabeng, Ghana, it was estimated that approximately 40 percent of schoolchildren would be infected with *Schistosoma haematobium*. This estimate was based on research conducted by a previous graduate student, Ms. Charline Han (Dept. Civil and Environmental Engineering, ’06). The schoolchildren were believed to contract the parasite in the Awusu River where they play and collect water for domestic use. TIE funding was requested to pay for praziquantel, compensation to study participants, samplings materials, and a textbook.

I hypothesized that a novel water recreation structure would be an effective and sustainable intervention against schistosomiasis. The original design consisted of a merry-go-round that
would pump groundwater to a holding tank, which in turn would fill a wading pool. Excess water would have been made available for domestic water collection. When the study began in June of 2007, all children ages 6 to 13 in Kwabeng were invited to participate in the study. In August of 2007, a total of 1,152 children were enrolled and tested for schistosomiasis by both a dipstick test for microhaematuria and a filtration test for schistosome eggs. Some of these children had previously been tested by Ms. Han and treated for the disease. Children who were positive by one or both of the tests were considered positive for schistosomiasis; this is the same criteria used by Ms. Han.

I collaborated with a trained laboratory technician from Noguchi Memorial Institute for Medical Research (NMIMR) in Ghana to collect and test samples in August of 2007. The work was overseen in Ghana by a member of the faculty of the University of Ghana, Dr. Kwabena Bosompem. Unexpectedly, we found that only 6.9 percent of all children were positive for schistosomiasis by dipstick and/or urine filtration. The reasons for the discrepancy between this finding and the previous findings of Ms. Han is unknown, but may be due to a number of factors, including: past treatment of some children with praziquantel, normal environmental fluctuations that affect snail populations and river levels, or variations in the way sampling was conducted. Nurses from the local health clinic administered Praziquantel purchased with TIE funds to all children who tested positive or reported seeing blood in their urine. Praziquantel is the drug of choice to kill adult schistosomes.

Originally, I planned to assess the effectiveness of a water recreation structure in lowering schistosomiasis reinfection rates. I thought that it would be possible to follow a cohort of children for twenty months and collect urine samples from five percent of randomly selected children on a monthly basis. Urine egg counts would have been used to establish disease recurrence rates and severity status for each child. I had planned to analyze the data to determine whether or not schistosomiasis reinfection is inversely proportional to use of the play area. I expected that disease recurrence and severity would be higher in the population that continued to use river water as compared with children who predominantly utilized the play area.

Unfortunately, because only 6.9 percent of children were positive by blood and/or eggs, and only 3 percent by eggs, it will no longer be possible to carry out the proposed study in Kwabeng, Ghana. I will not be able to demonstrate that a water recreation structure is efficacious or cost-effective in terms of preventing a disease that affects such a small number of people. Instead, I recommended to the community of Kwabeng, and specifically to the Chief and Council of Elders and to nurses at the Health Center, that children be monitored locally for signs of disease. The children should be treated with praziquantel if they report seeing blood in their urine or if they test positive for blood or eggs. In collaboration with the NMIMR laboratory technician, I trained local nurses in the use of the dipstick test for microhaematuria and donated several hundred dipsticks to the clinic for this purpose. I also left several hundred praziquantel tablets with the local clinic for future treatment of residents. The town was made aware, via communication from the Chief’s palace, that schistosomiasis appears to be greatly reduced in the town from levels seen in years past. However, residents were cautioned that transmission may still be occurring and that prolonged contact with river water is still not considered safe.
In follow-up work conducted in the fall of 2007, a town located less than ten miles from Kwabeng, Ghana was selected as the new study site. This new town, Adasawase, has a population of approximately 3,000 people. Preliminary work suggests that local schoolchildren are much more affected by urinary schistosomiasis than are Kwabeng schoolchildren. Following discussions with all members of my PhD thesis committee, I have decided to carry out the rest of my thesis work in Adasawase.
Budget

The following budget was submitted to TIE in the application package.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity and Price</th>
<th>Justification</th>
<th>Sub Total (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Praziquantel</td>
<td>3000 doses at $0.79 each</td>
<td>Approximately 1000 children in the study, each child will receive 2 baseline doses and potentially 1 follow-up dose</td>
<td>2370</td>
</tr>
<tr>
<td>Subject Compensation</td>
<td>1000 units of compensation at $2.00 each</td>
<td>Study subjects will be compensated for their study participation</td>
<td>2000</td>
</tr>
<tr>
<td>Urine sample cups, microscope slides, Nuclepore filter paper, misc. supplies</td>
<td>1100</td>
<td>Disposable supplies needed to collect and carry out urine sample egg counts</td>
<td>575</td>
</tr>
<tr>
<td>Textbook: &quot;Critical Appraisal of Epidemiological Studies and Clinical Trials&quot;, 2nd ed., Mark Elwood</td>
<td>1 at $55.00</td>
<td>Reference manual for epidemiology and statistical calculations</td>
<td>55</td>
</tr>
</tbody>
</table>

Total = 5000

The actual expenditures varied and are shown in table below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Price</th>
<th>Justification</th>
<th>Sub Total (US $)</th>
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</thead>
<tbody>
<tr>
<td>Praziquantel</td>
<td>400</td>
<td>$0.80</td>
<td>Positive children were dosed and additional doses were purchased and left at the local Health Center</td>
<td>320</td>
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<tr>
<td>Subject Compensation</td>
<td>1152</td>
<td>$1.50</td>
<td>Study subjects were compensated for their study participation</td>
<td>1728</td>
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<tr>
<td>Nuclepore Membranes</td>
<td>1200</td>
<td>$1.30</td>
<td>Filtration of each urine sample requires a single membrane</td>
<td>1560</td>
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<tr>
<td>Urine sample cups, microscope slides, gloves, disinfectant, misc. supplies</td>
<td>N/A</td>
<td>$1,100.00</td>
<td>Disposable supplies used to carry out urine sampling</td>
<td>1337</td>
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<tr>
<td>Textbook: &quot;Critical Appraisal of Epidemiological Studies and Clinical Trials&quot;, 2nd ed., Mark Elwood</td>
<td>1</td>
<td>$55.00</td>
<td>Reference manual for epidemiology and statistical calculations</td>
<td>55</td>
</tr>
</tbody>
</table>

Total = 5000