Predictors of Urogenital Schistosomiasis Knowledge Among Schoolchildren in the Eastern Region of Ghana

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Literature Review

Part 1: Effectiveness of Educational Interventions for Improving Knowledge of Schistosomiasis

Schistosomiasis is a parasitic disease that results from infection with a blood fluke of the genus *Schistosoma*. Adult worms localize near the bladder or the intestines, where they mate and produce eggs. These eggs migrate into the lumen of the bladder or the intestine and are excreted in urine or feces. Pathology results from the immune system's inflammatory response to the movement of eggs through the tissues. Eggs that are released via urination or defecation into fresh water bodies will produce a miracidium, which seeks out a snail host. After asexual multiplication in the snail, cercariae emerge from the snails and seek out a human host. They enter the host by burrowing through the skin. An estimated 200 million people worldwide are infected with schistosomes, contributing to 14,000 deaths per year and 1.532 million DALYs lost (Gryseels et al. 2006). Schoolchildren are a population that is highly exposed to infection (Freudenthal et al. 2006). While mass drug administration (MDA) with the drug praziquantel is the cornerstone of schistosomiasis control efforts, MDA alone is not sufficient to achieve elimination or eradication of the disease (Lansdown et al. 2002).

This literature review analyzes the impact of schistosomiasis education programs in primary schools on knowledge, attitudes, and behaviors with respect to schistosomiasis in rural communities across Africa and South East Asia. Specifically, it will address effective education practices, interventions that should be combined with education, the importance of integrating education programs into existing community structures, and involving children as agents of change in their communities.

Effective Education Practices

Many studies have found that multimedia, such as comics and videos, and active engagement are necessary for schistosomiasis educational interventions to be effective (Yuan et al. 2000, Lansdown et al. 2002, Hu et al. 2005, Yuan et al. 2005). For a study of fourth-graders in the Dongting Lakes region of China, Yuan et al. (2000) developed a 15-minute educational video and an accompanying comic book. 25 schools were randomly assigned to receive the intervention, and 25 schools were designated as control schools. Treatment schools screened the video twice, discussed the video, and distributed the comic to students. Compared to baseline testing, children who received the intervention were significantly more likely to answer correctly on a schistosomiasis knowledge survey, and were also significantly more likely to report choosing safe over unsafe water-contact sites. Self-reported water use was confirmed through direct observation of behavior at water contact sites. Researchers concluded that a multimedia approach to education in which a print source reinforces what it seen in a video is an effective intervention, which will be most effective if repeated every year (Yuan et al. 2000).

A similar study of primary schools in Lushoto district, Tanzania examined 25 treatment and 25 control schools. All schools were randomly selected from the 125 primary schools in Lushoto. Treatment schools received nine months of health education classes, which focused on personal hygiene practices that reduce the risk of helminth and schistosomiasis infection. Songs, poems, plays, and discussions were used to actively involve students. Compared to a baseline test, students in treatment schools had increased knowledge of risks to health and ways to prevent parasitic infection, while knowledge of students in control schools did not increase (although the authors did not mention whether the results were statistically significant). Additionally, positive behavior changes regarding sanitation and hygiene were observed at the treatment schools. Follow-up testing 15 months after cessation of the intervention indicated that results were sustainable (Lansdown et al. 2002). A study in rural Kenya also emphasized that active and participatory student engagement is essential for effective behavior change (Onyango_Ouma et al. 2005). Similarly, a study on two schools in Mwanga District Tanzania actively involved students through drama, dance, song, production of educational videos, and creation of slogans for the prevention of infection. Teachers at the schools concluded that these activities were important, and proceeded to design a schistosomiasis curriculum that included active involvement of students to present to regional and district level officials for approval. (Freudenthal et al. 2006).

A study in the Poyang Lake area of China examined 3 pairs of treatment and control villages. A total of 120 schoolchildren in treatment villages watched a video explaining the harmful effects of schistosomiasis, attended a schistosomiasis prevention training program, and were either rewarded or punished by their teachers following an evaluation of their behavior towards schistosomiasis. Compared to baseline testing, schoolchildren in the treatment group were significantly more likely to answer correctly on a schistosomiasis knowledge survey, comply with praziquantel chemotherapy, and reduce their water-contact. Rates of re-infection in the treatment group also dropped from around 15% to 0% in the 12 years post-intervention. Schoolchildren in the control group did not perform significantly differently on their baseline and follow-up knowledge and attitudes tests. They also did not significantly reduce their water contact behavior, increase their compliance towards chemotherapy. Researchers concluded that the intervention could effectively control schistosomiasis in their area of study (Hu et al. 2005).

A study in Hunan, China evaluated fifth-grade students in 15 treatment and 15 control schools. Schoolchildren (n=604) in treatment schools watched a 15-minute cartoon and a video of schoolchildren discussing schistosomiasis with adults, and discussed both. Children then created a poster advocating for chemotherapy compliance. A comic book was also distributed. Schoolchildren (n=527) in control schools received a two-hour lecture on schistosomiasis. 99.8% of students in the experimental group passed a schistosomiasis knowledge survey (score of at least 60/100), while only 16.7% of students did so in the control group. Students receiving the intervention were more likely to be present for, and comply with, treatment. Researchers concluded that a multimedia educational approach can significantly change knowledge and treatment behaviors (Yuan et al. 2005).

A study in the Ga and Akuapem South Districts of Ghana evaluated the impact of two educational interventions. Area 1, consisting of two communities, was given a passive educational intervention. Leaders of existing community organizations were briefly trained to present poster and flip-chart material on schistosomiasis. A video on schistosomiasis was shown to the community once at the beginning of the intervention. Area two, which also consisted of two communities, was given no health intervention. Area 3, which consisted of four communities, was given an active intervention. Specially trained community health volunteers visited parents/guardians of schoolchildren twice a week for 18 months. Video shows for the entire community were organized once a month. A spelling bee with schistosomiasis-related words was held. Prevalence data from before and after the health interventions indicates that the active interventions had a greater impact than the passive intervention on schistosomiasis prevalence. 24 months after the intervention, prevalence in Area 3 was 0.15 as frequent as Area 2, and 0.24 as frequent as in Area 1. Thus, the authors concluded that active rather than passive education is a better strategy (Nsowah-Nuamah et al. 2001).

Ineffective Education Practices

A study of a rural village in northern Senegal showed that seven years of community-wide education did not effectively establish adequate levels of schistosomiasis knowledge in the community. Knowledge of 556 individuals was assessed through a survey. Only 54% of respondents adequately named disease symptoms, and 43% named water at the main source of disease transmission following the intervention. Education consisted of billboards, radio and television messaging, community meetings, and activities at the local health center. After a review of past literature, researchers noted that health education interventions specifically through schools have the potential to be more effective (Sow et al. 2003).

A study with 229 children from five primary schools on Unguja Island, Tanzania found that distribution of an educational comic book did not change knowledge about and attitudes towards schistosomiasis (Stothard et al. 2006). Children aged 11-15 were given a booklet. Over the course of one week, teachers guided children through the booklet for 10-15 minutes each day. There were no activities or discussions. Compared to baseline testing before the books were distributed, children scored slightly higher on a knowledge and attitudes test at the end of the week. However, these increases were not statistically significant, and were likely a result of the children taking the same survey twice, rather than a direct result of the comic book. Researchers concluded that a long-term educational intervention might have been more successful at changing knowledge and attitudes and instigating behavior change (Stothard et al. 2006).

A review of educational interventions pertaining to schistosomiasis identified ineffective intervention models and recommended the PRECEDE model (Table 1) as the best way to structure health education programs (Kloos_1995). The PRECEDE model suggests that researchers must first identify the factors within a specific community that predispose community members to a particular infection, and then implement interventions that address those factors (Kloos_1995).

Health Education Model	Summary
Health Belief Model	Aims to alter health related behavior through changing perceptions of: disease severity, susceptibility to disease, benefits of behavior change, and barriers to behavior change. Has been criticized for failing to address accompanying social and economic conditions.
Empowering Education Model	Aims to reduce top-down teaching methods by inspiring communities to identify and solve their own problems. Is often unrealistic in practice.
Social Marketing Model	The use of mass media such as television to disperse educational messaging. Can be effective in changing knowledge and attitudes but has not been shown to change behaviors.
Folk Media Approach	Use of traditional media such as music, art, drama, and videos to disperse educational messaging. Must be culturally specific and developed with input from community members.
PRECEDE Model	Identifies factors that contribute to disease transmission in a community and then plans educational interventions according to these factors.

Table 1. Health education models that have been used to structure educational interventions that address schistosomiasis. Compiled by the author with information from (Kloos 1995)

Combined Interventions

While many accept the efficacy of education in changing schistosomiasis knowledge (Yuan et al. 2000, Lansdown et al. 2002, Hu et al. 2005, Yuan et al. 2005), behavior change is unlikely to occur without accompanying interventions outside of the realm of education (Koos_1995, Hu et al. 2005). Where safe-water is unavailable or difficult to acquire, increased knowledge is not sufficient to change water contact behaviors due to occupational, social, religious, and recreational factors (Kloos 1995, Hu et al. 2005).

Additionally, improved sanitation is necessary in order to prevent environmental contamination and reinfection (Kloos 1995). Effective health education should be tied to changes in water contact behavior, which can only occur if safe water is easily attainable. Additionally, education must also be tied to improved sanitation (Kloos 1995).

Health education interventions also must be accompanied by access to praziquantel. Compliance with chemotherapy programs is one of the main objectives of schistosomiasis education (Kloos 1995). While chemotherapy does not have the same potential for sustainable change as interventions that address sanitation and water-related infrastructure, chemotherapy interventions are easier to implement for financial and organizational reasons (Kloos 1995). A review of health education and sanitation interventions concluded that both health education and improved sanitation are effective at reducing the prevalence of schistosomiasis and soil-transmitted helminth infections separately and together. While the review showed that dual education and sanitation interventions were no more effective than a single intervention, it emphasized that reductions in prevalence are significantly higher when education and/or sanitation campaigns are combined with chemotherapy. However, the authors concluded that sustainable disease prevention is impossible without both health education and improved sanitation (Asaolu and Ofoezie 2003).

Integrating Education into the Community

For educational interventions to be maximally effective, they must be built into existing community structures and frameworks. Interventions often fail because they are primarily controlled by outsiders rather than by community members (Kloos 1995). Prior to implementing an intervention, researchers must assess the structure of the community and decide how to include existing health workers and teachers (Kloos 1995). Additionally, curricula should be developed to apply specifically to the cultural and socioeconomic factors of the community in which they will be implemented (Kloos 1995). Finally, women must be involved in the design and implementation of schistosomiasis control programs, as they have a large impact on the education of their children and are frequently in contact with water (Kloos 1995).

A study in Mwanga district, Tanzania used screening and treatment for schistosomiasis as an impetus for community participation. Community members used prevalence data and data from a sanitation survey to identify issues, such as the development of safe places to swim. During screening, teachers were encouraged to assist in weighing and measuring children. Schoolchildren were trained to assist in the sanitation survey by recording observations on household sanitation. After researchers implemented several schistosomiasis education activities within schools, educators within the community concluded that there was still a need for education and decided to develop their own primary school curricula on schistosomiasis. Researchers concluded that educational interventions are only sustainable if they are built into existing community structures (Freudenthal et al. 2006).

Researchers implementing an educational intervention in Lusotho, Tanzania found that their project “took on a new dimension of vitality” once teachers were given responsibility for structuring lessons. The authors found that the project progressed more rapidly and more efficiently when enthusiasm was internally generated. They found that the more control teachers had over planning and teaching, the better the outcome in terms of student knowledge (Lansdown et al. 2002). Similarly, a study in the Poyang Lake area of China found that health education interventions are more effective when teachers take an active role, as their approval or disapproval can be a strong catalyst for behavioral changes in students (Hu et al. 2005).

Children as Agents of Change in the Community

Many have voiced skepticism over whether children have the necessary social capital to affect change. In particular, there is a worry that adults will be unwilling to change behavior based on information from their children (Freudenthal et al. 2006, Lansdown et al. 2002). A study in Bondo district, Kenya explored whether children can affect change both at school and at home following a health education intervention. A group of 40 grade five schoolchildren from two different schools received two months of participatory and action-based health education on malaria, diarrhea, and hygiene. These children were designated as "health communicators" for fourteen months and chose one student from grade three and one adult with whom to share what they learned. Results indicate that children can effectively change behaviors both at school and in the home. Compared to baseline testing, after four months mean scores on a health knowledge survey increased 8.25 points for health communicators out of a maximum possible score of 46, while there was a mean increase of 6.09 points for child recipients and 2.35 points for adult recipients. There was a direct correlation between how health communicators scored on knowledge exams and how their child and adult recipients scored. Effects of the intervention were sustained when participants were retested at 14 months. Additionally, following the intervention, researchers observed positive behavior changes with regards to personal hygiene and sanitation at the schools. Most importantly, children catalyzed behavior change at home. Hygiene in latrines improved, and two months into the study, 71% of students had introduced hand-washing facilities into their homes. Children also introduced boiling and filtering of drinking water in 71% of homes (Onyango-Ouma et al. 2005).

Researchers in Magu District, Tanzania conducted a total of 43 focus group discussions with 119 primary schoolchildren, 40 teachers and 147 parents. The goal was to ascertain attitudes towards a participatory action style of teaching, in which children are actively involved in the classroom and act as health change agents in the community. Researchers found that children strongly preferred to be actively engaged in the classroom, and were eager to convey health education messages to the rest of the community. Teachers also supported participatory action methods within the classroom and believed that children could effectively change behaviors in the community. However, they stressed that large class sizes, lack of teaching supplies, and lack of time are significant barriers to implementing health education classes where children are empowered to participate, submit their own ideas, and prepare to convey messages to their community. Finally, 97% of parents interviewed stated that they were in favor of children communicating health messages to adults. Parents were willing to learn from their children, and respected them as agents of change. The study emphasized that strong school/community relationships are a necessity for children to act as effective agents of change (Mwanga et al. 2007).

Significance of Schistosomiasis Education Practices

Schistosomiasis education programs have the potential to effectively change knowledge, attitudes, and behaviors with respect to schistosomiasis. However, in order to successfully change knowledge and attitudes, interventions must actively engage students and include substantial student participation. The use of multimedia such as videos and comic books is effective as long as students actively discuss the presented material. Behavior change cannot be realized unless educational interventions are accompanied by access to safe water and sanitation facilities. Additionally, educational interventions should be accompanied by chemotherapy with praziquantel. Furthermore, educational interventions are most effective and sustainable when they are fully integrated into existing community structures. Input from teachers, parents, and community health workers is an integral aspect of any such intervention. Finally, studies have demonstrated that children in primary school have the potential to act as health change agents in their communities, and can make concrete changes both at school and at home. Overall, if interventions are correctly implemented, schistosomiasis education in primary schools can be both cost-effective and lead to significant positive changes in knowledge, attitudes and practices.

Part 2: Measuring Knowledge of Urogenital Schistosomiasis

Background

Schistosomiasis is one of the most important parasitic infections worldwide. An estimated 200 million individuals are infected (Gryseels et al., 2006), and 93% of those cases are concentrated in sub-Saharan Africa (Hotez & Kamath, 2009). Urogenital schistosomiasis (UGS) is one type of schistosomiasis that commonly affects humans. It is a water-based disease that results from infection with the blood-fluke *Schistosoma haematobium* (Gryseels et al., 2006). Schistosomiasis is of particular importance for children, who are at increased risk of contracting infection due to their recreational and domestic water contact patterns (Sow et al., 2011; Chandiwana et al., 1991). Thus, some UGS prevention efforts have included UGS health education specifically targeted at school-aged children. Despite evidence that health education interventions can be an effective means of increasing UGS knowledge, little is known about the baseline knowledge of schoolchildren regarding UGS in sub-Saharan Africa. Studies that have attempted to describe knowledge regarding schistosomiasis have found that knowledge is generally erroneous or incomplete.

Community Knowledge of Schistosomiasis

In Western Kenya, 32 focus group discussions were used to assess knowledge of urogenital schistosomiasis among unmarried youths aged 18-24 and married adults aged 24-60. Focus groups were also broken down by gender. Focus groups assessed knowledge of signs and symptoms of the disease, transmission of the disease, control of the disease, groups most at risk for the disease, and how to seek care for the disease. Participants were also asked about the perceptions of others who have the disease, and their perceptions of the treatment process in terms of cost and where one should go to seek treatment. A total of 237 individuals participated in the study. Although the majority of participants had heard about urogenital schistosomiasis, most did not feel as though they had adequate information about the disease. Participants suggested erroneous control strategies such as cooking food properly, and avoiding wearing clothes washed in contaminated water. Participants also named drinking contaminated water as a means of transmitting the disease. Generally, participants did not believe that certain gender or age groups are at increased risk of infection. Participants believed that urogenital schistosomiasis is a serious disease and can be cured. However, there were various beliefs regarding how it can be cured, including prayers, traditional healers, hospitals, and chemists. Most participants thought that seeking treatment at a hospital is very expensive, and thus preferred to seek alternative treatment (Musova et al. 2014).

Another study in Western Kenya also used focus groups to assess knowledge of schistosomiasis, and also used key informant interviews. Focus groups were conducted with community members, while interviews were conducted with opinion leaders in the community. Eight focus groups and eight interviews were conducted with a total of 88 participants in the study. Although most participants had heard about schistosomiasis and recognized the name, awareness of transmission mechanisms and symptoms of the disease was low. Participants thought that the disease could be transmitted through the air, through contaminated drinking water, through the lack of a latrine, through sharing a latrine, through contaminated food, or through walking barefoot. Participants thought that cracks in the feet and yellow eyes were symptoms of the disease. Participants named deforestation, wearing shoes, avoiding contact with stagnant water, snail insecticides, drinking treated water, and health education as control strategies. Participants generally felt that there was not much they could do to avoid exposure. They perceived the disease as very dangerous, yet added that buying medication for it was too expensive. They sought treatment from herbal remedies and pain-killers instead (Odhiambo et al. 2014).

In Uganda, an interviewer-administered questionnaire was used to evaluate the knowledge, attitudes, and practices of teachers, pupils, household heads, and health workers regarding schistosomiasis. Participants were considered knowledgeable about schistosomiasis if they answered three quarters of the questions correctly. 908 household heads were interviewed: 87.3% knew of schistosomiasis; 52.9% of household heads knew that schistosomiasis is contracted through contact with contaminated water; only 25.2% and 22.0% thought that fishing and poor sanitary conditions were involved in transmission, respectively. 14.1% of household heads did not know how transmission occurs at all. 30% of household heads though that the disease could be prevented by boiling drinking water. 51% knew that disease burden could be reduced through mass treatment. Knowledge was higher among those with a tertiary education than among those with no education. Males were more likely to know the disease than females, and those older than 25 were more likely to know the disease than those aged 16-24. Length of time living in the area was positively correlated with knowledge of the disease (Kabatereine et al. 2014).

The same study in Uganda found that even health workers have misconceptions about schistosomiasis: 92.3% knew of schistosomiasis; only 38% of participants knew that poor methods of fecal disposal are associated with transmission; and only 21.3% knew that contact with lake water is associated with transmission. Drinking dirty water and eating contaminated food were mentioned as risky behaviors. 12.8% of participants had no idea how transmission occurs. Most knew that treatment is beneficial (Kabatereine et al. 2014).

A study conducted in Yemen surveyed adults from 250 households across five rural provinces. A questionnaire was used to collect data regarding demographics, water and hygiene practices, history of receiving schistosomiasis treatment, and knowledge about schistosomiasis with regards to etiology, transmission, symptoms, prevention, and control. Knowledge questions were open-ended to avoid guessing. 92.4% of participants had heard of schistosomiasis, and 68% could mention a symptom. Results showed that there is a lack of knowledge regarding transmission of the disease, as only 49.8% of respondents were able to mention a mode of transmission. 47.2% of people were able to give a correct measure of prevention. Misconceptions include that the disease can be transmitted through playing with soil, dirty hands, and eating contaminated food or drinking contaminated water. Less than half of respondents believed schistosomiasis can be prevented, and many thought treatment was expensive. Only 13% knew about the role of feces and urine. Education level was the most important factor associated with schistosomiasis knowledge. Age and previous infection status were also significant factors (Sady et al. 2015).

A study in Cote d'Ivoire conducted interviews with 207 household heads in two communities regarding perception, treatment, and prevention of intestinal worms and intestinal schistosomiasis. Questions were open ended, and participants were asked about symptoms, causes, treatment, and prevention of the diseases, as well as water use and sanitation practices. In one town, 57% of respondents viewed schistosomiasis as common, but in the other town, only 5% viewed the disease as common. Less than half of respondents claimed to have knowledge of urogenital schistosomiasis. Both drinking and bathing in dirty surface water were identified as modes of transmission, with most identifying drinking water as the most important mode of transmission. This affected their protective behaviors. 14% of participants in one community thought that schistosomiasis was an “inborn” disease. Blood in stool was the most commonly identified symptom. The disease is commonly confused with bloody diarrhea, dysentery, or hemorrhoids. Many participants failed to seek treatment because of a lack of knowledge of disease symptoms. Most interviewees had more knowledge of intestinal worms than intestinal schistosomiasis (Acka et al. 2010).

A study conducted in the Volta Basin of Ghana examined the knowledge, perceptions, and practices regarding schistosomiasis of 3,301 adults from 30 communities. A structured questionnaire was used to gather data. The study found that 99.4% of males and 88.7% of females associated the disease with the Volta Lake/River. Fishermen were the most likely to report having knowledge of the disease. Age and education level did not impact association with the river. Despite this association with water, knowledge about transmission varied. 60% of respondents knew that contact with the Volta was the cause of infection; however, men were significantly more likely to have this knowledge than women. 36.5% of men and 22.2% of women said they did not know the source of infection. Misconceptions in terms of transmission included sexual contact, punishment from God, drinking lake water, and eating sugar-cane. Interestingly, knowledge did not differ significantly by educational level. Knowledge of prevention was low, with only 35.4% of males and 24.7% of females answering that avoiding water contact is the best way to avoid infection. Many believed that taking drugs could help one to avoid infection. Blood in urine was the most commonly reported symptom. In terms of health seeking behavior, doing nothing, visiting a health facility, and self-medication were commonly reported, with the majority doing nothing and the minority visiting a health facility. Higher educational level was correlated with visiting a health facility. Cost was the most frequently reported reason for not seeking care (Yirenya-Tawiah et al. 2011).

A study in Zimbabwe asked participants open-ended questions about schistosomiasis and found that while most participants understood symptoms of the disease, disease transmission was not well understood. 52.9% of participants considered schistosomiasis to be a problem. 31% of participants said they did not know how the disease is transmitted, 41.1% said it is transmitted through drinking dirty water, and only 24.1% associated transmission with surface water contact (Taylor et al. 1987).

A study in Malaysia examined knowledge, attitudes, and practices of community members from 215 households regarding soil-transmitted helminth infections. An open-ended questionnaire was used to avoid guessing. Additionally, information on household water, sanitation, and hygiene, was observed. Multivariate analysis was used to find factors significantly associated with knowledge, attitudes and practices. The authors concluded that there was a lack of knowledge regarding signs, symptoms, and transmission of the disease. The authors also found that men had more knowledge than women, respondents over the age of 32 had higher levels of knowledge than those under the age of 32, and respondents with a formal education were more knowledgeable than respondents without a formal education (Nasr et al. 2013).

Focus groups and individual interviews conducted in Zanzibar indicate low knowledge of schistosomiasis. 16 focus groups of primary schoolchildren and 13 focus groups of secondary schoolchildren were conducted (n=150), along with five focus groups of community members (n=47) and individual interviews with 21 teachers, 16 parents, and 12 community leaders. Knowledge of the transmission cycle of the disease was low. Only a few students and teachers could correctly describe the cycle, and misconceptions included standing in someone else's urine, witchcraft, hexes, walking in dirt infected with organisms, eating chilies, and sexual intercourse. Parents knew the least about transmission. Symptoms were most often described as abdominal pain, itching, pain during urination, and bloody urine. Most associate the disease with boys rather than girls. Reportedly, many self-treat the disease with plant-based teas or drinking an excess of water to flush out the causative agent. Many fail to seek treatment because they feel that the medication or the transportation to get the medication would be too expensive. People also were doubtful that medication would be available even if they wanted it. Many identified children urinating in rivers as a risk factor for infection. They suggested punishing children for the practice, but also admitted that such a method might not have a great impact (Knopp et al. 2013).

A study conducted in Kano State, Nigeria amongst 505 individuals (>10 years of age) used a questionnaire with open-ended questions to assess schistosomiasis knowledge, attitudes and practices. Awareness of schistosomiasis was high, with 74.5% of respondents being aware of the disease. However, knowledge of details of the transmission cycle, source of infection, and preventative measures against infection was comparably low. 67% had no idea how the disease is transmitted, and 63.8% had no idea how to avoid becoming infected. Only 6.1% mentioned avoiding water contact as a preventative measure, although half realized that water is a transmission foci, with 27% mentioning actual water contact as the transmission mechanism. No one mentioned snails. 59% recognized blood in urine as a symptom, but few other symptoms were mentioned. 75% of those studied viewed the disease as serious, but most self-treated rather than seeking professional medical care.

Male participants were significantly more knowledgeable than female participants, and respondents under the age of 18 had a greater understanding of transmission than respondents over the age of 18. Knowledge was higher among more highly education and employed respondents. Overall, age, gender, education level, and history of infection are the most significant factors associated with participant responses (Dawaki et al. 2015).

Student Knowledge of Schistosomiasis

In Uganda, an interviewer-administered questionnaire was used to evaluate the knowledge, attitudes and practices of teachers, pupils, household heads, and health workers regarding schistosomiasis. Students were asked about disease symptoms, preventative measures, the impact of infections, treatment seeking behavior, and perceived benefits of treatment. Participants were considered knowledgeable about schistosomiasis if they answered three quarters of the questions correctly. A total of 181 students participated. 84.3% knew of schistosomiasis. Males were as knowledgeable as females, and knowledge was higher among those who had been treated for the disease. Many believed that drinking un-boiled water was responsible for schistosomiasis transmission (Kabatereine et al. 2014).

A study in Zimbabwe looked at soil-transmitted helminth, malaria, and schistosomiasis knowledge among 172 grade three schoolchildren across four schools. A questionnaire was administered that contained questions on demographics, sources of water, sanitation facilities, and knowledge of the causes and preventative strategies for schistosomiasis, soil transmitted helminthiasis, and malaria. Causes that were considered correct for schistosomiasis include: swimming or bathing in surface water, playing in the river, contact with snail infested/contaminated water, crossing the river barefoot, washing clothes or dishes in the river, urinating/defecating in the river, and fishing in the river. Preventative measures that were considered correct include avoidance of the above activities, as well as killing snails with chemicals and visiting the health center for treatment. 63.4% of students said they knew of schistosomiasis. 32% of children knew the causes of schistosomiasis while 50.6% of student had no idea of the causes. Common misconceptions included drinking dirty water, eating too much salt, and entering the toilet without shoes. Knowledge of causes did not translate to knowledge of prevention, as only 5 students mentioned avoiding swimming in rivers as a preventative strategy, while 30 mentioned swimming in rivers as a cause. 73.3% of students said they had no idea of how to prevent the disease (Midzi et al. 2011).

A study was conducted in Swaziland to evaluate the schistosomiasis knowledge, attitudes, and practices of 146 primary school children in grades 5-7. A 22-question multiple choice knowledge questionnaire was administered alongside an attitudes survey and a practices survey. 97.3% of students had heard of schistosomiasis. Only 16.4% knew the cause of the disease is *Schistosoma* worms. 74.5% identified water contact as a risk factor for infection. 52.7% identified avoiding surface water contact as means of prevention. Authors concluded that schistosomiasis knowledge was average, with a mean score on the survey of 11±1.45 points. Results indicated that knowledge is correlated to practice (Maseko et al. 2015).

Teacher Knowledge of Schistosomiasis

In Uganda, an interviewer-administered questionnaire was used to evaluate the knowledge, attitudes, and practices of teachers, pupils, household heads, and health workers regarding schistosomiasis. Teachers were asked about disease symptoms, preventative measures, the impact of infections, treatment-seeking behavior, and perceived benefits of treatment. Participants were considered knowledgeable about schistosomiasis if they answered three quarters of the questions correctly. 104 teachers participated in the study and 80.4% of teachers knew of schistosomiasis. Males were not found to be more knowledgeable than females. Those who had been treated for the disease had more knowledge than those who had never been treated. Many believed that drinking un-boiled water was responsible for schistosomiasis transmission (Kabatereine et al. 2014).

Barriers to Improving Knowledge

There are a variety of barriers to improving knowledge through educational initiatives. In Western Kenya, many people have attitudes that make schistosomiasis control more difficult. People believe that having the disease indicates sexual promiscuity, as it can be confused with diseases like syphilis and HIV. Others believe that having the disease denotes dirtiness. Additionally, community members may not view the disease as serious (Musova et al. 2014). Researchers in Uganda found that health education messages can be conveyed in a manner that appears irrelevant to local experience, or point to actions that community members feel are out of their control (Kabatereine et al. 2014). In Yemen, many community members were confused regarding the differences between schistosomiasis and soil-transmitted helminth diseases. This might result from mass drug administration that targets many diseases at the same time, thus conflating the diseases in the minds of those who are treated (Sady et al. 2015). A study in Cote d'Ivoire also mentioned that schistosomiasis is frequently confused with other diseases, and that knowledge is a combination of information received from health education and prevailing cultural wisdom, and can thus contain many inconsistencies (Acka et al. 2010).

Conclusions and Next Steps

A study in Western Kenya concluded that strengthening the role of teachers in health education in order to deliver health education messages is essential. The authors said that there is a great need for health education on transmission, symptoms, and risk factors of the disease, and that this knowledge can be effectively delivered in schools. Researchers proposed that perhaps community members have erroneous knowledge because there is apathy surrounding the disease. Communities have various health issues to contend with, and may not consider urogenital schistosomiasis the most important disease to understand and learn about. Thus, understanding the symptoms of the disease and the threat that it poses to one's health is of utmost importance. Researchers also discussed the fact that erroneous beliefs about treatment increase the risk of individual morbidity and place the entire community at greater risk of infection (Musova et al. 2014).

Another study in Western Kenya highlighted the importance of understanding gaps in the knowledge before performing a health education intervention, so that interventions can be appropriately targeted. The study stressed the need for educational interventions that focus on causes, transmission, treatment, and prevention of schistosomiasis (Odhiambo et al. 2014).

A study in Uganda concluded that awareness and knowledge about schistosomiasis is low, especially with regard to disease transmission and prevention. Thus, school health education should be strengthened so that schoolchildren can spread correct knowledge throughout the community (Kabatereine et. al 2014). A study in Yemen similarly concluded that health education is necessary (Sady et al. 2015). A study in Cote d'Ivoire also concluded that health education should be prioritized, and school and community structures should be integrated so that students can spread knowledge within their communities (Acka et al. 2010). A study in Ghana also recommended health education as means of controlling the disease (Yirenya-Tawiah et al. 2011).

A study in Zimbabwe identified gaps in the knowledge of third grade students regarding schistosomiasis. The study found that there is a lack of health education on the disease, and information is failing to reach its target age group. Education of school aged children is an integral aspect of schistosomiasis disease control (Midzi. et al. 2011).

Part 3: Measuring Water, Sanitation, and Hygiene Infrastructure

Insert a general introductory sentence for this section on measuring WASH. A study in Western Kenya assessed the water and sanitation infrastructure at the school level. They calculated students per latrine. If there was no soap or if soap was sometimes present, a score of zero was given, and if there was soap, a score of 1 was given (Freeman et al. 2015).

A study in Ethiopia calculated both a water and a sanitation score at schools. For the sanitation score, researchers used several characteristics including the ratio of boys' latrines to boys and girls' latrines to girls, whether latrines were shared by gender, presence of doors, type of sanitation, the condition of the floors, the cleanliness of the floor and walls, the presence of flies, and the presence of odor. For the water score, researchers considered exposure to potentially schistosome-infested water. Schools that did not use surface water were given a score of 0, as were those schools in which students did not bring water to school. For schools that collected surface water, a score was calculated based on the frequency of water collection (Grimes et al. 2016).

A study that combined data from 70 countries calculated a water metric based only off of where water was collected. Boreholes, protected wells, and unprotected wells were defined as basic water technology, while piped water systems were defined as advanced water technology. Surface water was considered to be no access to water and was used as a reference category (Gunther and Fink 2010). Similar methodology was used in their 2011 paper, except they used the groups 'improved', 'unimproved', and 'advanced' (Gunther and Fink 2011).

In a separate study, water source quality was coded as poor if the primary source of water was surface water such as rivers, lakes, or standing rainwater. The water source was coded as of intermediate quality if the primary source was below the surface, such as all springs, boreholes, standpipes, wells and dug wells, but not part of a public piped system. Lastly, water source quality was coded as high if the household reported direct access to piped water or bought drinking water from vendors. (Fink_et al.2011)

A study in Benin defined unimproved water as water from a dam, pool, river, stream, or rainwater tank, and improved water as piped water, water from a drilled well, or water from a water tower (Johnson et al. 2015). A study in Haiti calculated children per latrine at each school participating in the study. The study also surveyed the reasons why children chose not to use latrines even if they were present. The study surveyed the water resources at each school and the hand washing facilities at each school including presence of soap (Giardina_et al. 2013). In Nicaragua, researchers calculated a student to toilet ratio. They also assessed if schools had access to water infrastructure and if that water infrastructure was working (Jordanova et al. 2015).

Significance

Data on UGS knowledge among endemic populations in the Eastern Region of Ghana is extremely limited. This is the first study that has attempted to comprehensively describe the baseline knowledge of students regarding UGS in Ghana. Additionally, the use of a multivariate regression model to predict individual student knowledge is a tool that is not often used when assessing UGS knowledge. Previous studies among have determined what participants know and do not know regarding UGS, but have stopped short at determining the factors that predict high and low levels of knowledge (Midzi et al. 2011; Odhiambo et al. 2014; Acka et al. 2010; Musuva et al. 2014). Data on the baseline knowledge of schoolchildren regarding UGS is imperative so that the Ghanaian government can implement effective UGS interventions, especially those that specifically target gaps in knowledge regarding UGS. Additionally, it is important to understand the factors that predict high and low levels of UGS knowledge, so that UGS educational interventions can be targeted towards populations that have low levels of knowledge regarding the disease.

Research Questions

1. Describe the baseline knowledge of students and teachers regarding UGS
2. Describe the water and sanitation infrastructure at each school included in the study
3. Determine significant predictors of UGS knowledge among schoolchildren

Methods

Study Population

Data about the study population was collected in the Eastern Region of Ghana from 15 June to 1 July 2015. The Eastern Region was purposively selected because it is highly endemic for UGS and surface water is widely available and used. The method of selecting study communities is explained in detail elsewhere (Kulinkina et al. 2017); briefly, we created a sampling frame of 226 communities in the Eastern Region with between 500 and 5,000 inhabitants (2000 Census). 75 communities in 10 adjacent districts outside of a 20-kilometer buffer from Lake Volta were selected on the basis of their water infrastructure; this was done for a separate study on water quality and quantity (Kulinkina et al. 2017). For the present study, we chose a random sample of 40 towns from among the list of 75 towns, given that a series of water-infrastructure geospatial data layers were available for these 75 towns.

In each of the selected study towns, the largest available public school was approached for participation in the study. If the largest available school did not have both a primary school and a junior high school, then the largest available primary school and the largest available junior high school were separately selected. Out of the 40 towns selected, 37 had schools that participated in the study. Two schools did not participate because all students were absent from school on the day that the school would have been surveyed. A third school did not participate because the school closed for the day before it could be surveyed. We did not attempt to survey these schools again due to limited time and resources.

We contacted school heads at each selected school and asked if we could survey their primary school four (P4) and junior high school two (JHS2) students about UGS knowledge. We also asked if we could survey the P4 class teacher (or the P4 science teacher if the school conducts subject teaching in primary school), and the JHS2 science teacher. School heads were contacted on the day we visited the school to perform the survey, and students and teachers were surveyed immediately following school head approval. P4 refers to students in their fourth year of primary school, while JHS2 refers to students in their second year of junior high school. All P4 and JHS2 students in selected schools were invited to participate in the study. P4 students were surveyed because they are typically 9-12 years of age, an age group that is particularly at risk of contracting UGS (WHO 1993, Bradley and McCullough 1973, King et al. 2004, Oladejo and Ofoezie 2006). P3 students, who also fall in this critical age group, were not surveyed because their English reading skills were not sufficient to participate. JHS2 students were surveyed because they were the most senior students available in school at the time the study was conducted, and their knowledge levels were expected to represent a cumulative knowledge of UGS gained from all of their prior years of school attendance.

Data Collection: UGS Knowledge Among Schoolchildren

Student knowledge data was collected via a written survey during normal school hours. All study participants were aware that the study was intended to assess schistosomiasis knowledge. Participants completed their written surveys independently in their regular classroom. The survey was written in English, which is the language of instruction in Ghana. However, to ensure understanding, a native Twi speaker read each question aloud in Twi before students recorded their answers. The entire classroom of students proceeded through the survey at the same pace. The question was read aloud as many times as necessary to ensure understanding.

The survey was anonymous in that no identifying information was collected. It consisted of 22 questions (Appendix A), 21 of which were closed-ended and students were prompted to respond by underlining either "true," "false," or "I don't know." The "I don't know" option was included to reduce guessing. One question was open-ended. The survey tested knowledge of UGS transmission (11 questions), UGS prevention (4 questions), UGS symptoms (4 questions), and UGS treatment (3 questions). The survey was originally written in English, translated into Twi, and back translated into English by a separate translator. It was pilot tested in non-participating schools in the Atiwa District of the Eastern Region. Questions were developed based on the peer-reviewed literature and educational materials developed by the World Health Organization (WHO 2002).

Data Collection: UGS Knowledge Among Teachers

All teachers were matched with the students who participated in the study. Only P4 and JHS2 teachers who were directly responsible for teaching science were included in the study. This was either the science teacher or the general class teacher. Science teachers are responsible for teaching about health, and are thus the teachers who deliver the Ghana Education Service UGS curriculum to students. Participating teachers were given a paper survey in English, which they completed independently and in a room separate from their students. The knowledge survey for teachers had two parts. The first part asked teachers to recall 5 facts about UGS and asked two questions about UGS treatment, one of which was closed-ended and one of which was open-ended (Appendix A). The two treatment questions matched questions from the student UGS survey. Open-ended questions were used to avoid bias from recognition. The second part of the survey contained 49 questions, one of which was open-ended, three of which were multiple choice, and 45 of which were closed-ended and could be answered with either “yes” or “no.” 18 of the closed-ended questions matched questions from the student UGS survey (Appendix A). Teachers answered “yes” or “no” because they took the survey in English without a Twi translation. Students answered “true” or “false” because it made more sense in the context of the spoken Twi translation. Additionally, the format of the questions that appeared on both the student and teacher surveys sometimes differs because the student survey had to make sense in the context of a Twi translation while the teacher survey did not. Given that the goal of the study was to identify predictors of student knowledge of UGS, the 20 teacher survey questions that matched questions from the student survey were extracted for further analysis.

Data Collection: WASH Infrastructure

Water, hygiene, and sanitation infrastructure data was collected in the study communities a year after the student and teacher knowledge surveys (May-June 2016). At each school, the drinking water infrastructure, hand-washing infrastructure, and sanitation infrastructure were evaluated using a standardized observation checklist. We asked the teacher in charge of hygiene at each school to show us where drinking and hand-washing water were stored and to state the original source of the water. Wherever possible, we visited the original water source to confirm the type of infrastructure used. To assess sanitation infrastructure, we asked the teacher to show us the school’s urinals and latrines.

If there was no teacher specifically in charge of hygiene, we asked the school head to nominate a knowledgeable teacher to show us the water and sanitation infrastructure.

Data Collection: District and Town Level Variables

Information describing the 9 districts surveyed was found in reports authored by the Ghana Statistical Service. The data was collected by the government in the 2010 census and aggregated into reports on each district and on the Eastern Region as a whole. We extracted information on district population, literacy rates, educational attainment, employment status, incidence of poverty, toilet facilities, and water collection. Metrics describing the water resources found in the 37 participating towns and town populations were extracted from a previous study on water resources in the Eastern Region (Kulinkina et al. 2017).

Data Coding

Data collected during this study were entered into Microsoft Excel for Mac 2011 (Version 14.5.1). We coded student knowledge data by assigning each student a score according to their performance on the 22 question UGS knowledge survey. Students were assigned one point for each question answered correctly, and were assigned no points for answering incorrectly or answering "I don't know." Scores out of 22 were converted into a percentage out of 100, and we treated incorrect responses as being different from answers of "I don't know" in further analysis.

We assigned each teacher two scores according to their performance on the teacher UGS knowledge survey. The first score was calculated by scoring teacher performance at naming five facts about UGS. Given that these were open-ended response questions, two independent study team members coded each response as correct, incorrect, or missing. Following the independent coding, we discussed and rectified discrepancies. Teachers were awarded one point for each correct response and awarded no points for each incorrect or missing response; incorrect and missing responses were treated as different values in subsequent analyses. Responses were coded as missing if teachers named fewer than five facts, named a fact that repeated information from a previous fact, or named a fact that was non-specific (such as, "the disease is painful.") The second score was calculated using the 20 teacher survey questions that matched student survey questions. Teachers were assigned one point for each question answered correctly, and were assigned no points for answering incorrectly, or, in the case of the one open-ended question, answering "I don't know." Scores out of 20 were converted into a percentage out of 100.

For each school, we calculated a water infrastructure metric, a hygiene metric, a sanitation metric, and an overall WASH metric. Metrics were constructed based on a review of the literature, and we followed the WHO definitions of improved and unimproved water sources (Freeman et al. 2015, Grimes et al. 2016, Gunther and Fink 2010, Gunther and Fink 2011, Fink_et al.2011, Johnson et al. 2015, Giardina_et al. 2013, Jordanova et al. 2015). For the water metric, schools were assigned a 2 if they collected water from an improved source and stored water in a covered container with a tap; schools were assigned a 1 if they collected water from an improved source and stored water in a covered container; and the remaining schools were assigned a 0. For the hygiene metric, schools were assigned a 2 if they collected water from an improved source, stored the water in a covered container with a tap, and provided soap to students; schools were assigned a 1 if they collected water and provided soap; and the remaining schools were assigned a 0. For the sanitation metric, schools were assigned a 2 if there were < 50 students per latrine and < 75 students per urinal; schools were assigned a 1 if there were ≥ 50 students per latrine or ≥ 75 students per urinal or they were lacking either a urinal or a latrine; and the remaining schools were assigned a 0. To calculate the overall WASH metric, the water, hygiene, and sanitation metrics were summed.

Data Analysis

Data analysis was conducted in SPSS (Version 23). Chi-squared and ANOVA analyses were used to determine preliminary associations between student demographic characteristics and their score on the urogenital schistosomiasis knowledge survey. Exploratory data analysis confirmed that knowledge scores were normally distributed. We then used univariate and multivariate linear regression models to assess the differential effects of potential predictor variables in terms of explaining the variability in schoolchild knowledge of UGS. The outcome variable of each model was the percentage of questions answered correctly on the 22-question student UGS knowledge survey. Predictor variables explored were sex, year in school, district of residence, town of residence, teacher knowledge of UGS, school WASH infrastructure, town water infrastructure, and district characteristics.

Ethics Statement

This study was granted exemption under category one by the Institutional Review Board of Tufts University in Medford, Massachusetts. Permission was obtained from school heads prior to inviting any students to participate in the study. All study participants were informed that they could opt out of the study at any time. We did not collect any personal identifying information, and results were presented in such a way that scores cannot be traced back to individual students or teachers.

Results

Descriptive Statistics: Schoolchild Knowledge of UGS

We surveyed 1,813 schoolchildren across 9 districts in the Eastern Region of Ghana; 875 (51.4% female) were P4 students and 938 (45.1% female) were JHS2 students (Table 1). The average score on the UGS knowledge survey for all students was 57.4% correct (SD=13.2), while for P4 students the average score was 51% correct (SD=13.5) and for JHS2 students the average score was 63% correct (SD=10.2). Figure 1 presents the distribution of scores for all students, while Figure 2 presents the distribution of scores for P4 students, and Figure 3 presents the distribution of scores for JHS2 students. All three figures indicate distributions that are approximately normal, with a slight left skew. The distribution of scores is tighter for JHS students than for P4 students (Figure 4).

The average score for boys was 60% correct (SD=12.4), while the average score for girls was 55% correct (SD=13.4) The difference between boys and girls was more pronounced for P4 students than for JHS students (Figure 4). Table 2 indicates how students performed on average, split by grade and sex, in each district. Tables 3 through 7 indicate how students performed, on average, and split by grade and sex in each town. Boys outperformed girls in the majority of cases and JHS2 students generally outperformed P4 students.

Students performed best on the “symptoms” and “protective measures” sections of the survey, with average scores of 76% correct (SD=20.6) and 69% correct (SD=25.2), respectively. Students performed worst on the “treatment” and “transmission” sections of the survey, with average scores of 44% correct (SD=22.5), and 50% correct (SD=15.1), respectively (Figure 5). Students expressed the most uncertainty on the question that asked them to name the drug that treats UGS. Only 5 students (0.23% of the total students) answered this question correctly. All of these students were in JHS2, 3 were boys, 1 a girl, and 1 did not specify their gender. 84.8% of JHS2 boys, 85.9% of P4 boys, 92.4% of JHS2 girls, and 92.9% of P4 girls answered "I don't know" to this question. The remaining students offered an incorrect answer. Students also demonstrated high uncertainty on the question that asked them whether one contracts UGS from washing a car with river or pond water. Only 5.3% of JHS2 boys, 9.5% of P4 boys, 5.2% of JHS2 girls, and 10.0% of P4 girls answered this question correctly. Students performed best on the question that asked them whether it is fine to urinate in the river. 97% of JHS2 boys, 91% of P4 boys, 96% of JHS2 girls, and 89% of P4 girls answered this question correctly.

Table 1. Age and sex of students for all P4 and JHS2 students in all 9 districts surveyed (n=1,813).

	P4		JHS2	
District	Mean Age (SD)	% Female	Mean Age (SD)	% Female
Atiwa (N=104)	11.1 (1.3)	45.3	15.1 (1.6)	41.2
Ayensuano (N=191)	11.6 (1.4)	46.1	15.5 (1.5)	44.1
Birim Central (N=69)	11.8 (1.1)	40.0	15.3 (1.6)	51.0
Birim South (N=185)	11.8 (1.3)	50.0	15.3 (1.0)	43.2
Denkyembour (N=91)	11.5 (1.1)	61.0	15.1 (1.2)	50.0
Kwaebibirem (N=191)	11.3 (1.4)	56.4	15.6 (1.3)	54.9
Suhum (N=119)	11.5 (1.6)	69.7	15.8 (1.5)	47.2
Upper West Akim (N=530)	11.8 (1.5)	49.6	15.5 (1.6)	42.6
West Akim (N=333)	11.4 (1.6)	49.4	15.6 (1.6)	41.2

Table 2. Average performance on the 22-question UGS knowledge survey by district.

District	Class Year	Sex	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Atiwa	JHS2	boys	29	50	86.4	67.1	9.8
		girls	21	45.5	81.8	65.2	9.5
	P4	boys	29	27.3	86.4	59.1	14.0
		girls	24	36.4	77.3	55.5	11.6
District Totals			104	27.3	86.4	61.8	12.2
Ayensuano	JHS 2	boys	57	45.5	86.4	63.2	9.1
		girls	45	27.3	77.3	57.7	11.9
	P4	boys	47	13.6	81.8	53.4	14.2
		girls	41	18.2	68.2	43.9	11.1
District Totals			191	13.6	86.4	55.1	13.7
Birim Central	JHS 2	boys	24	50.0	81.8	69.1	8.2
		girls	25	54.6	81.8	65.8	6.4
	P4	boys	10	45.5	68.2	56.8	7.2
		girls	8	36.4	68.2	52.8	11.1
District Totals			69	36.4	81.8	63.4	10.4
Birim South	JHS 2	boys	53	45.5	77.3	63.6	7.5
		girls	41	40.9	72.7	59.8	9.5
	P4	boys	45	9.1	77.3	57.2	11.9
		girls	45	27.3	77.3	54.7	12.1
District Totals			185	9.1	77.2	59.1	10.8
Denkyembour	JHS 2	boys	25	45.5	77.3	64.7	8.0
		girls	25	45.5	77.3	62.4	9.0
	P4	boys	16	22.7	68.2	53.1	11.9
		girls	25	27.3	81.8	53.5	13.5
District Totals			91	22.7	81.8	58.9	11.8
Kwaebibirem	JHS 2	boys	50	40.9	86.4	64	9.6
		girls	62	36.4	81.8	61.9	10.1
	P4	boys	34	27.3	72.7	55.6	9.4
		girls	44	22.7	68.2	45.5	11.4
District Totals			191	22.7	86.4	57.5	12.4
Suhum	JHS 2	boys	28	40.9	81.8	59.1	10.9
		girls	25	45.5	72.7	60.7	8.8
	P4	boys	19	27.3	72.7	53.1	12.8
		girls	46	13.6	68.2	43.1	13.7
District Totals			119	13.6	81.8	51.9	14.6
Upper West Akim	JHS 2	boys	153	27.3	86.4	64.7	10.3
		girls	116	27.3	81.8	62.8	11.0
	P4	boys	122	9.1	81.8	53.5	13.3
		girls	128	18.2	77.3	48.7	13.1
District Totals			530	9.1	86.4	57.5	13.8
West Akim	JHS 2	boys	88	40.9	86.4	63.9	9.5
		girls	63	36.4	77.3	60.8	10.8
	P4	boys	89	13.6	81.8	51.8	14.1
		girls	89	9.1	77.3	51.9	13.3
District Totals			333	9.0	86.4	56.7	13.5
Population Totals			1813	9.1	86.4	57.4	13.2

Table 3. Average performance for all students on the 22-question UGS knowledge survey by town.

Town	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Banso	41	36.4	86.4	66.3	11.3
Akim Batabi	45	40.9	81.8	64.5	8.0
Kwaboanta	43	18.2	81.8	61.7	14.4
Asikasu	60	31.8	81.8	61.4	13.3
Akim Akroso	24	31.8	81.8	61.4	13.7
Akim Anamase	34	40.9	77.3	61.1	8.9
Akim Kokoben	58	9.1	77.3	60.3	12.2
Akim Osorase	57	36.4	77.3	60.0	9.1
Bomso	65	22.7	72.7	59.9	9.9
Asamang-Tamfoe	43	31.8	81.8	59.7	12.0
Awaham	76	13.6	86.4	59.4	12.7
Topremang	40	27.3	77.3	59.0	10.9
Okorase	79	31.8	81.8	58.9	9.0
Akim Wenchi	51	22.7	81.8	58.9	12.5
Densuso	23	45.5	72.7	58.7	8.0
Mepom	82	18.2	86.4	58.4	16.9
Krodua	43	36.4	81.8	58.2	10.7
Kakoase Anomakojo	32	40.9	77.3	58.0	10.0
Kuano	39	22.7	86.4	57.8	14.4
Sukurong-Bethlehem	44	27.3	81.8	57.7	13.2
Ekorso	20	27.3	81.8	57.3	12.1
Ammako	48	22.7	72.7	57.2	9.3
Kwasi Nyarko	54	9.1	81.8	57.1	15.2
Otumi	72	22.7	86.4	56.6	14.8
Tweapease	54	31.8	77.3	55.9	11.4
Brekumanso	61	22.7	77.3	55.5	12.9
Asuotwene	48	22.7	77.3	55.4	11.7
Asuokaw	101	18.2	86.4	55.0	15.9
Ekoso	116	9.1	86.4	54.9	16.2
Kofi Pare	24	36.4	77.3	54.4	10.3
Akim Anyinam	36	27.3	72.7	53.7	11.2
Breman	19	36.4	72.7	53.6	10.0
Nankese	28	18.2	81.8	53.1	14.2
Dome	43	22.7	77.3	52.0	11.0
Kukua	32	27.3	68.2	51.6	9.8
Akyeansa	42	13.6	72.7	49.6	13.5
Adarkwa	36	9.1	81.8	46.8	19.6

Table 4. Average performance of JHS2 boys on the 22-question UGS knowledge survey by town.

Town	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Asikasu	16	68.2	81.8	71.9	4.5
Kuano	10	59.1	86.4	70.5	8.4
Akim Akroso	7	50.0	81.8	70.1	11.7
Banso	12	54.6	86.4	69.3	8.3
Akim Batabi	17	59.1	81.8	68.7	6.6
Awaham	19	59.1	86.4	68.4	8.1
Asuokaw	30	45.5	86.4	67.7	9.1
Asamang-Tamfoe	9	50.0	81.8	67.7	9.8
Ekoso	26	54.6	86.4	67.5	8.1
Kwaboanta	12	54.6	81.8	67.4	8.4
Otumi	16	40.9	86.4	67.3	13.2
Mepom	18	45.5	86.4	66.2	11.7
Akim Kokoben	20	50.0	77.3	65.7	6.7
Sukurong-Bethlehem	14	27.3	81.8	65.6	14.7
Akim Wenchi	14	45.5	77.3	65.3	9.2
Akim Osorase	15	50.0	77.3	64.2	9.5
Topremang	11	50.0	72.7	64.0	6.6
Tweapease	13	50.0	72.7	64.0	7.3
Densuso	1	63.6	63.6	63.6	.
Ekorso	8	54.6	81.8	63.1	12.0
Krodua	17	40.9	81.8	62.8	10.4
Kakoase Anomakojo	7	54.6	77.3	62.3	10.4
Nankese	10	40.9	81.8	62.3	12.9
Dome	10	54.6	77.3	62.3	6.8
Bomso	21	50.0	72.7	61.5	7.0
Okorase	32	45.5	81.8	61.4	8.6
Akim Anyinam	11	45.5	68.2	61.2	6.5
Asuotwene	14	45.5	77.3	61.0	9.9
Brekumanso	19	40.9	72.7	60.8	9.5
Kwasi Nyarko	7	50.0	81.8	60.4	12.5
Breman	5	54.6	72.7	60.0	7.5
Adarkwa	7	40.9	81.8	59.7	13.2
Kofi Pare	7	45.5	77.3	59.7	10.6
Akim Anamase	7	54.6	68.2	59.7	4.9
Akyeansa	18	45.5	72.7	58.3	7.2
Ammako	17	45.5	72.7	58.0	8.6
Kukua	10	40.9	63.6	55.0	6.9

Table 5. Average performance of P4 boys on the 22-question UGS knowledge survey by town.

Town	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Banso	10	54.6	86.4	68.6	9.4
Kwaboanta	11	36.4	81.8	63.6	12.2
Akim Anamase	9	50.0	77.3	63.1	10.3
Okorase	13	45.5	72.7	59.1	7.7
Akim Batabi	6	50.0	68.2	59.1	6.4
Bomso	8	45.5	72.7	59.1	7.7
Kakoase Anomakojo	8	40.9	77.3	58.5	11.2
Topremang	8	40.9	68.2	56.8	9.7
Tweapease	14	40.9	72.7	56.5	8.7
Asamang-Tamfoe	15	31.8	72.7	56.4	13.3
Densuso	5	50.0	63.6	56.4	6.9
Akim Osorase	15	45.5	68.2	56.4	6.8
Asikasu	22	31.8	72.7	56.2	10.5
Kuano	12	36.4	77.3	56.1	12.0
Ammako	9	40.9	72.7	56.1	11.4
Akim Anyinam	7	40.9	68.2	55.8	10.7
Asuotwene	13	22.7	72.7	54.9	12.6
Krodua	14	36.4	72.7	54.9	12.2
Akim Kokoben	14	9.1	77.3	54.9	16.7
Breman	7	40.9	68.2	54.5	10.8
Kwasi Nyarko	12	9.1	81.8	54.5	18.4
Nankese	4	50.0	54.6	53.4	2.3
Akim Akroso	4	45.5	63.6	53.4	7.8
Adarkwa	4	27.3	72.7	52.3	21.8
Otumi	12	27.3	68.2	52.3	10.9
Sukurong-Bethlehem	8	31.8	63.6	51.7	10.3
Brekumanso	6	36.4	63.6	51.5	12.1
Kukua	6	27.3	68.2	50.8	15.6
Dome	7	40.9	59.1	50.6	7.6
Asuokaw	19	18.2	77.3	50.5	15.9
Ekoso	38	22.7	81.8	50.5	15.3
Awaham	28	13.6	77.3	50.3	14.4
Kofi Pare	10	36.4	63.6	50.0	10.3
Akim Wenchi	8	22.7	63.6	49.4	13.4
Ekorso	4	27.3	54.6	45.5	12.3
Mepom	14	18.2	68.2	45.1	15.3
Akyeansa	7	13.6	72.7	40.3	19.4

Table 6. Average performance of JHS2 girls on the 22 question UGS knowledge survey by town.

Town	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Mepom	26	50.0	81.8	71.3	6.8
Kwaboanta	11	63.6	77.3	70.2	4.2
Banso	11	59.1	81.8	69.0	7.3
Ekoso	15	50.0	77.3	68.8	8.2
Asikasu	11	50.0	77.3	68.6	9.2
Kwasi Nyarko	13	54.6	81.8	67.8	7.8
Densuso	7	54.6	72.7	66.2	6.9
Akim Batabi	16	54.6	72.7	65.9	4.4
Awaham	9	54.6	77.3	65.7	6.9
Akim Akroso	9	54.6	81.8	65.7	9.4
Topremang	12	50.0	77.3	64.0	8.5
Otumi	23	36.4	81.8	63.6	11.0
Bomso	23	40.9	72.7	63.6	7.1
Akim Kokoben	10	45.5	72.7	63.2	10.4
Asamang-Tamfoe	6	45.5	77.3	62.9	11.9
Adarkwa	7	50.0	72.7	62.3	9.4
Akim Osorase	16	45.5	72.7	61.9	7.9
Akim Wenchi	13	45.5	72.7	60.8	9.6
Kofi Pare	4	54.6	68.2	60.2	6.8
Akim Anamase	8	50.0	72.7	60.2	6.8
Sukurong-Bethlehem	11	45.5	77.3	59.9	11.1
Asuokaw	19	27.3	77.3	58.6	12.3
Okorase	17	45.5	81.8	58.3	9.5
Kuano	10	45.5	72.7	58.2	9.3
Ekorso	4	50.0	63.6	58.0	6.8
Ammako	12	50.0	68.2	57.6	6.2
Tweapease	16	36.4	77.3	57.1	11.5
Nankese	6	45.5	68.2	56.8	8.5
Brekumanso	24	36.4	77.3	56.6	12.4
Kukua	5	50.0	68.2	55.5	7.5
Asuotwene	10	40.9	72.7	55.5	9.0
Breman	2	50.0	59.1	54.5	6.4
Dome	10	40.9	68.2	54.1	8.4
Kakoase Anomakojo	3	45.5	59.1	53.0	6.9
Krodua	7	40.9	63.6	52.6	7.4
Akim Anyinam	7	40.9	63.6	49.4	8.1
Akyeansa	10	27.3	63.6	45.9	11.8

Table 7. Average performance of P4 girls on the 22-question UGS knowledge survey by town.

Town	N	Minimum (%)	Maximum (%)	Mean (%)	Std. Deviation
Akim Anamase	10	40.9	77.3	60.9	11.8
Awaham	20	50.0	72.7	60.7	6.3
Ammako	9	54.6	63.6	60.1	3.8
Krodua	5	54.6	63.6	60.0	3.8
Ekorso	4	50.0	72.7	56.8	10.8
Asamang-Tamfoe	13	40.9	72.7	56.6	10.1
Akim Wenchi	16	31.8	81.8	56.5	14.0
Kakoase Anomakojo	14	40.9	77.3	56.5	9.7
Akim Osorase	11	36.4	72.7	56.2	10.6
Akim Kokoben	14	31.8	77.3	56.2	11.5
Okorase	17	31.8	68.2	54.8	9.4
Akim Batabi	6	40.9	68.2	54.5	10.4
Densuso	10	45.5	63.6	54.1	5.4
Banso	7	36.4	77.3	52.6	15.5
Kwasi Nyarko	20	27.3	77.3	51.8	14.9
Bomso	12	22.7	68.2	51.1	14.6
Asikasu	11	31.8	72.7	49.2	15.5
Sukurong-Bethlehem	10	36.4	63.6	49.1	9.5
Asuotwene	11	22.7	68.2	48.8	12.5
Kofi Pare	3	45.5	50.0	48.5	2.6
Topremang	9	27.3	63.6	48.0	11.2
Akim Akroso	2	36.4	59.1	47.7	16.1
Kukua	11	31.8	59.1	47.1	8.4
Brekumanso	12	22.7	72.7	47.0	15.1
Kuano	6	27.3	68.2	45.5	15.2
Breman	5	36.4	54.6	45.5	8.5
Akim Anyinam	10	27.3	63.6	45.0	10.6
Dome	16	22.7	63.6	44.9	10.7
Ekoso	34	9.1	68.2	44.5	14.0
Asuokaw	30	18.2	72.7	44.4	13.2
Tweapease	11	31.8	59.1	43.8	8.9
Mepom	19	18.2	63.6	43.8	13.7
Otumi	21	22.7	59.1	43.1	9.8
Akyeansa	7	31.8	59.1	41.6	9.6
Kwaboanta	9	18.2	54.6	41.4	12.7
Nankese	8	18.2	54.6	38.6	11.9
Adarkwa	17	13.6	68.2	36.1	15.9

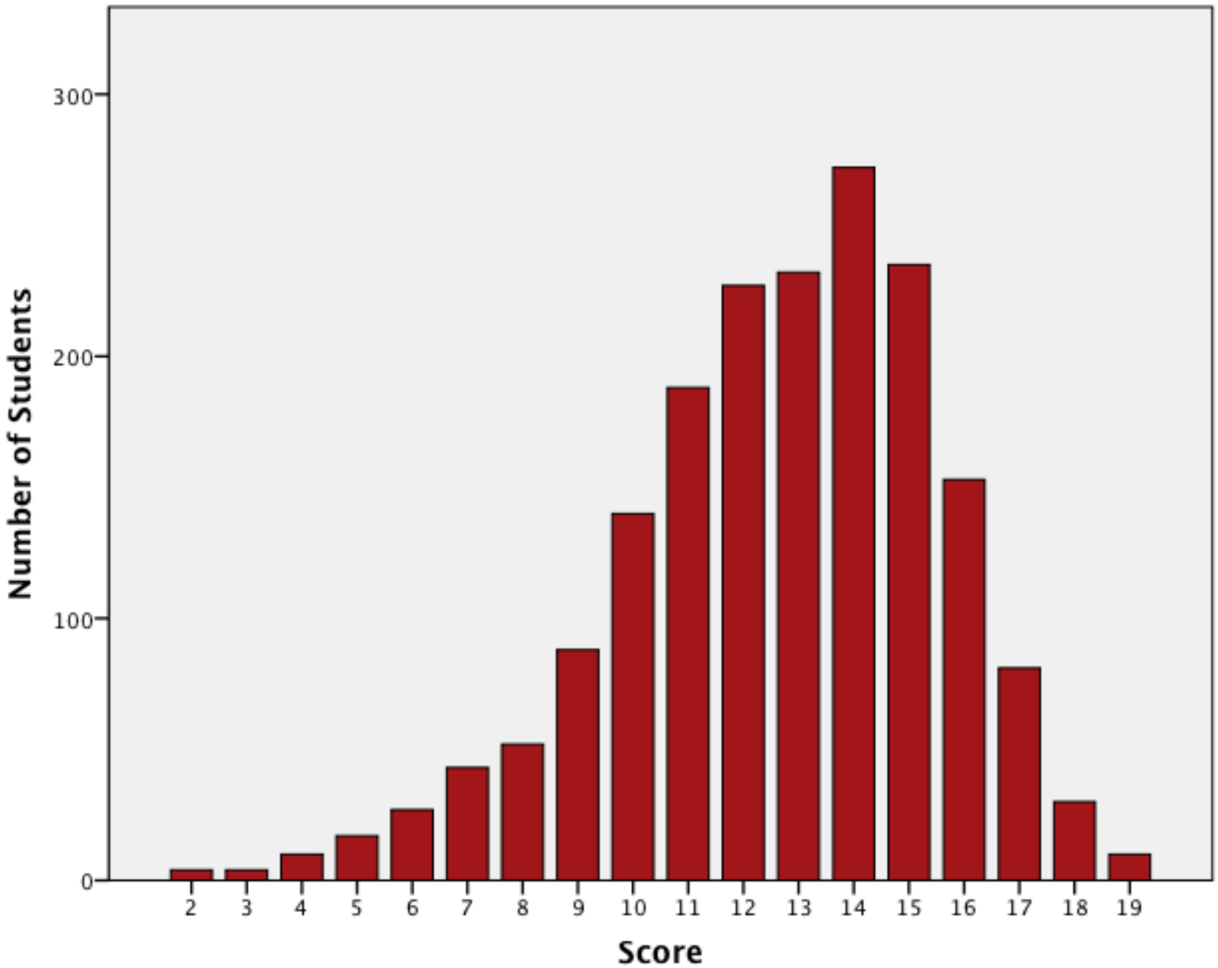


Figure 1. The distribution of scores for all 1,813 schoolchildren who took the 22-question urogenital schistosomiasis knowledge survey. Scores are presented as a raw tally of questions answered correctly out of 22.

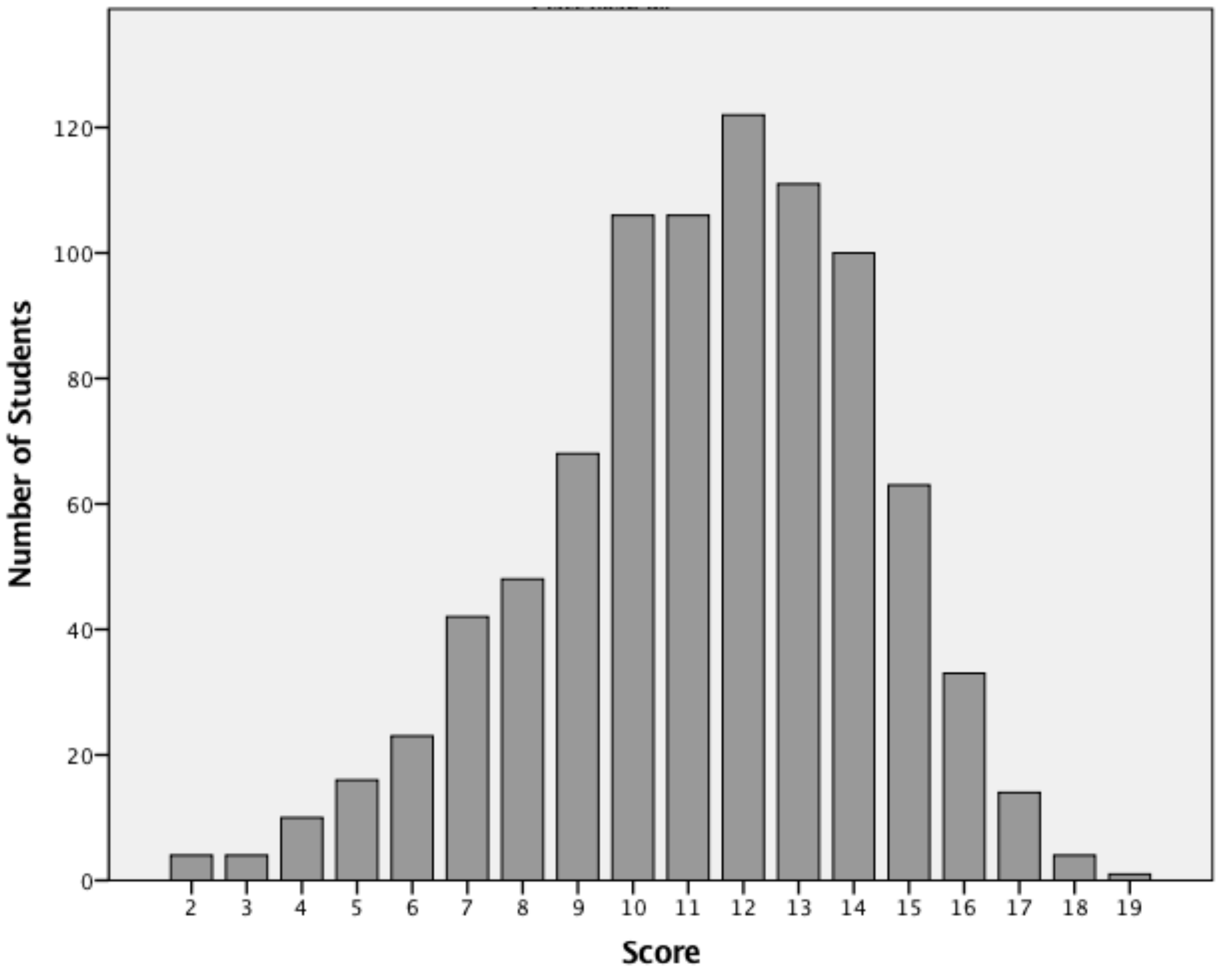


Figure 2. The distribution of scores for all P4 schoolchildren (n=938) who took the 22-question urogenital schistosomiasis knowledge survey. Scores are presented as a raw tally of questions answered correctly out of 22.

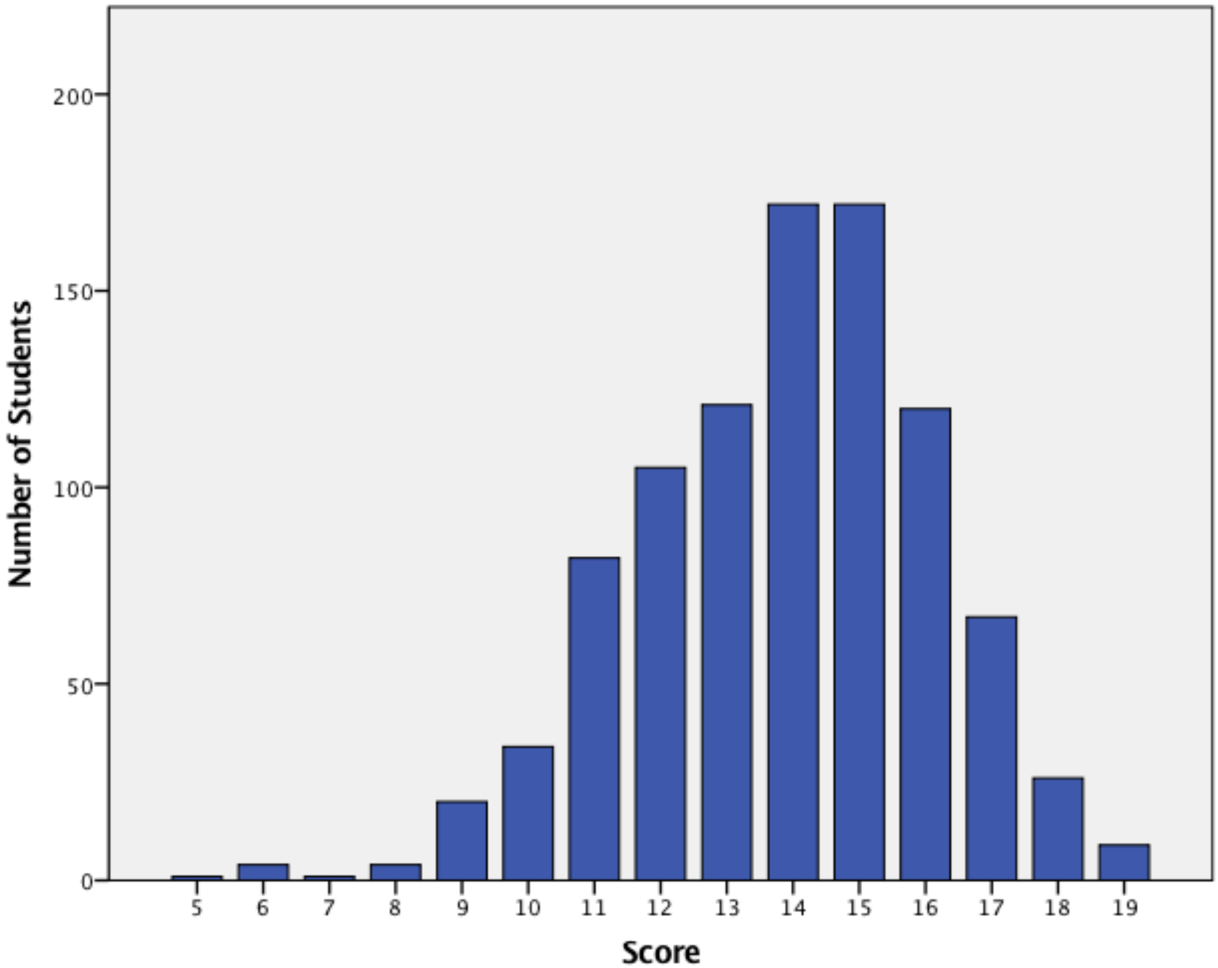


Figure 3. The distribution of scores for all JHS2 schoolchildren (n=875) who took the 22-question urogenital schistosomiasis knowledge survey. Scores are presented as a raw tally of questions answered correctly out of 22.

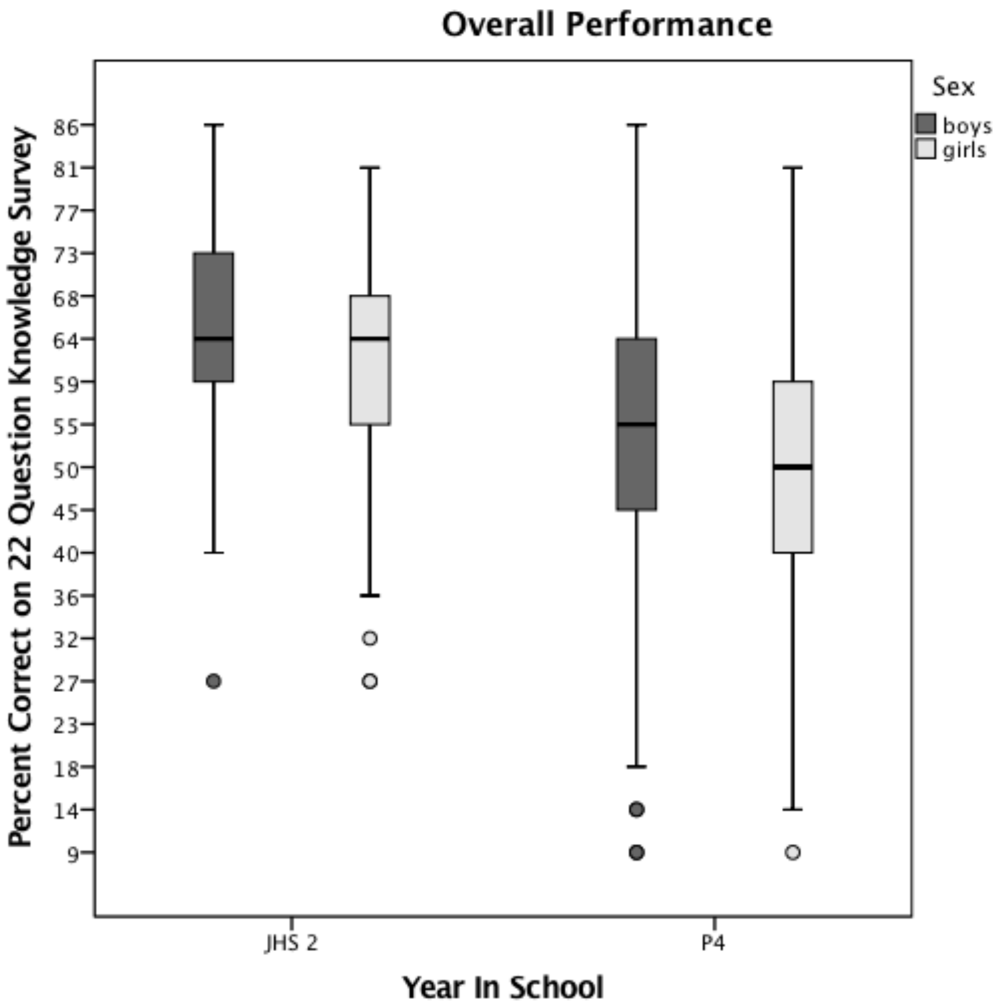
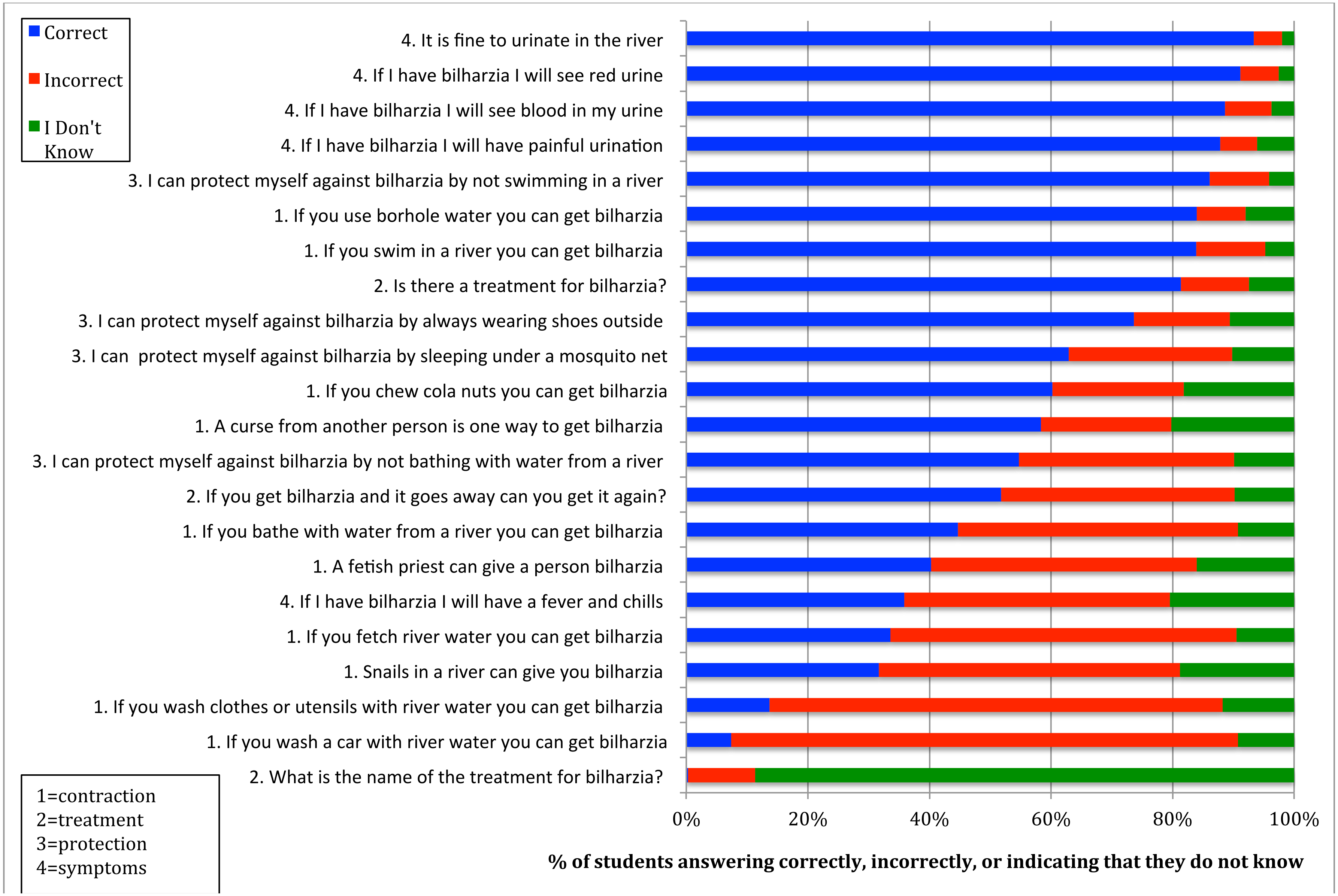


Figure 4. Boxplots depicting average scores on the 22-question UGS knowledge survey for JHS and P4 boys and girls.


Correct
Incorrect
I Don't Know
4. It is fine to urinate in the river
4. If I have bilharzia I will see red urine
4. If I have bilharzia I will see blood in my urine
4. If I have bilharzia I will have painful urination
3. I can protect myself against bilharzia by not swimming in a river
1. If you use borhole water you can get bilharzia
1. If you swim in a river you can get bilharzia
2. Is there a treatment for bilharzia?
3. I can protect myself against bilharzia by always wearing shoes outside
3. I can protect myself against bilharzia by sleeping under a mosquito net
1. If you chew cola nuts you can get bilharzia
1. A curse from another person is one way to get bilharzia
3. I can protect myself against bilharzia by not bathing with water from a river
2. If you get bilharzia and it goes away can you get it again?
1. If you bathe with water from a river you can get bilharzia
1. A fetish priest can give a person bilharzia
4. If I have bilharzia I will have a fever and chills
1. If you fetch river water you can get bilharzia
1. Snails in a river can give you bilharzia
1. If you wash clothes or utensils with river water you can get bilharzia
1. If you wash a car with river water you can get bilharzia
2. What is the name of the treatment for bilharzia?
1=contraction
2=treatment
3=protection
4=symptoms
0%
20%
40%
60%
80%
100%
% of students answering correctly, incorrectly, or indicating that they do not know

Descriptive Statistics: Teacher Knowledge of UGS

We surveyed 57 teachers, 30 of whom were JHS2 teachers and 27 of whom were P4 teachers. On average, teachers were able to name 2.9 (SD=1.2) correct, distinct facts about UGS, and the distribution of responses was approximately normal (Figure 6). On average, teachers listed 0.67 (SD=0.79) incorrect facts about UGS, and left 1.5 (SD=1.3) spaces blank. Answers were counted as blank if teachers repeated information from a previous fact, or if answers were non-specific (for example, "the disease is painful"). On average, JHS2 teachers had a slightly higher score than P4 teachers. The average score for P4 teachers was 2.7 (SD=1.3) and the average score for JHS2 teachers was 3.0 (SD=1.1). Figure 7 indicates that more JHS2 teachers named 3 and 4 correct facts than P4 teachers; however, more P4 teachers named 5 correct facts than JHS2 teachers. A paired t-test comparing the scores of JHS2 and P4 teachers from the same town indicated that there was no significant difference in score on the open-ended UGS survey between JHS2 and P4 teachers (p=0.25). However, many towns were excluded from this test because we did not have data for both JHS2 and P4 teachers, which may have biased the results towards a null finding due to a smaller sample size.

When listing five facts about UGS, the two most common correct responses were that urinating blood is a symptom of UGS, and it is a waterborne or water-related disease. While the technical definition of a waterborne disease is that the disease is transmitted through drinking water, for the purposes of this study, it was considered to be correct, as it indicates recognition that UGS is tied to the use of surface water. Additionally, it is probable that teachers did not use the term waterborne in its technical sense, but rather to describe the presence of water in the transmission cycle of UGS. The answer that UGS is a "river-borne" disease or a disease that one gets from rivers and ponds was also included in this category. The two most common incorrect responses were that one can contract the disease by drinking unclean water, and the causative organism of UGS is a bacterium (Table 8).

Of the 49 questions on the teacher true/false UGS knowledge survey, 20 of them were also on the schoolchild UGS knowledge survey. These 20 questions were extracted for analysis because they allowed for direct matching between teacher knowledge and student knowledge. On average, teachers answered 79.9% (SD=8.0) of the 20 questions correctly. JHS2 teachers answered 82.8% (SD= 7.0) of the questions correctly, while P4 teachers answered 76.7% (SD= 8.0) of the questions correctly. A paired t-test comparing the scores of JHS2 and P4 teachers from the same town indicated that there is a significant difference in performance between the two groups of teachers for the 20 questions extracted from the 49-question survey ($p=.004$). However, as with the previous t-test, many towns were excluded from this test because we did not have data for both JHS2 and P4 teachers, which may have biased the results away from a null finding.

56 of the 57 teachers knew that UGS can be treated, but only 10 of the 57 teachers (17.5%) knew that the treatment for UGS is praziquantel. Teachers performed best on the questions that asked them whether sleeping under a mosquito net is protective against UGS, and whether it is fine to urinate in the river (Figure 8). A paired t-test indicated that teachers performed significantly worse in terms of mean percentage of correct answers on the open-ended versus on the true/false surveys, respectively ($p<0.005$).

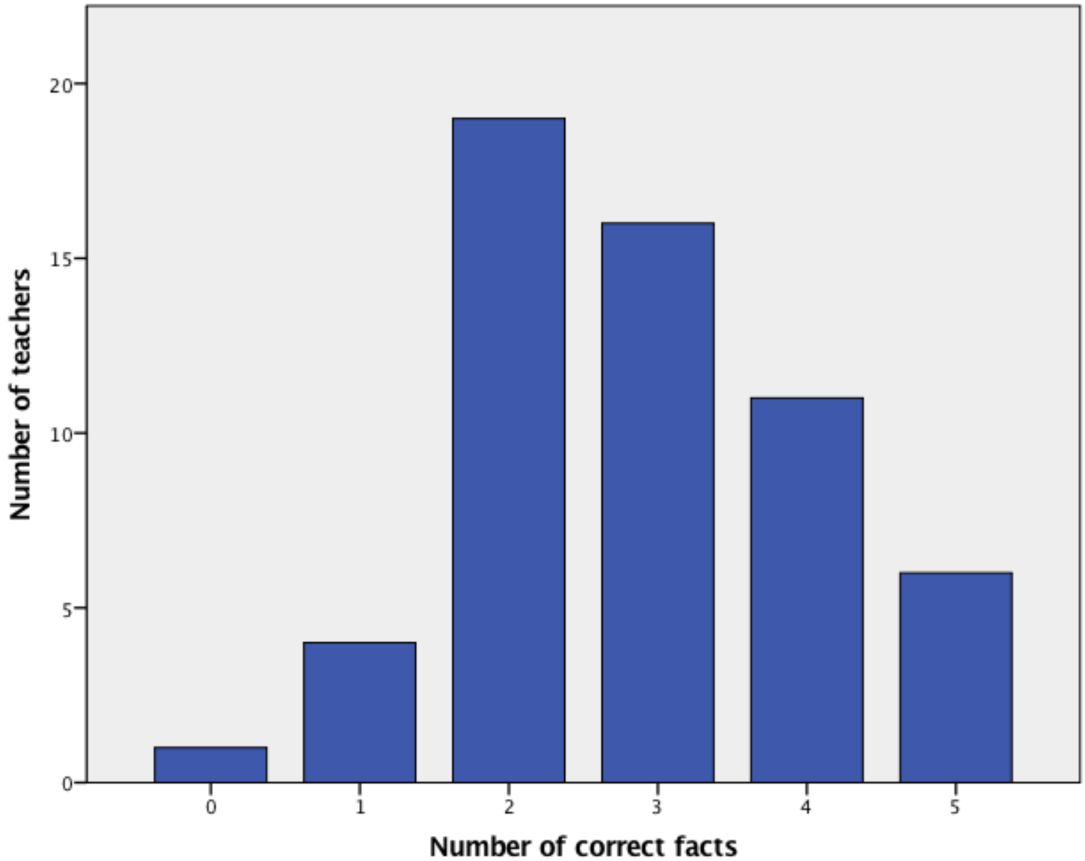


Figure 6. The number of correct facts listed on the open-ended urogenital schistosomiasis knowledge survey by all surveyed teachers (N=57).

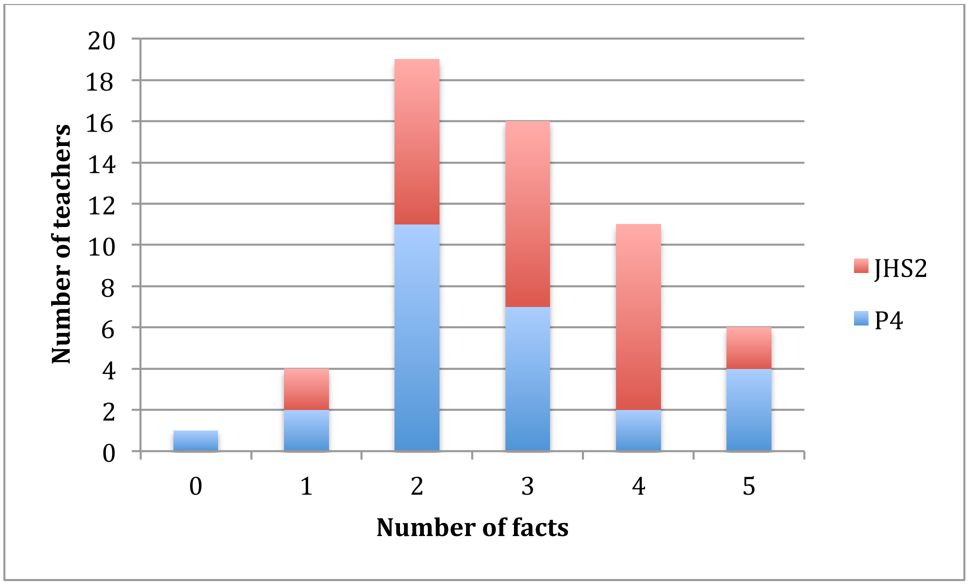
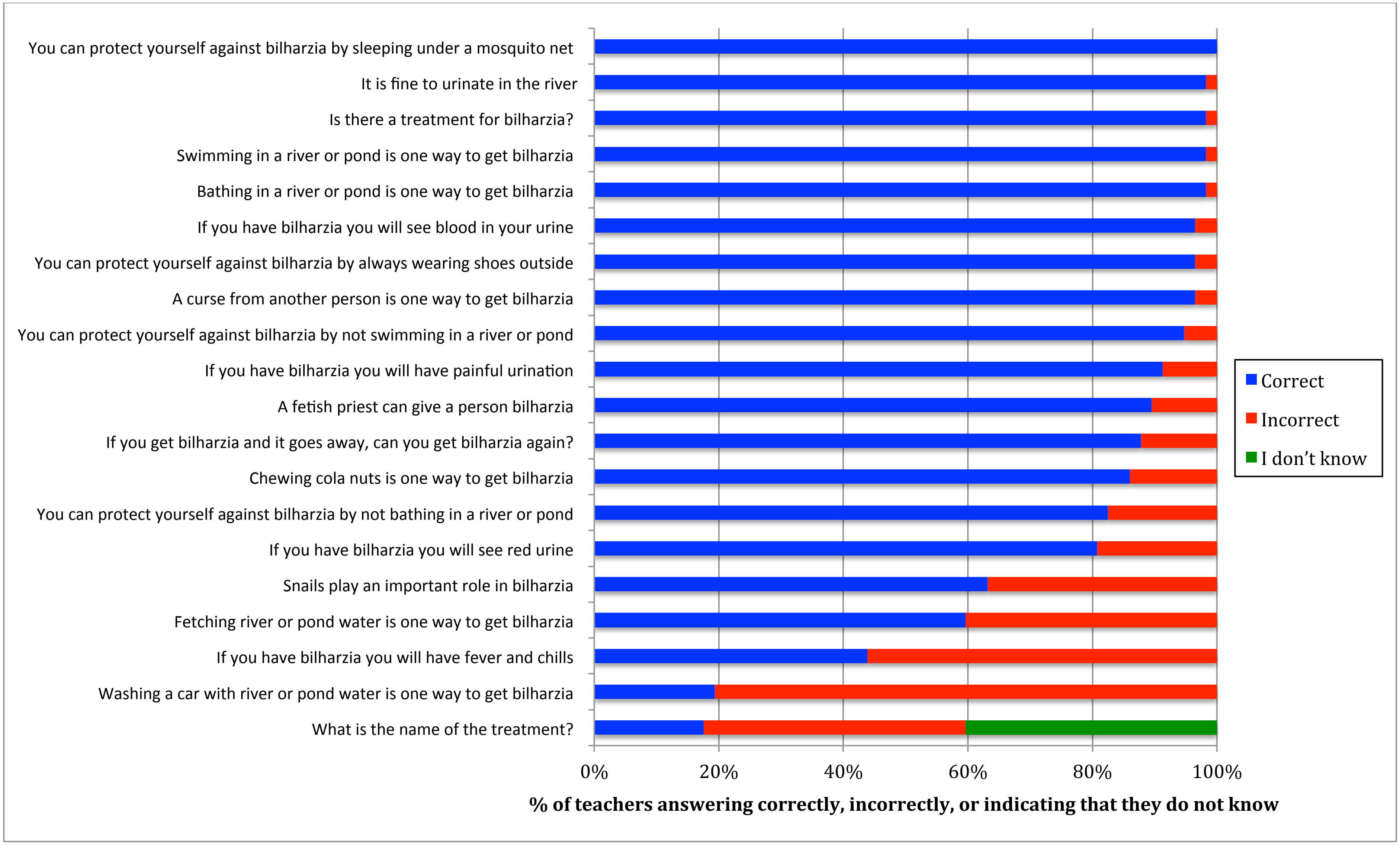


Figure 7. The number of correct facts listed on the open-ended urogenital schistosomiasis knowledge survey by P4 schoolteachers (N=27) and JHS 2 teachers (N=30).

Table 8. The most common correct and incorrect responses recorded by teachers (N=57) on the open-ended UGS knowledge survey. All responses that were recorded 3 or more times are included in the table.

	# of Mentions
Correct Responses	
Urinating blood is a symptom	42
It is a water borne/related disease	30
Contract it by swimming/bathing in surface water	18
Painful urination is a symptom	12
The causative organism lives in snails	8
It can be cured	6
It is caused by worms	6
Skin itching is a symptom	6
Abdominal pain is a symptom	4
It can be treated	4
It can cause infertility	4
It is caused by a blood fluke	3
Incorrect Responses	
Contract it by drinking unclean water	6
It is caused by bacteria	5


You can protect yourself against bilharzia by sleeping under a mosquito net
It is fine to urinate in the river
Is there a treatment for bilharzia?
Swimming in a river or pond is one way to get bilharzia
Bathing in a river or pond is one way to get bilharzia
If you have bilharzia you will see blood in your urine
You can protect yourself against bilharzia by always wearing shoes outside
A curse from another person is one way to get bilharzia
You can protect yourself against bilharzia by not swimming in a river or pond
If you have bilharzia you will have painful urination
A fetish priest can give a person bilharzia
If you get bilharzia and it goes away, can you get bilharzia again?
Chewing cola nuts is one way to get bilharzia
You can protect yourself against bilharzia by not bathing in a river or pond
If you have bilharzia you will see red urine
Snails play an important role in bilharzia
Fetching river or pond water is one way to get bilharzia
If you have bilharzia you will have fever and chills
Washing a car with river or pond water is one way to get bilharzia
What is the name of the treatment?
0%
20%
40%
60%
80%
100%
% of teachers answering correctly, incorrectly, or indicating that they do not know
Correct
Incorrect
I don't know

Descriptive Statistics: Observational Variables

74 schools were surveyed in terms of their water and sanitation infrastructure, 37 of which were junior high schools and 37 of which were primary schools. The most commonly used type of drinking water at schools was borehole water, followed by sachet water, surface water, water from a hand-dug well, and water from a pipe-system, standpipe, or tap. Three schools did not have drinking water on the premises (Table 9). Of the 74 schools, 49 stored water in a container on the premises. 37 of these containers had a lid, and 16 of them had a tap. 34 of the containers had cups near them that were used for dipping. 52 of the schools stored water for hand washing on the premises, and 34 schools had soap present on the premises.

Of the 74 schools surveyed, 25 did not have latrines and 10 did not have urinals. Of schools with latrines and urinals, there were an average of 52.1 students per latrine, and 83.4 students per urinal. There is a wide range in terms of the ratio of students to latrines, and the majority of schools had a student to latrine ratio that exceeds UNICEF recommendations (Figure 9).

Table 9. The number of schools (N=74) using each type of water infrastructure observed in the study.

Water Infrastructure	Number of schools using this type of infrastructure
Borehole	24
Sachet	15
Surface water	14
Hand-dug well	9
Pipe-system, Standpipe, or Tap	9
None	3

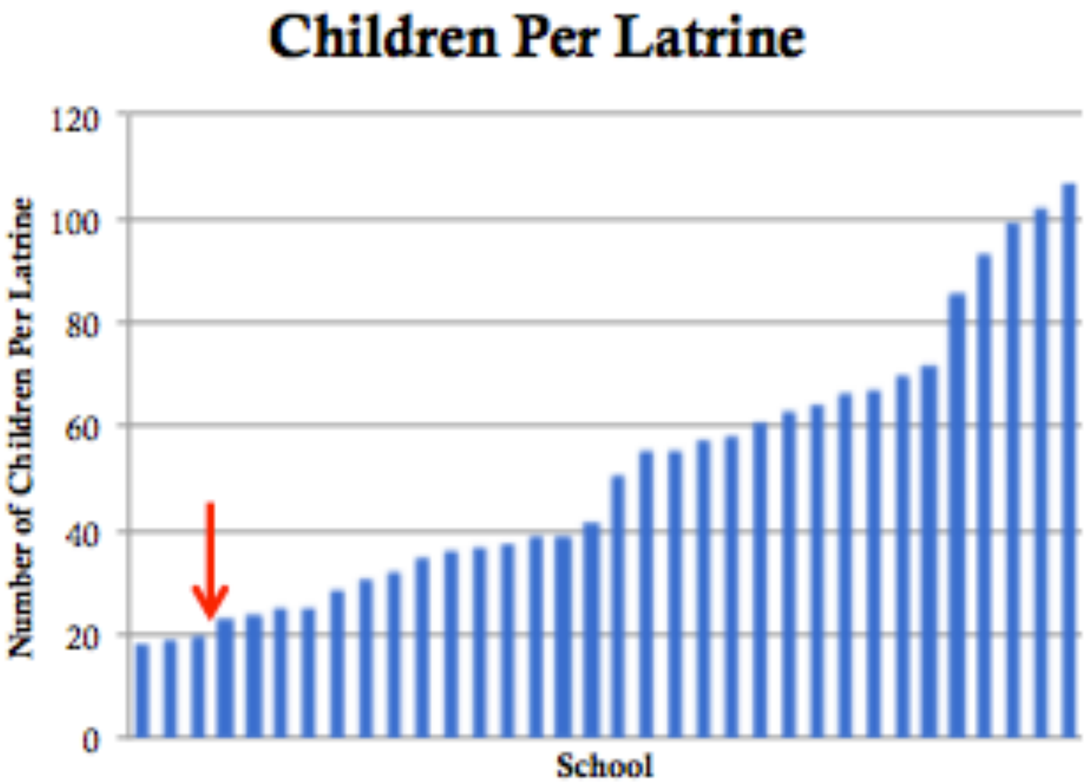


Figure 9. The number of children per latrine for all surveyed schools that had latrines on their premises. The red arrow indicates the number of children per latrine that UNICEF recommends in its core commitments for children in humanitarian action.

Exploratory Data Analysis: Student Comparisons by Sex

There is a statistically significant difference between the average percentage of questions answered correctly by male students and female students on the UGS knowledge survey ($p<0.0005$). Additionally, chi-squared tests indicate that there is a statistically significant difference in terms of individual questions. Boys were significantly more likely to answer 11 of the 22 questions correctly, and 1 of the 22 questions incorrectly. Girls were significantly more likely to answer 3 of the 22 questions incorrectly, and to answer "I don't know" on 14 of the 22 questions (Figure 10, Table 10).

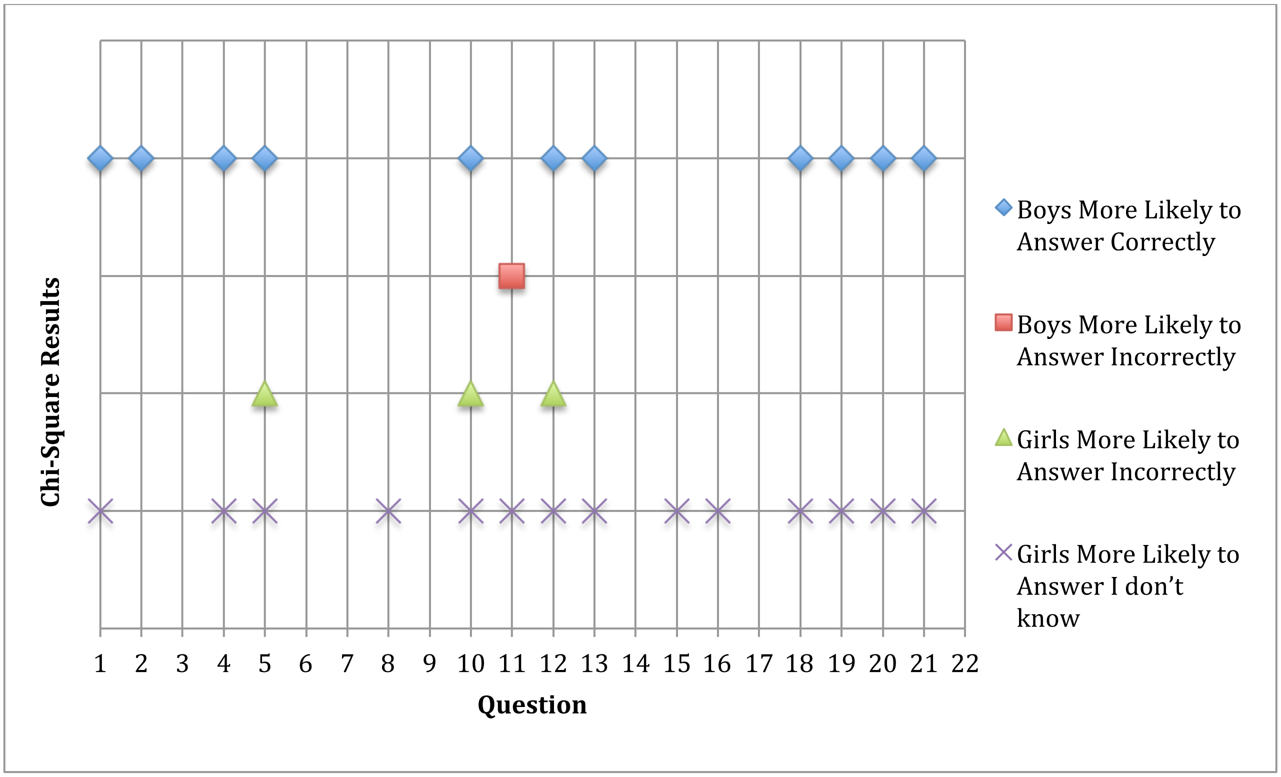


Figure 10. The complete list of questions, with statistical significance shown in terms of whether boys or girls were more likely to answer correctly, incorrectly, or indicate that they do know.

Table 10. The percentage of girls and boys answering correctly, incorrectly, or indicating that they do not know for every question on the 22-question knowledge survey. Chi-squared p-values in red indicate a statistically significant difference between male and female responses. Questions are listed in the order in which they were asked.

	Answering Correctly			Answering Incorrectly			Answering I don't Know		
	Girls (%)	Boys (%)	p-value*	Girls (%)	Boys (%)	p-value*	Girls (%)	Boys (%)	p-value*
If you chew cola nuts you can get bilharzia	56.9	63.6	0.004	22.1	20.9	0.565	20.8	15.1	0.002
If you fetch river or pond water you can get bilharzia	30.7	36.4	0.012	58.6	55.4	0.181	10.5	8.1	0.073
If you bathe with water from a river or pond you can get bilharzia	42.4	46.9	0.057	47.4	44.6	0.236	10.1	8.2	0.163
A curse from another person is one way to get bilharzia	56	60.7	0.049	20.4	22.3	0.327	23.6	16.7	0
If you swim in a river or pond you can get bilharzia	79.5	88	0	13.6	8.9	0.002	6.6	2.8	0
If you wash a car with river or pond water you can get bilharzia	7.7	7.2	0.719	82.5	84.4	0.28	9.7	8.2	0.247
If you wash clothes or utensils with river or pond water yoh can get bilharzia	13.7	13.5	0.891	73.9	75.3	0.515	12.3	11	0.418
A fetish priest can give a person bilharzia	39.4	40.5	0.63	42.5	45.4	0.216	18	14.1	0.024
If you use borehole water you can get bilharzia	82.6	85.5	0.093	9.2	6.9	0.081	8.1	7.6	0.726
Is there a treatment for bilharzia?	77.9	85	0	12.9	9.7	0.03	9.2	5.2	0.001
What is the name of the treatment for bilharzia?	0.1	0.3	0.625	7.2	14.4	0	92.7	85.3	0
If you get bilharzia and it goes away, can you get it again?	45.2	58.4	0	42.5	34.2	0	12	7.3	0.001
I can protect myself against bilharzia by sleeping under a mosquito net	59.1	66.7	0.001	28.5	25.2	0.11	12.1	8.2	0.006
I can protect myself against bilharzia by not swimming in a river or pond	85.3	87.1	0.273	9.5	0.811	0.937	4.6	3.3	0.18
I can protect myself against bilharzia by not bathing in a river or pond	52.3	56.9	0.058	35.1	35.5	0.843	12.3	7.3	0
I can protect myself against bilharzia by always wearing shoes outside	72.2	75.4	0.132	15.5	15.9	0.845	12.1	8.7	0.02
If I have bilharzia I will see red urine	90.5	91.6	0.409	6.1	6.4	0.77	3.2	2	0.102
If I have bilharzia I will see blood in your urine	87.1	90.3	0.03	8.2	6.8	0.243	4.7	2.6	0.022
If I have bilharzia I will have painful urination	85.3	90.6	0.001	6.9	5.1	0.135	7.7	4.1	0.002
If I have bilharzia I will have a fever and chills	31	40.3	0	45	42.5	0.295	23.9	17	0
Snails in a river or pond can give you bilharzia	29.2	34.5	0.017	49.6	49.1	0.85	21.2	16.3	0.009
It is fine to urinate in the river	92.4	94.6	0.083	5.3	3.9	0.177	2.3	1.4	0.218

Exploratory Data Analysis: Student Comparisons by Grade

On average, JHS2 students were significantly more likely to answer questions correctly on the UGS knowledge survey than P4 students ($p<0.0005$). Additionally, chi-squared tests indicate that there is a statistically significant difference in terms of individual questions: JHS2 students were more likely to answer correctly on 16 of the 22 questions and more likely to answer incorrectly on 6 of the 22 questions. P4 students were more likely to answer correctly on 5 of the 22 questions, more likely to answer incorrectly on 14 of the 22 questions, and more likely to answer "I don't know" on 20 of the 22 questions (Figure 11, Table 11).

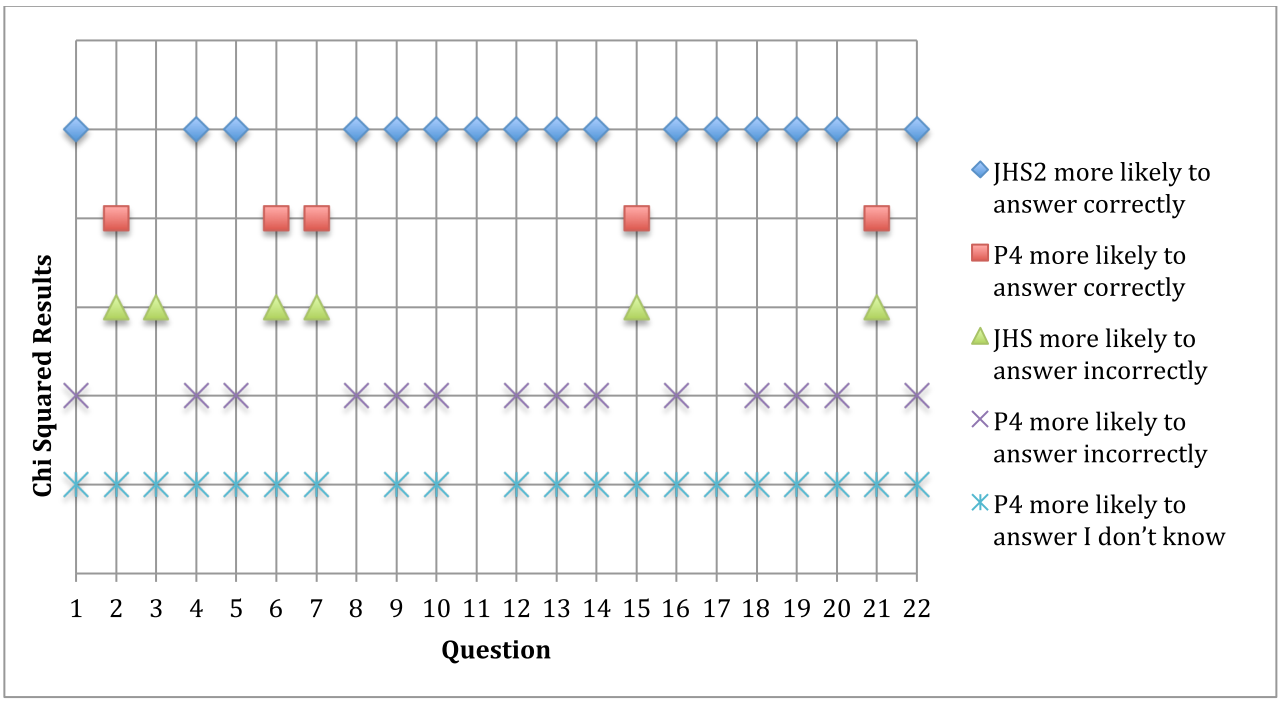


Figure 11. The number of questions that had statistical significance in terms of whether JHS2 or P4 students were more likely to answer correctly, incorrectly, or indicate that they do know.

Table 11. The percentage of JHS2 and P4 students answering correctly, incorrectly, or indicating that they do not know for every question on the 22-question knowledge survey. An * indicates that a chi-squared test was performed. Chi-squared p-values in red indicate a statistically significant difference between male and female responses. Questions are listed in the order in which they were asked.

	Answering Correctly			Answering Incorrectly			Answering I Don't Know		
Question	P4 (%)	JHS2 (%)	p-value*	P4 (%)	JHS2 (%)	p-value*	P4 (%)	JHS2 (%)	p-value*
If you chew cola nuts you can get bilharzia	44.9	74.2	0	32	11.8	0	22.6	14	0
If you fetch river or pond water you can get bilharzia	35.5	31.7	0.045	50.6	62.8	0	13.7	5.4	0
If you bathe with water from a river or pond you can get bilharzia	44.5	44.8	0.464	41.6	50	0	13.7	5	0
A curse from another person is one way to get bilharzia	42.5	72.9	0	30.6	12.8	0	26.9	14	0
If you swim in a river or pond you can get bilharzia	75.5	91.3	0	16	7	0	8.5	1.3	0
If you wash a car with river or pond water you can get bilharzia	9.7	5.2	0	75.3	90.6	0	15	3.8	0
If you wash clothes or utensils with river or pond water yoh can get bilharzia	19.1	8.6	0	63.5	84.5	0	17	6.8	0
A fetish priest can give a person bilharzia	27.8	51.9	0	55.5	32.6	0	16.7	15.4	0.239
If you use borehole water you can get bilharzia	79	88.6	0	10.6	5.5	0	10.3	5.9	0
Is there a treatment for bilharzia?	70.6	91.3	0	16.6	6.3	0	12.8	2.3	0
What is the name of the treatment for bilharzia?	0	0.5	0.037	10.9	11.2	0.439	89.1	88.3	0.305
If you get bilharzia and it goes away, can you get it again?	41.3	61.4	0	44.6	32.5	0	13.9	6	0
I can protect myself against bilharzia by sleeping under a mosquito net	43.7	80.8	0	39.7	14.8	0	16.6	4.3	0
I can protect myself against bilharzia by not swimming in a river or pond	77.7	93.7	0	14.6	5.2	0	7.5	0.9	0
I can protect myself against bilharzia by not bathing in a river or pond	58.4	50.9	0.001	27	43.1	0	14.3	5.8	0
I can protect myself against bilharzia by always wearing shoes outside	57.1	88.9	0	25.1	6.9	0	17.1	3.9	0
If I have bilharzia I will see red urine	88.8	93.2	0.001	6.6	6	0.315	4.6	0.6	0
If I have bilharzia I will see blood in your urine	83.4	93.2	0	9.8	5.7	0.001	6.4	1.2	0
If I have bilharzia I will have painful urination	80.6	94.5	0	9.3	3.1	0	9.9	2.5	0
If I have bilharzia I will have a fever and chills	23.1	47.8	0	53.7	34.2	0	23.1	17.9	0.004
Snails in a river or pond can give you bilharzia	38.7	25.2	0	40.2	58.2	0	21	16.6	0.01
It is fine to urinate in the river	89.8	96.5	0	6.5	3	0	3.5	0.5	0

Exploratory Data Analysis: Student Comparisons by Town and District of Residence

A one-way ANOVA indicated that students from different districts performed significantly differently on the 22 question UGS knowledge survey in terms of their average percentage of questions answered correctly ($p<0.0005$) (Figure 12). Fisher's least significant difference tests indicate that significance differs between individual districts (Table 12). A one-way ANOVA also indicated that students from different towns performed significantly differently on the survey ($p<0.0005$). As with districts, Fisher's least significance difference test indicates that significance differs between individual towns (Table 13).

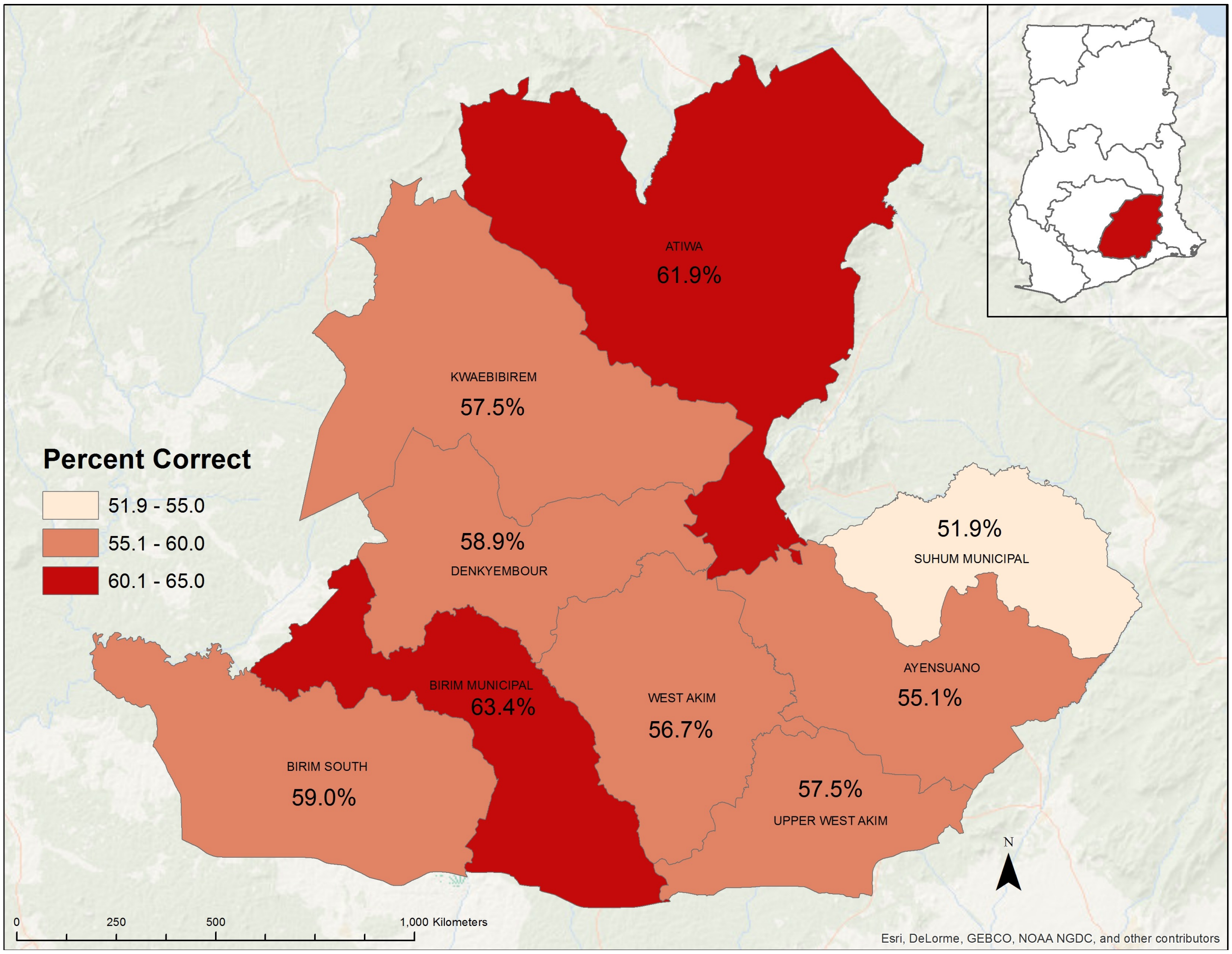


Figure 12. The 9 districts in the Eastern Region included in the study; percentages indicate the average percentage correct on the 22-question UGS knowledge survey for all students within that district. Darker colors indicate a higher average, while lighter colors indicate a lower average (created by Madeleine Wrable, 2016).

Table 12. Fischer's least significant difference tests results for all 9 districts; the test compares the average percentage correct on the 22-question UGS knowledge survey for all students in each district. An * indicates that the test was significant at the .05 level.

District	Comparison District	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Atiwa	Ayensuano	6.7*	1.6	0.0	3.6	9.8
	Birim.Central	-1.6	2.0	0.4	-5.6	2.4
	Birim.South	2.8	1.6	0.1	-0.4	5.9
	Denkyembour	2.9	1.9	0.1	-0.8	6.6
	Kwaebibirem	4.3*	1.6	0.0	1.2	7.5
	Suhum	9.9*	1.8	0.0	6.5	13.4
	Upper West Akim	4.3*	1.4	0.0	1.6	7.1
	West Akim	5.2*	1.5	0.0	2.3	8.0
Ayensuano	Birim.Central	-8.3	1.8	0.0	-11.9	-4.7
	Birim.South	-3.9	1.3	0.0	-6.6	-1.3
	Denkyembour	-3.8	1.7	0.0	-7.1	-0.5
	Kwaebibirem	-2.4	1.3	0.1	-5.0	0.3
	Suhum	3.3*	1.5	0.0	0.3	6.3
	Upper West Akim	-2.4	1.1	0.0	-4.5	-0.2
	West Akim	-1.5	1.2	0.2	-3.9	0.8
Birim Central	Birim.South	4.4*	1.8	0.0	0.8	8.0
	Denkyembour	4.5*	2.1	0.0	0.4	8.6
	Kwaebibirem	5.9*	1.8	0.0	2.3	9.5
	Suhum	11.6*	2.0	0.0	7.7	15.4
	Upper West Akim	5.9*	1.7	0.0	2.6	9.2
	West Akim	6.8*	1.7	0.0	3.4	10.1
Birim South	Denkyembour	0.1	1.7	0.9	-3.2	3.4
	Kwaebibirem	1.6	1.3	0.2	-1.1	4.2
	Suhum	7.2*	1.5	0.0	4.2	10.2
	Upper West Akim	1.5	1.1	0.2	-0.6	3.7
	West Akim	2.4*	1.2	0.0	0.0	4.7
Denkyembour	Kwaebibirem	1.4	1.7	0.4	-1.8	4.7
	Suhum	7.1*	1.8	0.0	3.5	10.6
	Upper West Akim	1.4	1.5	0.3	-1.5	4.3
	West Akim	2.3	1.5	0.1	-0.8	5.3
Kwaebibirem	Suhum	5.6*	1.5	0.0	2.6	8.6
	Upper West Akim	0.0	1.1	1.0	-2.2	2.1
	West Akim	0.8	1.2	0.5	-1.5	3.1
Suhum	Upper West Akim	-5.6	1.3	0.0	-8.2	-3.1
	West Akim	-4.8	1.4	0.0	-7.5	-2.1
Upper West Akim	West Akim	0.8	0.9	0.4	-0.9	2.6

Table 13. Fisher's least significant difference tests results for all 37 towns studied; the test compares the average percentage correct on the 22-question UGS knowledge survey for all students in each town. Only comparisons that yielded a significant difference are presented. Significance was calculated at the .05 level.

Town	Comparison Town	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Asamang-Tamfoe	Banso	-6.6*	2.8	0.0	-12.1	-1.1
	Nankese	6.6*	3.1	0.0	0.5	12.8
	Adarkwa	12.9*	2.9	0.0	7.2	18.6
	Dome	7.7*	2.8	0.0	2.3	13.2
	Akyeansa	10.2*	2.8	0.0	4.7	15.6
	Kukua	8.2*	3.0	0.0	2.3	14.1
	Asuokaw	4.7*	2.3	0.0	0.1	9.3
	Ekoso	4.8*	2.3	0.0	0.3	9.3
	Akim Anyinam	6.1*	2.9	0.0	0.4	11.8
Banso	Ekorso	9.0*	3.5	0.0	2.1	15.9
	Nankese	13.2*	3.2	0.0	7.0	19.4
	Adarkwa	19.5*	2.9	0.0	13.7	25.2
	Densuso	7.6*	3.4	0.0	1.0	14.2
	Kuano	8.5*	2.9	0.0	2.8	14.1
	Dome	14.3*	2.8	0.0	8.8	19.8
	Akyeansa	16.7*	2.8	0.0	11.2	22.3
	Kukua	14.7*	3.0	0.0	8.8	20.7
	Kofi Pare	11.9*	3.3	0.0	5.5	18.4
	Ammako	9.1*	2.7	0.0	3.7	14.5
	Brekumanso	10.8*	2.6	0.0	5.7	15.9
	Mepom	7.9*	2.5	0.0	3.0	12.7
	Asuokaw	11.3*	2.4	0.0	6.6	16.0
	Sukurong-Bethlehem	8.5*	2.8	0.0	3.1	14.0
	Awaham	6.9*	2.5	0.0	2.0	11.8
	Kakoase Anomakojo	8.3*	3.0	0.0	2.4	14.3
	Asuotwene	10.9*	2.7	0.0	5.5	16.3
	Okorase	7.4*	2.5	0.0	2.5	12.2
	Breman	12.7*	3.6	0.0	5.7	19.7
	Krodua	8.1*	2.8	0.0	2.5	13.6
	Kwasi Nyarko	9.2*	2.7	0.0	4.0	14.5
	Topremang	7.3*	2.9	0.0	1.7	12.9
	Otumi	9.7*	2.5	0.0	4.8	14.7
	Ekoso	11.4*	2.3	0.0	6.8	15.9
	Akim Kokoben	5.9*	2.6	0.0	0.8	11.1
	Akim Anyinam	12.6*	2.9	0.0	6.9	18.4
	Akim Osorase	6.3*	2.6	0.0	1.2	11.5

	Akim Wenchi	7.4*	2.7	0.0	2.1	12.7
	Bomso	6.4*	2.6	0.0	1.4	11.5
	Tweapease	10.4*	2.7	0.0	5.2	15.6
Ekorso	Adarkwa	10.4*	3.6	0.0	3.4	17.5
	Akyeansa	7.7*	3.5	0.0	0.8	14.6
	Akim Batabi	-7.3	3.5	0.0	-14.1	-0.5
Nankese	Awaham	-6.3	2.8	0.0	-11.9	-0.7
	Okorase	-5.8	2.8	0.0	-11.4	-0.3
	Asikasu	-8.3	2.9	0.0	-14.1	-2.5
	Kwaboanta	-8.6	3.1	0.0	-14.8	-2.5
	Akim Akroso	-8.3	3.6	0.0	-15.3	-1.3
	Akim Kokoben	-7.3	3.0	0.0	-13.1	-1.4
	Akim Anamase	-8.0	3.3	0.0	-14.5	-1.6
	Akim Osorase	-6.9	3.0	0.0	-12.7	-1.1
	Akim Batabi	-11.5	3.1	0.0	-17.5	-5.4
	Bomso	-6.8	2.9	0.0	-12.5	-1.1
Adarkwa	Densuso	-11.9	3.4	0.0	-18.6	-5.1
	Kuano	-10.9	3.0	0.0	-16.8	-5.1
	Kofi Pare	-7.5	3.4	0.0	-14.2	-0.9
	Ammako	-10.4	2.8	0.0	-15.9	-4.8
	Brekumanso	-8.7	2.7	0.0	-14.0	-3.4
	Mepom	-11.6	2.6	0.0	-16.6	-6.5
	Asuokaw	-8.2	2.5	0.0	-13.1	-3.3
	Sukurong-Bethlehem	-10.9	2.9	0.0	-16.6	-5.2
	Awaham	-12.5	2.6	0.0	-17.7	-7.4
	Kakoase Anomakojo	-11.1	3.1	0.0	-17.2	-5.0
	Asuotwene	-8.6	2.8	0.0	-14.1	-3.0
	Okorase	-12.1	2.6	0.0	-17.2	-7.0
	Asikasu	-14.5	2.7	0.0	-19.8	-9.2
	Krodua	-11.4	2.9	0.0	-17.1	-5.7
	Kwasi Nyarko	-10.2	2.8	0.0	-15.7	-4.8
	Kwaboanta	-14.9	2.9	0.0	-20.6	-9.2
	Topremang	-12.1	3.0	0.0	-17.9	-6.3
	Otumi	-9.7	2.6	0.0	-14.9	-4.6
	Akim Akroso	-14.5	3.4	0.0	-21.2	-7.9
	Ekoso	-8.1	2.5	0.0	-12.9	-3.3
	Akim Kokoben	-13.5	2.7	0.0	-18.9	-8.1
	Akim Anamase	-14.3	3.1	0.0	-20.3	-8.2
	Akim Anyinam	-6.8	3.0	0.0	-12.8	-0.9
	Akim Osorase	-13.1	2.7	0.0	-18.5	-7.7
	Akim Batabi	-17.7	2.9	0.0	-23.3	-12.1
	Akim Wenchi	-12.1	2.8	0.0	-17.6	-6.6

	Bomso	-13.0	2.7	0.0	-18.3	-7.8
	Tweapease	-9.0	2.8	0.0	-14.5	-3.6
Densuso	Dome	6.7*	3.3	0.0	0.2	13.2
	Akyeansa	9.1*	3.3	0.0	2.6	15.7
	Kukua	7.1*	3.5	0.0	0.2	14.0
Kuano	Dome	5.8*	2.8	0.0	0.2	11.4
	Akyeansa	8.2*	2.9	0.0	2.6	13.9
	Kukua	6.2*	3.1	0.0	0.2	12.3
	Akim Batabi	-6.7	2.8	0.0	-12.3	-1.2
Dome	Mepom	-6.4	2.4	0.0	-11.2	-1.7
	Sukurong-Bethlehem	-5.7	2.8	0.0	-11.2	-0.3
	Awaham	-7.4	2.5	0.0	-12.2	-2.6
	Kakoase Anomakojo	-5.9	3.0	0.0	-11.8	-0.1
	Okorase	-6.9	2.4	0.0	-11.7	-2.1
	Asikasu	-9.4	2.6	0.0	-14.4	-4.3
	Krodua	-6.2	2.8	0.0	-11.7	-0.8
	Kwaboanta	-9.7	2.8	0.0	-15.2	-4.3
	Topremang	-6.9	2.8	0.0	-12.5	-1.4
	Akim Akroso	-9.4	3.3	0.0	-15.8	-2.9
	Akim Kokoben	-8.3	2.6	0.0	-13.4	-3.3
	Akim Anamase	-9.1	3.0	0.0	-14.9	-3.3
	Akim Osorase	-7.9	2.6	0.0	-13.1	-2.9
	Akim Batabi	-12.5	2.7	0.0	-17.9	-7.2
	Akim Wenchi	-6.9	2.7	0.0	-12.1	-1.7
	Bomso	-7.9	2.5	0.0	-12.8	-2.9
Akyeansa	Ammako	-7.6	2.7	0.0	-13.0	-2.3
	Brekumanso	-5.9	2.6	0.0	-11.0	-0.9
	Mepom	-8.9	2.4	0.0	-13.7	-4.1
	Asuokaw	-5.4	2.4	0.0	-10.1	-0.8
	Sukurong-Bethlehem	-8.2	2.8	0.0	-13.6	-2.7
	Awaham	-9.8	2.5	0.0	-14.7	-5.0
	Kakoase Anomakojo	-8.4	3.0	0.0	-14.3	-2.5
	Asuotwene	-5.8	2.7	0.0	-11.2	-0.5
	Okorase	-9.4	2.5	0.0	-14.2	-4.5
	Asikasu	-11.8	2.6	0.0	-16.9	-6.7
	Krodua	-8.7	2.8	0.0	-14.2	-3.2
	Kwasi Nyarko	-7.5	2.6	0.0	-12.7	-2.3
	Kwaboanta	-12.2	2.8	0.0	-17.6	-6.7
	Topremang	-9.4	2.8	0.0	-15.0	-3.8
	Otumi	-6.9	2.5	0.0	-11.9	-2.1
	Akim Akroso	-11.8	3.3	0.0	-18.3	-5.3

	Ekoso	-5.4	2.3	0.0	-9.9	-0.8
	Akim Kokoben	-10.8	2.6	0.0	-15.9	-5.7
	Akim Anamase	-11.5	3.0	0.0	-17.4	-5.7
	Akim Osorase	-10.4	2.6	0.0	-15.5	-5.3
	Akim Batabi	-14.9	2.8	0.0	-20.4	-9.6
	Akim Wenchi	-9.3	2.7	0.0	-14.6	-4.1
	Bomso	-10.3	2.5	0.0	-15.3	-5.3
	Tweapease	-6.3	2.6	0.0	-11.5	-1.1
Kukua	Mepom	-6.7	2.7	0.0	-12.1	-1.6
	Sukurong-Bethlehem	-6.2	3.0	0.0	-12.1	-0.3
	Awaham	-7.8	2.7	0.0	-13.1	-2.5
	Kakoase Anomakojo	-6.4	3.2	0.0	-12.7	-0.1
	Okorase	-7.4	2.7	0.0	-12.6	-2.1
	Asikasu	-9.8	2.8	0.0	-15.3	-4.3
	Krodua	-6.7	3.0	0.0	-12.6	-0.8
	Kwaboanta	-10.2	3.0	0.0	-16.1	-4.3
	Topremang	-7.4	3.1	0.0	-13.4	-1.4
	Akim Akroso	-9.8	3.5	0.0	-16.6	-3.0
	Akim Kokoben	-8.8	2.8	0.0	-14.3	-3.2
	Akim Anamase	-9.5	3.2	0.0	-15.8	-3.3
	Akim Osorase	-8.4	2.8	0.0	-14.0	-2.8
	Akim Batabi	-12.9	3.0	0.0	-18.8	-7.1
	Akim Wenchi	-7.4	2.9	0.0	-13.0	-1.7
	Bomso	-8.3	2.8	0.0	-13.8	-2.8
Kofi Pare	Asikasu	-7.0	3.1	0.0	-13.1	-0.9
	Kwaboanta	-7.4	3.3	0.0	-13.8	-0.9
	Akim Anamase	-6.7	3.4	0.1	-13.5	0.0
	Akim Batabi	-10.2	3.3	0.0	-16.6	-3.8
Ammako	Akim Batabi	-7.3	2.7	0.0	-12.6	-2.1
Brekumanso	Asikasu	-5.8	2.3	0.0	-10.4	-1.3
	Kwaboanta	-6.2	2.6	0.0	-11.2	-1.2
	Akim Kokoben	-4.8	2.4	0.0	-9.5	-0.2
	Akim Anamase	-5.6	2.8	0.0	-11.0	-0.2
	Akim Batabi	-9.0	2.5	0.0	-14.0	-4.1
Mepom	Akim Batabi	-6.1	2.4	0.0	-10.8	-1.4
Asuokaw	Awaham	-4.4	2.0	0.0	-8.2	-0.6
	Okorase	-3.9	1.9	0.0	-7.7	-0.1
	Asikasu	-6.4	2.1	0.0	-10.5	-2.3
	Kwaboanta	-6.7	2.3	0.0	-11.3	-2.1
	Akim Akroso	-6.4	2.9	0.0	-12.1	-0.6
	Akim Kokoben	-5.3	2.1	0.0	-9.5	-1.2
	Akim Anamase	-6.1	2.6	0.0	-11.1	-1.1

	Akim Osorase	-4.9	2.1	0.0	-9.2	-0.8
	Akim Batabi	-9.5	2.3	0.0	-14.1	-5.0
	Bomso	-4.9	2.0	0.0	-8.9	-0.8
Sukurong-Bethlehem	Akim Batabi	-6.8	2.7	0.0	-12.2	-1.4
Awaham	Ekoso	4.5*	1.9	0.0	0.7	8.2
	Akim Anyinam	5.7*	2.6	0.0	0.6	10.8
	Akim Batabi	-5.2	2.4	0.0	-9.9	-0.4
Kakoase Anomakojo	Akim Batabi	-6.6	3.0	0.0	-12.4	-0.8
Asuotwene	Asikasu	-5.9	2.5	0.0	-10.9	-1.1
	Kwaboanta	-6.3	2.7	0.0	-11.6	-1.0
	Akim Kokoben	-4.9	2.5	0.0	-9.9	0.0
	Akim Anamase	-5.7	2.9	0.0	-11.4	0.0
	Akim Batabi	-9.1	2.7	0.0	-14.4	-3.9
Okorase	Ekoso	3.9*	1.9	0.0	0.3	7.7
	Akim Anyinam	5.3*	2.6	0.0	0.2	10.3
	Akim Batabi	-5.6	2.4	0.0	-10.3	-0.9
Asikasu	Breman	7.8*	3.4	0.0	1.1	14.4
	Otumi	4.8*	2.3	0.0	0.4	9.2
	Ekoso	6.4*	2.0	0.0	2.4	10.4
	Akim Anyinam	7.7*	2.7	0.0	2.4	13.0
	Tweapease	5.5*	2.4	0.0	0.7	10.2
Breman	Kwaboanta	-8.1	3.5	0.0	-15.1	-1.2
	Akim Akroso	-7.8	4.0	0.0	-15.5	0.0
	Akim Kokoben	-6.8	3.4	0.0	-13.4	-0.1
	Akim Anamase	-7.5	3.7	0.0	-14.7	-0.3
	Akim Batabi	-10.9	3.5	0.0	-17.9	-4.0
Krodua	Akim Batabi	-6.3	2.7	0.0	-11.7	-0.9
Kwasi Nyarko	Akim Batabi	-7.5	2.6	0.0	-12.6	-2.4
Kwaboanta	Otumi	5.2*	2.5	0.0	0.3	10.0
	Ekoso	6.8*	2.3	0.0	2.3	11.3
	Akim Anyinam	8.1*	2.9	0.0	2.4	13.8
	Tweapease	5.8*	2.6	0.0	0.7	11.0
Topremang	Akim Batabi	-5.6	2.8	0.0	-11.1	-0.1
Otumi	Akim Batabi	-7.9	2.4	0.0	-12.8	-3.2
Akim Akroso	Ekoso	6.4*	2.9	0.0	0.8	12.1
	Akim Anyinam	7.7*	3.4	0.0	1.0	14.4
Ekoso	Akim Kokoben	-5.4	2.1	0.0	-9.5	-1.3
	Akim Anamase	-6.2	2.5	0.0	-11.1	-1.2
	Akim Osorase	-5.0	2.1	0.0	-9.1	-0.9
	Akim Batabi	-9.6	2.3	0.0	-14.0	-5.2
	Bomso	-4.9	2.0	0.0	-8.8	-1.0
Akim Kokoben	Akim Anyinam	6.7*	2.7	0.0	1.3	12.0

Akim Anamase	Akim Anyinam	7.4*	3.1	0.0	1.4	13.5
Akim Anyinam	Akim Osorase	-6.3	2.7	0.0	-11.7	-0.9
	Akim Batabi	-10.9	2.9	0.0	-16.5	-5.2
	Bomso	-6.2	2.7	0.0	-11.4	-1.0
Akim Batabi	Akim Wenchi	5.6*	2.6	0.0	0.5	10.8
	Tweapease	8.7*	2.6	0.0	3.6	13.8

Univariate Analysis: Sex

Univariate linear regression analysis indicates that sex is a significant predictor of schoolchild performance on the 22-question UGS knowledge survey ($p<0.0005$). Performance is measured as percentage of questions answered correctly. The model has an R^2 value of 0.03. The β value of -4.4 indicates that boys systematically outperform girls by 4.4 percentage points (Table 14).

Table 14. Univariate linear regression model that predicts schoolchild (n=1,813) performance on a 22-question UGS knowledge survey using sex as a predictor variable. For the purposes of the model, boys were coded as 0 and girls were coded as 1. The coefficient for sex therefore indicates how girls performed relative to boys.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	59.7	0.4	140.2	0.0	58.9	60.6
Sex	-4.4	0.6	-7.3	0.0	-5.6	-3.2

Univariate Analysis: Grade

Univariate linear regression analysis indicates that grade is a significant predictor of schoolchild performance on the 22-question UGS knowledge survey ($p<0.0005$). . Performance is measured in percentage of questions answered correctly. The model has an r^2 of 0.19. The β value of 11.6 indicates that JHS2 students systematically outperform P4 students by 11.6 percentage points (Table 15).

Table 15. Univariate linear regression model that predicts schoolchild (n=1,813) performance on a 22-question UGS knowledge survey using class year as a predictor variable. For the purposes of the model, P4 students were coded as 0 and JHS2 students were coded as 1. The coefficient for class year therefore indicates how JHS2 students performed relative to P4 students.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	51.4	0.4	127.9	0.0	50.7	52.2
Class Year	11.6	0.6	20.7	0.0	10.5	12.7

Univariate Analysis: District of Residence

Univariate linear regression analysis indicates that district is a significant predictor of schoolchild performance on the 22-question UGS knowledge survey ($p<0.0005$). . However, the r^2 for the model is only 0.03. The reference district for the model is Upper West Akim, which means that all districts are presented in comparison to Upper West Akim. Suhum and Ayensuano performed significantly worse than Upper West Akim by 5.7 and 2.4 percentage points, respectively. Atiwa, and Birim Central performed significantly better than Upper West Akim by 4.3 and 5.9 percentage points, respectively, and the remaining districts were not significantly different from the reference (Table 16).

Table 16. Linear regression model that predicts schoolchild (n=1,813) performance on a 22-question UGS knowledge survey using district as a predictor variable. Upper West Akim was used as a reference category, and coefficients therefore indicate how districts performed in comparison to Upper West Akim.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	57.5	0.6	101.5	0.0	56.4	58.6
Atiwa	4.3	1.4	3.1	0.0	1.6	7.1
Ayensuano	-2.4	1.1	-2.2	0.0	-4.5	-0.2
Birim Central	5.9	1.7	3.5	0.0	2.6	9.2
Birim South	1.5	1.1	1.4	0.2	-0.6	3.7
Denkyembour	1.4	1.5	1.0	0.3	-1.5	4.3
Kwaebibirem	0.0	1.1	0.0	1.0	-2.2	2.1
Suhum	-5.7	1.3	-4.3	0.0	-8.2	-3.1
West Akim	-0.8	0.9	-0.9	0.4	-2.6	0.9

Univariate Analysis: Town

Univariate linear regression analysis indicates that town is a significant predictor of schoolchild performance ($p<0.0005$). , but the r^2 for the model is only 0.07. The reference town for the model is Ekoso, which means that all towns are presented in comparison to Ekoso. Asamang-Tamfoe, Banso, Awaham, Okorase, Asikasu, Kwaboanta, Akim-Akroso, Akim-Kokoben, Akim-Anamase, Akim-Osorase, Akim-Batabi, and Bomso significantly outperformed Ekoso. Adarkwa and Akyeansa significantly underperformed compared with Ekoso, and the remaining towns were not significantly different from the reference (Table 17).

Table 17. Linear regression model that predicts schoolchild (n=1,813) performance on a 22 question UGS knowledge survey using town as a predictor variable. Ekoso was used as a reference category, and coefficients therefore indicate how towns performed in comparison to Ekoso.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	54.9	1.2	46.0	0.0	52.6	57.3
Asamang Tamfoe	4.8	2.3	2.1	0.0	0.3	9.3
Banso	11.4	2.3	4.9	0.0	6.8	15.9
Ekorso	2.3	3.1	0.7	0.5	-3.8	8.5
Nankese	-1.9	2.7	-0.7	0.5	-7.2	3.5
Adarkwa	-8.1	2.5	-3.3	0.0	-12.9	-3.3
Densuso	3.8	2.9	1.3	0.2	-2.0	9.5
Kuano	2.9	2.4	1.2	0.2	-1.8	7.5
Dome	-2.9	2.3	-1.3	0.2	-7.4	1.6
Akyeansa	-5.4	2.3	-2.3	0.0	-9.9	-0.8
Kukua	-3.4	2.6	-1.3	0.2	-8.4	1.7
Kofi.Pare	-0.6	2.9	-0.2	0.8	-6.2	5.1
Ammako	2.3	2.2	1.0	0.3	-2.1	6.6
Brekumanso	0.6	2.0	0.3	0.8	-3.4	4.6
Mepom	3.5	1.9	1.9	0.1	-0.2	7.1
Asuokaw	0.1	1.8	0.0	1.0	-3.4	3.5
Sukurong Bethlehem	2.8	2.3	1.2	0.2	-1.7	7.3
Awaham	4.5	1.9	2.3	0.0	0.7	8.2
Kakoase Anomakojo	3.0	2.6	1.2	0.2	-2.0	8.1
Asuotwene	0.5	2.2	0.2	0.8	-3.9	4.8
Okorase	4.0	1.9	2.1	0.0	0.3	7.7
Asikasu	6.4	2.0	3.1	0.0	2.4	10.4
Breman	-1.3	3.2	-0.4	0.7	-7.6	4.9
Krodua	3.3	2.3	1.4	0.2	-1.2	7.8
Kwasi.Nyarko	2.1	2.1	1.0	0.3	-2.0	6.3
Kwaboanta	6.8	2.3	3.0	0.0	2.3	11.3
Topremang	4.0	2.4	1.7	0.1	-0.6	8.7
Otumi	1.6	1.9	0.8	0.4	-2.2	5.4
Akim Akroso Nazareth	6.4	2.9	2.2	0.0	0.8	12.1
Akim Kokben	5.4	2.1	2.6	0.0	1.3	9.5
Akim Anamase	6.2	2.5	2.5	0.0	1.2	11.1
Akim Anyinam	-1.3	2.5	-0.5	0.6	-6.1	3.5
Akim Osorase	5.0	2.1	2.4	0.0	0.9	9.1
Akim Batabi	9.6	2.3	4.2	0.0	5.2	14.0
Akim Wenchi	4.0	2.2	1.8	0.1	-0.3	8.2
Bomso	4.9	2.0	2.5	0.0	1.0	8.8
Tweapease	1.0	2.1	0.5	0.7	-3.2	5.1

Univariate Analysis: Teacher Score

Univariate linear regression analysis indicates that teacher performance on the open-ended survey in which they were asked to name five facts about bilharzia was not a significant predictor of schoolchild performance (p=.057). For students, performance was measured as the percentage of 22 questions answered correctly, and for teachers, performance was measured as the number of correct facts named. The r^2 for the model is .002 (Table 18). Univariate linear regression analysis indicates that teacher performance on 20 questions that match questions from the student knowledge survey is a significant predictor of schoolchild performance on the 22-question UGS knowledge survey ($p<0.0005$), but the r^2 for the model is small, at 0.053 (Table 19).

Table 18. Linear regression model that predicts schoolchild (n=1,813) performance on a 22-question UGS knowledge survey using teacher (n=57) performance naming five facts about UGS.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	56.481	0.885	63.79	0	54.745	58.218
Teacher Score	0.027	0.014	1.905	0.057	-0.001	0.054

Table 19. Linear regression model that predicts schoolchild (n=1,813) performance on a 22-question UGS knowledge survey using teacher (n=57) performance on 20 questions that match questions from the 22-question student knowledge survey.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	30.095	3.107	9.688	0	24.001	36.189
Teacher Score	0.354	0.039	9.046	0	0.277	0.43

Univariate Analysis: WASH Score

Univariate linear regression analysis indicates that the water infrastructure at the school level is a significant predictor of schoolchild performance on the UGS knowledge survey. However, the r^2 value is only .022, and the relationship is in the opposite direction than what would be intuitively expected; having a water score of 2 predicts a lower score on the knowledge survey than having a score of 1, with 0 as a reference category (Table 20). Sanitation infrastructure at the school level is a significant predictor of schoolchild performance on the UGS survey. The r^2 value is only .014; however, the relationship proceeds in the direction that is intuitively expected: a sanitation score of 1 predicts a higher score on the UGS knowledge survey than the reference category 0, and a sanitation score of 2 predicts a higher score on the UGS knowledge survey than a score of 1 (Table 21). Hygiene at the school level is not a significant predictor of schoolchild survey performance (Table 22). The composite WASH score is a significant predictor of performance on the schoolchild WASH survey. However, similar to the water metric, the r^2 is low at only .017, and the relationship does not proceed in the direction that is intuitively expected (Table 23).

Table 20. Results of a univariate regression model that predicts student (n=1,813) performance on the 22-question UGS survey using school level water infrastructure as a predictor variable; a score of 0 is used as a reference category.

	Unstandardized Coefficients		t	Sig.	95% Confidence Interval for B	
	B	Std Error			Lower Bound	Upper Bound
Constant	57.4	0.37	156.1	0	56.7	58.1
Water Score 1	2.9	0.78	3.7	0	1.4	4.4
Water Score 2	-4.6	1.03	-4.5	0	-6.6	-2.6

Table 21. Results of a univariate regression model that predicts student (n=1,813) performance on a 22-question urogenital schistosomiasis knowledge survey using school level sanitation infrastructure as a predictor variable; a score of 0 is used as a reference category.

	Unstandardized Coefficients		t	Sig.	95% Confidence Interval for B	
	B	Std Error			Lower Bound	Upper Bound
Constant	56	0.49	114.9	0	55.0	57.0
Sanitation Score 1	1.6	0.67	2.3	0.01	0.3	2.9
Sanitation Score 2	4.8	0.93	5.2	0	3.0	6.6

Table 22. Results of a univariate regression model that predicts student (n=1,813) performance on a 22-question urogenital schistosomiasis knowledge survey using school level hygiene infrastructure as a predictor variable; a score of 0 is used as a reference category.

	Unstandardized Coefficients		t	Sig.	95% Confidence Interval for B	
	B	Std Error			Lower Bound	Upper Bound
Constant	57.6	0.41	141.7	0	55.2	58.4
Hygiene Score 1	0.06	0.69	0.09	0.93	-2.6	1.4
Hygiene Score 2	-1.7	1	-1.7	0.1	-4.7	0.3

Table 23. Results of a univariate regression model that predicts student (n=1,813) performance on a 22-question urogenital schistosomiasis knowledge survey using school level WASH infrastructure as a predictor variable; a score of 0 is used as a reference category.

	Unstandardized Coefficients		t	Sig.	95% Confidence Interval for B	
	B	Std Error			Lower Bound	Upper Bound
Constant	57.6	0.7	82.2	0	56.2	59.0
WASH Score 1	-1.5	0.86	-1.7	0.08	-3.2	0.2
WASH Score 2	1.4	1	1.4	0.17	-0.6	3.4
WASH Score 3	2.3	1.1	2.2	0.03	0.1	4.5
WASH Score 4	-2.8	1.2	-2.3	0.02	-5.2	-0.4
WASH Score 5	2.9	2.1	1.4	0.17	-1.2	7.0
WASH Score 6	-2.5	3.5	-0.72	0.47	-9.4	4.4

Univariate Analysis: Town Level Variables

Linear regression analyses indicate that town population (Appendix B) and town water infrastructure are not significant predictors of schoolchild performance on the 22-question UGS knowledge survey. A univariate linear regression model using town population as a predictor variable had an r^2 of 0.000 and a significance level of 0.73. Of 20 different predictor variables, all of which are metrics that describe water infrastructure at the town level (Kulinkina et al. 2017), none were statistically significant. All models had an r^2 of less than 0.002 (Table 24).

Table 24. The results of 20 different univariate regression models, all of which predict student (n=1,813) performance on the 22-question UGS knowledge survey using a different metric to describe town level water infrastructure. Information on these metrics can be found in Kulinkina et al. 2017.

Model		Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error			Lower Bound	Upper Bound
Population Access All	Constant	56.6	0.8	70.6	0.0	55.0	58.1
	Predictor Variable	0.0	0.0	1.2	0.2	0.0	0.0
Population Access Functional	Constant	57.8	0.6	95.4	0.0	56.6	59.0
	Predictor Variable	0.0	0.0	-0.7	0.5	0.0	0.0
All 100 Meters	Constant	58.0	0.7	78.3	0.0	56.6	59.5
	Predictor Variable	0.0	0.0	-0.9	0.4	-0.1	0.0
All 200 Meters	Constant	58.0	1.0	59.8	0.0	56.1	59.9
	Predictor Variable	0.0	0.0	-0.6	0.6	0.0	0.0
All 300 Meters	Constant	57.6	1.4	42.3	0.0	55.0	60.3
	Predictor Variable	0.0	0.0	-0.1	0.9	0.0	0.0
All 400 Meters	Constant	57.4	1.8	31.3	0.0	53.8	61.0
	Predictor Variable	0.0	0.0	0.0	1.0	0.0	0.0
All 500 Meters	Constant	57.5	2.2	26.1	0.0	53.1	61.8
	Predictor Variable	0.0	0.0	0.0	1.0	0.0	0.0
All 1000 Meters	Constant	58.7	2.8	21.3	0.0	53.3	64.1
	Predictor Variable	0.0	0.0	-0.5	0.6	-0.1	0.0
Functional 100 Meters	Constant	58.1	0.5	106.4	0.0	57.1	59.2
	Predictor Variable	0.0	0.0	-1.5	0.1	-0.1	0.0
Functional 200 Meters	Constant	58.0	0.6	91.4	0.0	56.8	59.2
	Predictor Variable	0.0	0.0	-1.0	0.3	0.0	0.0
Functional 300 Meters	Constant	57.5	0.8	75.6	0.0	56.0	59.0
	Predictor Variable	0.0	0.0	0.0	1.0	0.0	0.0
Functional 400 Meters	Constant	56.7	0.9	65.0	0.0	55.0	58.4
	Predictor Variable	0.0	0.0	0.9	0.3	0.0	0.0
Functional 500 Meters	Constant	56.1	0.9	59.9	0.0	54.2	57.9
	Predictor Variable	0.0	0.0	1.6	0.1	0.0	0.0
Functional 1000 Meters	Constant	55.4	1.0	55.5	0.0	53.5	57.4
	Predictor Variable	0.0	0.0	2.1	0.0	0.0	0.0
Surface Water 100 Meters	Constant	57.6	0.5	126.2	0.0	56.7	58.5
	Predictor Variable	0.0	0.0	-0.5	0.7	-0.1	0.1
Surface Water 200 Meters	Constant	57.8	0.5	120.2	0.0	56.8	58.7
	Predictor Variable	0.0	0.0	-0.9	0.4	0.0	0.0
Surface Water 300 Meters	Constant	57.7	0.6	104.8	0.0	56.6	58.8
	Predictor Variable	0.0	0.0	-0.6	0.6	0.0	0.0
Surface Water 400 Meters	Constant	57.4	0.6	91.8	0.0	56.2	58.7
	Predictor Variable	0.0	0.0	0.0	1.0	0.0	0.0

Surface Water 500 Meters	Constant Predictor Variable	57.1 0.0	0.7 0.0	79.8 0.5	0.0 0.6	55.7 0.0	58.5 0.0
Surface Water 1000 Meters	Constant Predictor Variable	55.5 0.0	1.0 0.0	56.5 2.1	0.0 0.0	53.6 0.0	57.4 0.0

Univariate Analysis: District Level Variables

Univariate linear regression analyses indicate that while some district level variables are significant predictors of schoolchild performance, none explain more than 1% of variation in schoolchild performance (Table 25).

Table 25. The capacity of nine different univariate regression models to predict student (n=1,813) performance using nine different metrics to assess district-level variation.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	49.742	1.8	27.0	0.0	46.1	53.4
Population	7.75E-5	0.0	4.2	0.0	N/A	N/A
Constant	60.553	1.3	47.2	0.0	58.0	63.1
Percent Rural	-0.049	0.0	-2.5	0.0	-0.1	0.0
Constant	56.986	0.7	86.3	0.0	55.7	58.3
Percent Illiterate	0.028	0.0	0.8	0.4	0.0	0.1
Constant	57.027	0.7	82.0	0.0	55.7	58.4
Percent literate in English and Ghanaian Language	0.009	0.0	0.7	0.5	0.0	0.0
Constant	69.019	8.1	8.5	0.0	53.2	84.9
Percent With Basic Education	-0.136	0.1	-1.4	0.2	-0.3	0.1
Constant	55.650	0.8	68.3	0.0	54.1	57.2
Poverty Head Count	0.088	0.0	2.4	0.0	0.0	0.2
Constant	56.676	1.0	59.4	0.0	54.8	58.5
Percent Without Toilet Facilities	0.073	0.1	0.9	0.4	-0.1	0.2
Constant	59.012	1.6	36.7	0.0	55.9	62.2
Percent Unemployment	-0.375	0.4	-1.0	0.3	-1.1	0.4
Constant	56.251	1.2	47.7	0.0	53.9	58.6
Percent Using Boreholes/Pumps/Tube Wells as Primary Water Source	0.039	0.0	1.1	0.3	0.0	0.1

Model: Grade, Sex, District

Multivariate linear regression indicates that district of residence, sex, and year in school are significant predictors of schoolchild performance on the UGS knowledge survey (($p<0.0005$). , with an r^2 value of 0.24. Class year leads to the largest difference in predicted score, with JHS2 students predicted to perform 11.1 percentage points higher than P4 students. Boys are predicted to perform 3.5 percentage points higher than girls. In the model, West Akim is used as a reference variable for district. Atiwa and Birim Central performed significantly better than West Akim, while Ayensuano and Suhum performed significantly worse than West Akim. The remaining districts did not perform significantly differently from the reference category (Table 26).

Table 26. Results of a multivariate regression model that predicts student (n=1,813) performance using sex, year in school, and district of residence as predictor variables. West Akim was used as a reference category for district of residence. Girls are the reference category for sex, and P4 is the reference category for class year. A star indicates significance as the 0.05 level.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	53.4*	0.7	72.8	0.0	51.9	54.8
Atiwa	4.5*	1.3	3.5	0.0	2.0	7.1
Ayensuano	-2.4*	1.0	-2.3	0.0	-4.5	-0.4
Birim Central	4.4*	1.5	2.8	0.0	1.3	7.4
Birim South	1.6	1.1	1.5	0.1	-0.5	3.7
Denkyembour	1.4	1.4	1.0	0.3	-1.3	4.1
Kwaebibirem	-0.4	1.1	-0.4	0.7	-2.5	1.7
Suhum	-4.0*	1.2	-3.2	0.0	-6.4	-1.6
Upper West Akim	0.2	0.8	0.3	0.8	-1.4	1.8
Sex	-3.5*	0.5	-6.5	0.0	-4.6	-2.5
Class Year	11.1*	0.5	20.2	0.0	10.0	12.2

Model: Grade, Sex, Town

Multivariate linear regression indicates that town of residence, sex, and year in school are significant predictors of schoolchild performance on the UGS knowledge survey ($p<0.0005$). The r^2 for the overall model is 0.28. Class year is the predictor variable that leads to the largest difference in predicted score, with JHS2 students outperforming P4 students by 11.4 percentage points. Boys outperform girls by 3.5 percentage points. Ekoso was used as a reference category for town. Asamang-Tamfoe, Banso, Awaham, Asikasu, Kwaboanta, Akim-Anamase, and Akim-Batabi performed significantly better than Ekoso, while Adarkwa, Akyeansa, and Kukua performed significantly worse, and there was no significant difference in performance between the remaining towns and Ekoso (Table 27).

Table 27. Results of a multivariate regression model that predicts student (n=1,813) performance using sex, year in school, and town of residence as predictor variables. Ekoso was used as a reference category for town of residence. Girls are used as a reference category for sex, and P4 is used as a reference category for class year. A star indicates significance at the 0.05 level.

	Unstandardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error			Lower Bound	Upper Bound
Constant	52.4*	1.1	47.5	0.0	50.2	54.6
Sex	-3.5*	0.5	-6.5	0.0	-4.6	-2.4
Class Year	11.4*	0.5	21.0	0.0	10.4	12.5
Asamang Tamfoe	4.9*	2.0	2.4	0.0	0.9	8.8
Banso	8.7*	2.1	4.2	0.0	4.7	12.8
Ekorso	-0.6	2.7	-0.2	0.8	-5.9	4.8
Nankese	-4.1	2.4	-1.7	0.1	-8.8	0.6
Adarkwa	-6.6*	2.2	-3.1	0.0	-10.9	-2.4
Densuso	4.9	2.6	1.9	0.1	-0.1	10.0
Kuano	1.8	2.1	0.8	0.4	-2.3	5.9
Dome	-3.6	2.0	-1.8	0.1	-7.5	0.4
Akyeansa	-9.0*	2.0	-4.4	0.0	-13.0	-5.0
Kukua	-4.4*	2.3	-2.0	0.0	-8.9	0.0
Kofi.Pare	-2.3	2.5	-0.9	0.4	-7.2	2.7
Ammako	0.0	2.0	0.0	1.0	-3.8	3.9
Brekumanso	-2.9	1.8	-1.6	0.1	-6.4	0.6
Mepom	1.7	1.7	1.0	0.3	-1.6	4.9
Asuokaw	-0.9	1.6	-0.6	0.6	-3.9	2.2
Sukurong Bethlehem	0.4	2.0	0.2	0.9	-3.6	4.3
Awaham	4.1*	1.7	2.5	0.0	0.8	7.4
Kakoase Anomakojo	3.8	2.3	1.7	0.1	-0.6	8.3
Asuotwene	-1.2	1.9	-0.6	0.5	-5.0	2.6
Okorase	0.9	1.7	0.6	0.6	-2.3	4.2
Asikasu	5.1*	1.8	2.8	0.0	1.6	8.6
Breman	-1.7	2.8	-0.6	0.5	-7.2	3.7
Krodua	0.4	2.0	0.2	0.8	-3.5	4.4
Kwasi.Nyarko	3.0	1.9	1.6	0.1	-0.7	6.7
Kwaboanta	4.8*	2.0	2.4	0.0	0.9	8.8
Topremang	1.8	2.1	0.9	0.4	-2.2	5.9
Otumi	0.1	1.7	0.1	0.9	-3.2	3.4
Akim Akroso Nazareth	4.3	2.6	1.6	0.1	-0.9	9.4
Akim Kokben	3.5	1.8	1.9	0.1	-0.1	7.0
Akim Anamase	5.5*	2.2	2.5	0.0	1.2	9.8
Akim Anyinam	-3.5	2.2	-1.6	0.1	-7.7	0.8
Akim Osorase	3.0	1.8	1.6	0.1	-0.6	6.6
Akim Batabi	5.5*	2.0	2.7	0.0	1.6	9.4
Akim Wenchi	2.5	1.9	1.3	0.2	-1.3	6.2
Bomso	1.7	1.8	0.9	0.3	-1.8	5.1
Tweapease	-0.9	1.9	-0.5	0.6	-4.5	2.8

Discussion

Student and Teacher Knowledge of UGS

Overall, student knowledge of UGS was inadequate, especially with regards to treatment and transmission of the disease. The average score for all 1,813 participating students on the 22-question UGS knowledge survey was 57.4% correct. P4 students had an average score of only 51% correct, while JHS2 students had an average score of 63% correct. As the survey was a true/false style survey, it is to be expected that students could earn a 50% if they were simply guessing on every question. Thus, the average score of 57.4% means that, overall, students were performing only slightly better than if they were guessing for every question.

However, patterns of knowledge emerge when questions are individually examined. On questions that asked about UGS symptoms specifically, students answered 76% of the questions correctly, on average. However, on questions that asked about UGS transmission, there was an average score of only 50%. Even within the transmission section, there are marked differences in how students performed on individual questions. Over 80% of students knew that swimming is a risk factor for bilharzia, and over 90% of students knew that urinating in the river is dangerous. Yet just over 40% of students knew that bathing with river water puts one at risk for transmission, just over 30% of students knew that fetching river water puts one at risk for transmission, and just over 10% of students knew that washing clothes or utensils with river water puts one at risk for transmission. Thus, while most students connect swimming with risk of UGS contraction, they do not associate the disease with other, similarly dangerous, water related activities. There is a disconnect between understanding that swimming puts one at risk, and understanding that any kind of skin contact with infested river water can lead to transmission. A similar gap emerges when looking at the treatment section of the survey. The overall score on the section was 44%. Over 80% of students knew that UGS can be treated, but when students were asked to name the treatment for the disease, only 5 of the 1,813 children knew that praziquantel is the name of the treatment. This means that even if children recognize the symptoms of the disease and know that there is a treatment, they cannot request the drug they need at a local pharmacy or health clinic.

Teacher knowledge of UGS was similarly inadequate. Teachers named an average of 2.9 correct facts about UGS. 42 of the 57 teachers named urinating blood as a symptom of UGS, meaning that the majority of teachers know how to identify the disease. While 30 teachers noted that UGS is a waterborne or water-related disease and 18 of the 42 teachers wrote that swimming is one way to contract the disease, not a single teacher named skin contact with infested water as a transmission mechanism. Additionally, many of the commonly named symptoms of the disease, such as itchy skin, abdominal pain, and infertility are uncommon symptoms (Gryseels et al. 2006). Thus, while teachers are aware of some the rare symptoms of UGS, they lack key information about how the disease is transmitted. They also lack key information about treatment. Only 17.5% of teachers could name praziquantel as the drug that treats UGS. Overall, teachers performed much better on the yes/no section of the survey, scoring a 79.9%, on average. This means that there is significant recognition bias when it comes to testing teacher knowledge of the disease. Yet the results of the closed-ended survey corroborate the results of the open-ended survey, as teachers performed worse on questions that asked them about disease transmission through alternative methods of water contact than they did on the question about disease transmission through swimming.

Correlations

Chi-squared and linear regression analyses indicate that JHS2 students are performing significantly better on the 22-question UGS survey than P4 students. This is to be expected, both because JHS2 students are older, and thus better able to solve problems and think analytically when taking a test, and also because they have received a greater amount of instructional time devoted to UGS. However, given that many P4 students fall in an age range that is particularly susceptible to UGS infection, it is imperative that their knowledge of the disease be equally as high as that of JHS2 students (and ideally higher, given that the average score for JHS2 students was only 63%).

Chi-squared and linear regression analyses also indicate that boys performed significantly better than girls on the UGS knowledge survey. There are several possible reasons. Boys are more likely to have the disease than girls (Gryseels et al. 2006), meaning that they may recognize the symptoms, treatment, and transmission mechanisms through experience. They may also be more likely than girls to attend school on a regular basis, and might thus be more likely to attend school on a day that UGS is taught. Additionally, it is possible that boys simply guessed more correctly than girls. Girls were significantly more likely than boys to choose the "I don't know" option on almost every question. In this way, more boys may have guessed correctly (50/50 chance by choosing "true" or "false", instead of 0% chance by choosing "I don't know") and gained points, where girls chose to express their uncertainty.

It is notable that teacher scores on the open-ended survey did not significantly predict student scores, and that while teacher scores on the 20-question closed-ended survey was significantly predictive of student score, the R^2 was only 0.053. This result is to be expected for P4 students, who do not receive a UGS curriculum from their P4 teachers (they received UGS lessons in P3). However, it is an unexpected result for the JHS2 students, who did receive UGS lessons from their JHS2 science teacher. An explanation for this could be that the Ghana Education Services lesson materials that are provided to teachers regarding UGS are inadequate, and sometimes provide wrong information. Some textbooks mention only that the causative organism is a schistosome and that the intermediate host is a water snail. Others include that the source of the disease is contaminated water, that symptoms include blood in urine, skin itching, and lower abdominal pain, and that one should avoid bathing in contaminated water. Yet these books also add that one should boil and filter drinking water, an activity that will not prevent UGS infection. It must be mentioned that there was a large amount of missing teacher data (only 57 out of 74 teachers were available to be surveyed), and this may have biased the results towards a null finding.

ANOVA and linear regression analyses indicate that both town and district of resident are significant predictors of student UGS knowledge. Town has a slightly higher R^2 than district (.07 vs .03). However, none of the specific indicators that we used to describe the towns and the districts more specifically were significant predictors of UGS knowledge. Water and sanitation facilities at individual schools, which in this study act as a proxy for the town, were also not predictive, or poor predictors, of UGS knowledge. This means that while we know that knowledge varies by location, we do not know the drivers of this variability.

Moving Forwards

An important next step for this research is to determine the drivers of variability at both the district and the town level. If these variables can be determined, it will be much easier for policy makers to determine areas that are likely to have low knowledge of UGS, and implement UGS educational interventions. While the results of this study indicate that town population and water variables, and indicators such as a district's population, literacy rate, poverty rate, or unemployment rate do not correlate with student UGS knowledge, there are many other variables that could be explored. The low R^2 values for the univariate regression models in this study indicate that there are many factors at play, each of which explains a small amount of the variability in the data. Our final model, which has an R^2 of 0.28, indicates that much of what explains the variability is still unknown, and could be explained by factors such as governmental structure, or patterns of school attendance between schools.

A future study should administer a knowledge survey to students at different schools within the same town. Exploring how knowledge varies across schools, and not just towns and districts, could give key insight into why some students know more than others.

Study Limitations

Due to time and money constraints, only one school per town was surveyed, which means that we could not explore variability at the school level. Additionally, we did not have the time or resources to track down teachers who were not present on the day their school was surveyed, and there is thus substantial missing teacher data. Only two grade levels were surveyed, which did not allow us to explore how UGS knowledge changes over time in a detail manner. Additionally, the 20 closed-ended teacher questions that were used for analysis were extracted from a larger survey of 49 questions. The fact that these 20 questions were a part of a larger questionnaire may have meant that teachers performed differently than if they were given the 20 questions on their own.

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Appendix A

Schoolchildren Urogenital Schistosomiasis Knowledge Survey

Bloody pee Survey

Are you a BOY or GIRL
What is your age?
What is your year in school?

How to get bloody pee

1. If you chew cola nuts you can get bloody pee

true/false/I don't know

2. If you fetch river or pond water you can get bloody pee

true/false/I don't know

3. If you bathe with water from a river or pond you can get bloody pee

true/false/I don't know

4. A curse from another person is one way to get bloody pee

true/false/I don't know

5. If you swim in a river or pond you can get bloody pee

true/false/I don't know

6. If you wash a car with river or pond water you can get bloody pee

true/false/I don't know

7. If you wash clothes or utensils with river or pond water you can get bloody pee

true/false/I don't know

8. A fetish priest can give a person bloody pee

true/false/I don't know

9. If you use borehole water you can get bloody pee

true/false/I don't know

Treatment for bloody pee

10. Is there a treatment for bloody pee?

yes/no/I don't know

11. What is the name of the treatment for bloody pee?

12. If you get bloody pee and it goes away, can you get bloody pee again?

yes/no/I don't know

How to protect against bloody pee

13. I can protect myself against bloody pee by <u>sleeping under a mosquito net.</u>

true/false/I don't know

14. I can protect myself against bloody pee by <u>not swimming in a river or pond.</u>

true/false/I don't know

15. I can protect myself against bloody pee by <u>not bathing with water from a river or pond.</u>

true/false/I don't know

16. I can protect myself against bloody pee by <u>always wearing shoes outside.</u>

true/false/I don't know

Symptoms of bloody pee

17. If I have bloody pee <u>I will see red urine</u>

True/false/I don't know

18. If I have bloody pee <u>I will see blood in my urine</u>

True/false/I don't know

19. If I have bloody pee <u>I will have painful urination</u>

True/false/I don't know

20. If I have bloody pee I will <u>have a fever and chills</u>

True/false/I don’t know

21. Snails in a river or pond can give you bloody pee

True/false/I don’t know

22. It is fine to urinate in the river

True/false/I don’t know

Appendix B

Teacher Urogenital Schistosomiasis Knowledge Survey

Bilharzia Survey

Are you MALE or FEMALE

1. List five facts that you know about bilharzia

2. Is there is a treatment for bilharzia?

yes/no

3. If you answered yes to question 3, what is the name of the treatment?

1. Is bilharzia in your syllabus?

yes/no

2. Skip this question if you answered yes to question one. If bilharzia is <u>not</u> in your syllabus have you ever taught your students about bilharzia from your own knowledge?

yes/no

3. <u>Chewing cola nuts</u> is one way to get bilharzia

yes/no

4. <u>Fetching river or pond water</u> is one way to get bilharzia

yes/no

5. <u>Drinking river or pond water</u> is one way to get bilharzia

yes/no

6. <u>Drinking dirty water</u> is one way to get bilharzia

yes/no

7. <u>Using a dirty latrine</u> is one way to get bilharzia

yes/no

8. <u>Fishing in a river</u> is one way to get bilharzia

yes/no

9. <u>Bathing in a river or pond</u> is one way to get bilharzia

yes/no

10. <u>Exercising too hard</u> is one way to get bilharzia

yes/no

11. <u>Eating spoiled food</u> is one way to get bilharzia

yes/no

12. A curse from another person is one way to get bilharzia

yes/no

13. Swimming in a river or pond is one way to get bilharzia

yes/no

14. Washing a car with river or pond water is one way to get bilharzia

yes/no

15. Crossing a river or pond is one way to get bilharzia

yes/no

16. A fetish priest can give a person bilharzia

yes/no

17. Touching the river when heavy rains have made it dirty is one way to get bilharzia

yes/no

18. Being a gold miner is one way to get bilharzia

yes/no

19. Splashing in the river is one way to get bilharzia

yes/no

20. If you get bilharzia and it goes away, can you get bilharzia again?

yes/no

21. The treatment for bilharzia protects against reinfection for:

a. it does not protect against reinfection
b. 24 hours
c. One week
d. One month

22. The treatment for bilharzia is called:

a. Mebendazole
b. praziquantel
c. ivermectin

d. albendazole

23. You can protect yourself against bilharzia by sleeping under a mosquito net.

yes/no

24. You can protect yourself against bilharzia by not swimming in a river or pond.

yes/no

25. You can protect yourself against bilharzia by wearing rubber boots while fishing or crossing streams.

yes/no

26. You can protect yourself against bilharzia by fetching water from boreholes instead of the river.

yes/no

27. You can protect yourself against bilharzia by only drinking pure water.

yes/no

28. You can protect yourself against bilharzia by not bathing in the river or pond.

yes/no

29. You can protect yourself against bilharzia by washing with soap after swimming in the river or pond.

yes/no

30. You can protect yourself against bilharzia by always wearing shoes outside.

yes/no

Risk factor: An action or exposure that increases the chance of getting an infection

31. Contact with river or pond water is a risk factor for bilharzia

yes/no

32. Urination in river or pond water is a risk factor for bilharzia

yes/no

33. Using a dirty latrine is a risk factor for bilharzia

yes/no

34. Drinking dirty water is a risk factor for bilharzia

yes/no

35. Getting bitten by a mosquito is a risk factor for bilharzia

yes/no

36. Women fetching water during menstruation is a risk factor for bilharzia

yes/no

37. Touching someone with bilharzia is a risk factor for bilharzia

yes/no

38. If you have bilharzia you will see red urine

Yes/no

39. If you have bilharzia you will see blood in your urine

Yes/no

40. If you have bilharzia you will have painful urination

Yes/no

41. If you have bilharzia you will have fever and chills

yes/no

42. If you think that you have bilharzia, you should (circle all that are true – it's okay to circle more than one answer):

a. Tell a parent
b. Tell a teacher
c. Go to a pharmacy
d. Go to a clinic
e. Wait for it to go away

43. Snails play an important role in bilharzia

Yes/no

44. The river is a good place to fetch drinking water.

Yes/no

45. A hand-dug well is a good place to fetch drinking water.

Yes/no

46. The river is a good source of bathing water.

Yes/no

47. A shallow well is a good source of bathing water.

Yes/no

48. It is fine to urinate in the river.

yes/no

49. What is the best strategy you would tell your students to use to avoid bilharzia? (For example, the best strategy to use to avoid malaria is sleeping under a mosquito net)

Appendix C

Observational Variables Survey

Drinking Water

1) From where is the water collected?

2) Where is the water stored?

3) Is the container covered?

4) Is there a tap?

5) Are there cups that are used to dip into the storage container?

6) How full is the container?

Handwashing Water

1) From where is the water collected?

2) Where is the water stored?

3) Is the water stagnant or moving?

3) Is the container covered?

4) Is there a tap?

5) Are there cups that are used to dip into the storage container?

6) How full is the container?

7) Is there soap?

Urinal

1) How many girls urinals are there?

2) How many boys urinals are there?

Latrines

1) How many girls latrines are there?

2) How many boys latrines are there?

3) Are there doors?

4) Are there partitions?

5) Are there flies present?

6) Is there a dustbin for papers?

Total population of the school:

Pictures of the registry

Pictures of the science books

Appendix D: The 2014 population of all 37 study towns.

Town	Population 2014
Adarkwa	1157
Akim Osorase	3347
Akim-Akroso Nazareth	1574
Akim-Anamase	3763
Akim-Anyinam	1789
Akim-Batabi	971
Akim-Kokoben	1737
Akim-Wenchi	6179
Akyeansa	1662
Ammako	1363
Asamang-Tamfoe	2512
Asikasu	3365
Asuokaw	6127
Asuotwene	3342
Awaham	1909
Banso	2534
Bomso	1780
Brekumanso	1497
Breman	1599
Densuso	664
Dome	793
Ekorso	942
Ekoso	4440
Kakoase Anomakojo	1427
Kofi Pare	2035
Krodua	1912
Kuano	1696
Kukua	896
Kwaboanta	1513
Kwasi nyarko	1488
Mepom	5026
Nankese	6189
Okorase	3345
Otumi	4551
Sukurong-Bethlehem	1280
Topremang	4901
Tweapease	3264