Urogenital Schistosomiasis in Women of Reproductive Age in Tanzania's Lake Victoria Region

Jennifer A. Downs,* Charles Mguta, Godfrey M. Kaatano, Katrina B. Mitchell, Heejung Bang, Harusha Simplicie, Samuel E. Kalluvya, John M. Changalucha, Warren D. Johnson Jr., and Daniel W. Fitzgerald

Weill-Cornell Medical College, New York, New York; Weill-Bugando University College of Health Sciences, Mwanza, Tanzania;
National Institute for Medical Research—Mwanza Research Centre, Mwanza, Tanzania;
New York Presbyterian Hospital Weill-Cornell Medical Center, New York, New York;
Sengerema Regional Hospital, Sengerema, Tanzania

Abstract. We conducted a community-based study of 457 women aged 18–50 years living in eight rural villages in northwest Tanzania. The prevalence of female urogenital schistosomiasis (FUS) was 5% overall but ranged from 0% to 11%. FUS was associated with human immunodeficiency virus (HIV) infection (odds ratio [OR] = 4.0, 95% confidence interval [CI] = 1.2–13.5) and younger age (OR = 5.5 and 95% CI = 1.2–26.3 for ages < 25 years and OR = 8.2 and 95% CI = 1.7–38.4 for ages 25–29 years compared with age > 35 years). Overall HIV prevalence was 5.9% but was 17% among women with FUS. We observed significant geographical clustering of schistosomiasis: northern villages near Lake Victoria had more *Schistosoma mansoni* infections ($P < 0.0001$), and southern villages farther from the lake had more *S. haematobium* ($P = 0.002$). Our data support the postulate that FUS may be a risk factor for HIV infection and may contribute to the extremely high rates of HIV among young women in sub-Saharan Africa.

INTRODUCTION

Female urogenital schistosomiasis (FUS) is predominantly caused by *Schistosoma haematobium* and has been estimated by the World Health Organization (WHO) to affect up to 45 million women living in sub-Saharan Africa.¹ Adult *S. haematobium* worms inhabit blood vessels surrounding the urinary bladder and female genital tract and lay eggs that migrate through tissue of proximate organs, causing chronic granulomatous inflammation most commonly in the urinary bladder, ureters, cervix, and vagina. Because the urinary and genital tracts are almost always both affected, the WHO has recently renamed this disease urogenital schistosomiasis, with detection of *S. haematobium* in the urine or genital tract being diagnostic.¹

Chronic female genital-tract inflammation caused by *S. haematobium* has been associated with vaginal itching and discharge,² post-coital bleeding,³ genitopelvic discomfort,⁴ marital discord,⁵ and infertility.^{6,7} Genital *S. haematobium* infection has been associated with human immunodeficiency virus (HIV) infection in one cross-sectional study⁷ and has been postulated to be a risk factor for HIV infection.^{8,9}

Tanzania's Lake Victoria region in northwestern Tanzania borders Kenya, Uganda, and Rwanda and is believed to have among the highest prevalence of *S. haematobium* in the world, with a prevalence of 50–90% reported in young schoolchildren.¹⁰ The prevalence of *S. haematobium* infection has not been quantified in women of reproductive age, the population at risk for increased HIV infection. Therefore, we conducted a study in Tanzania's Lake Victoria region to determine the prevalence and identify risk factors for FUS among women of reproductive age.

MATERIALS AND METHODS

Study sites and subjects. This cross-sectional study was conducted between August 2009 and May 2010 near Lake Victoria in northwest Tanzania in partnership with a cervical

cancer screening program being conducted at local health centers. Women who were receiving free cervical cancer screening between the ages of 18 and 50 years who provided written consent were invited to participate in the FUS prevalence study. Women who were menstruating or refused gynecologic examination were excluded. Pregnant and breastfeeding women were included.

Urine and gynecologic examination. A single urine sample was collected from women between 10 AM and 2 PM, and it was filtered and examined microscopically by a trained parasitologist for *Schistosoma* ova. A subset of the urine samples was read by two parasitologists for quality control.

Women who provided informed consent underwent a gynecological examination. A swab of vaginal secretions was collected for wet preparation and microscopic examination for diagnosis of *Candida* (using a potassium hydroxide preparation), *Trichomonas vaginalis* (using warm normal saline), and bacterial vaginosis by Amsel's criteria.¹¹ Next, a cervical smear was collected using a plastic spatula. Smears were stained with 0.5% Trypan Blue and examined for schistosomal ova while fresh. Acetic acid was then applied to the face of the cervix and was followed by inspection for abnormal areas after 1 minute. Abnormal cervical lesions were biopsied. Specimens were stained with Hematoxylin and Eosin (H&E) for histopathological examination and Trypan Blue to examine for schistosomal ova using the crush technique previously described.^{6,12} Biopsies were not performed on pregnant women.

FUS was defined using WHO criteria: the presence of at least one schistosomal ovum seen in the urine sample, cervical smear, or cervical biopsy.¹

Other laboratory studies. Single stool samples for *S. mansoni* ova were processed by the Kato-Katz technique. HIV voluntary counseling and testing were offered to all participants. For those who agreed to be tested, blood was collected and tested using a rapid test (SD Bioline, Standard Diagnostics, Inc., South Korea). Testing was performed in the field, and patients received their results immediately. Venous blood was also collected and tested for syphilis using the rapid plasma reagin (RPR) test, and positive tests were confirmed with the *Treponema pallidum* particle agglutination assay (TPPA).

Interview. Women also participated in a 20-minute structured interview about water contact, gynecologic symptoms, sexual

*Address correspondence to Jennifer A. Downs, Center for Global Health, Weill-Cornell Medical College, 440 East 69th Street, New York, NY 10065. E-mail: jna2002@med.cornell.edu

history, and depression. The interview was administered by a nurse in Kiswahili. Women were asked to use a four-point Likert scale to quantify how much, over the past 4 weeks, they had been bothered by dyspareunia, vaginal discharge, post-coital bleeding, abdominopelvic pain, infertility, menstrual abnormalities, genital itch, and incontinence. Using a five-point Likert scale to assess sexual dysfunction, women were also asked how much they worried about pain during intercourse, made excuses to avoid intercourse, had experienced decreased frequency or quality of intercourse, and were concerned about partner infidelity. We assessed the responses to these questions as binary variables, where answers of very much or somewhat were considered positive and answers of rarely or not at all were considered negative.

Depression was evaluated using a nine-item depression scale, the patient health questionnaire-9 (PHQ-9), that has been previously translated and validated in Kiswahili in several patient populations.^{13,14} The PHQ-9 consists of nine questions, each designed to assess for one of nine symptoms of depression delineated by the Diagnostic and Statistical Manual-IV (DSM-IV) for depression. These include anhedonia, sleeplessness or excessive sleep, hopelessness, poor or excessive appetite, difficulty concentrating, and feelings of failure. Participants receive between 0 and 3 points on each question, with 0 indicating that they experienced a given symptom not at all and 3 indicating that they experienced the given symptom nearly every day. A total score of 5–9 indicates mild depression, 10–14 indicates moderate depression, 15–19 indicates moderately severe depression, and above 20 indicates severe depression.¹⁵

Ethical considerations. The study was explained to women in a large group and subsequently one on one by a trained study nurse fluent in the local language. To participate in the study, women were asked to provide written informed consent or place their mark on the consent form. At the local level, permission was obtained from the District Medical Officers and clinicians stationed at participating dispensaries and health centers. Ethical approval was granted by the research ethics committee at Bugando Medical Center, the Medical Research Coordinating Committee of the National Institute for Medical Research in Tanzania, and the Institutional Review Board at Weill-Cornell Medical College.

Women diagnosed with urogenital or intestinal schistosomiasis, syphilis, trichomoniasis, candidiasis, or bacterial vaginosis received free treatment. Women with trichomoniasis were given medication both for themselves and their sexual partners. Women with syphilis and their sexual partners received three intramuscular injections of penicillin at the clinic. Patients diagnosed with HIV were referred to nearby district or regional hospital-based clinics for free care and treatment. Women with cervical dysplasia or cancer were referred to tertiary institutions for further management, and all of them accessed care successfully.

Statistical methods. Data were entered into a research electronic data capture (REDCap) database (Vanderbilt University, Nashville, TN). Continuous variables were summarized by median and interquartile range, and categorical variables were summarized by frequency and percentage. Regional disparity of infections was assessed by Fisher's exact test; the association of infection status and region was evaluated using northern versus southern designation (in a 2 × 2 table) as well as individual regions (in a 2 × 8 table). Factors that were associated with the endpoint (i.e., FUS) were examined by multiple logistic

regression. Backward elimination was adopted to reach the final parsimonious model that included significant factors only—starting from a full model with all of the candidate predictors (all factors presented in Tables 1–3) and deleting the least significant factor one at a time until only the predictors with *P* value < 0.05 remain in the model. We also confirmed that the automatic variable selection procedures (e.g., stepwise, forward, and backward selection) yielded the same final model. We analyzed age in two different ways—using a continuous variable and categorized variables (with 25, 30, and 35 years as cutoff points, which approximately corresponded to lower quartile, median, and upper quartile, respectively).

Association between factors and the endpoint was summarized in odds ratio (OR) along with 95% confidence interval (CI) and the associated *P* value. We also computed the area under the receiver-operating characteristic curve (AUC) to ascertain the discrimination capability of the factors for FUS cases versus non-cases—AUC of 0.5 means that the discrimination capability is no better than chance, and 1 means perfect discrimination.

SAS 9.2 (Cary, NC) was used for data analyses. Two-sided hypotheses/tests were assumed for computation of all CIs and *P* values.

RESULTS

Patient characteristics. Of 550 eligible women who presented to primary care clinics and were invited to participate in the study, 457 women (83.1%) consented to participate and completed all study procedures. Characteristics of study participants are shown in Table 1. The median age was 30 years (interquartile range [IQR] = 24–35 years). The great majority was married, had at least one child, and worked in

TABLE 1
Baseline characteristics of 457 women attending primary care clinics for schistosomiasis screening in Mwanza, Tanzania

Characteristic	Value
Age in years median (interquartile range)	30 (24–35)
Marital status (number)	
Single	10 (2.2%)*
Living with partner	31 (6.8%)
Married	357 (78.1%)
Divorced	21 (4.6%)
Widowed	7 (1.5%)
Having at least one child (number)	415 (90.8%)
People living in household (number)	
0–4	163 (35.7%)
5–7	150 (32.8%)
8–10	71 (15.5%)
More than 10	56 (12.3%)
Occupation (number)	
Agriculture and/or petty trade	404 (88.4%)
Homemaker	8 (1.8%)
Other	40 (8.7%)
Went to bed hungry in the past month (number)	27 (5.9%)
Number of water contacts per day median (interquartile range)†	14.1 (11.4–17.0)
Ever treated for schistosomiasis (number)	159 (34.8%)
Received an artemisinin-containing medication for malaria in the past 3 years (number)	163 (35.7%)

* Percentages were calculated using a denominator of the total sample size of 457. Missing data are present in some variables (with < 7%). Age was missing for six women, and water contact data were missing for 21 women.

† Water contact behaviors combined the following information (swimming, bathing oneself or a child, washing clothes, hands, animals, or dishes, collecting water for use in the home, fishing, using water for crops, wading in water to cross it, and cultivating rice) by summing their frequencies and dividing by 30.

TABLE 2
Prevalence of schistosomiasis and HIV in eight villages in the Mwanza region of Tanzania's Lake Zone

Village	Enrolled	No. with HIV infection	No. with <i>S. haematobium</i> infection	No. with <i>S. mansoni</i> infection	Regional prevalence of <i>S. haematobium</i>	Regional prevalence of <i>S. mansoni</i>
Northern villages						
Mwangika	67	5 (7.5%)	0	8 (11.9%)	10/337 (3.0%)	41/337 (12.2%)
Nyehunge	75	9 (12%)	6 (8.0%)	12 (16.0%)		
Sengerema	71	2 (2.8%)	1 (1.4%)	12 (16.9%)		
Kagunga	30	2 (6.7%)	1 (3.3%)	1 (3.3%)		
Badugu	23	4 (17.4%)	0	0		
Igaka	71	3 (4.2%)	2 (2.8%)	8 (11.3%)		
Southern villages						
Lubiri	45	0	5 (11.1%)	0	13/120 (10.8%)	0/120 (0%)
Nyamilama	75	2 (2.7%)	8 (10.7%)	0		
<i>P</i> value*			0.01	< 0.0001†	0.002	< 0.0001

*All *P* values were computed by Fisher's exact test.

†For this specific *P* value, Monte Carlo estimation of exact *P* values instead of direct exact *P* value computation was used because of time and memory problems encountered for exact computations.

farming and petty trade. Participants had a median number of 14 contacts with potentially infectious water per day, and no woman reported zero contacts. One-third reported receiving treatment for schistosomiasis in the past.

Prevalence of *S. haematobium* and *S. mansoni* infections. The prevalence rates for *S. haematobium* and *S. mansoni* are presented in Table 2, and a map of the area with the villages where screening took place is shown in Figure 1. The prevalence of *S. haematobium* infections was higher among women living in southern inland villages than in northern villages along the shores of Lake Victoria. The prevalence in the south was 13 of 120 (10.8%) compared with 10 of 337 (3%) in women who lived in northern lakeside villages ($P = 0.002$). Of the 23 women with urogenital schistosomiasis included in the analysis, 16 had *S. haematobium* ova detected in the urine only, 6 had *S. haematobium* ova detected in a genital specimen, and 1 had *S. mansoni* ova visualized on a cervical smear.

TABLE 3

Prevalence of gynecologic symptoms, sexual dysfunction, and depression in 457 women in Mwanza, Tanzania

	Number (percent)*
Gynecologic symptoms†	
Post-coital bleeding	24 (5.3%)
Dyspareunia	196 (42.9%)
Difficulty becoming pregnant	91 (19.9%)
Abdominal/pelvic pain	345 (75.5%)
Irregular menses	180 (39.4%)
Dysmenorrhea	248 (54.3%)
Genital itching	249 (54.5%)
Menorrhagia	256 (56.0%)
Urinary incontinence	41 (9.0%)
Foul-smelling vaginal discharge	142 (31.1%)
Sexual dysfunction‡	
Fearful of pain during sexual intercourse	291 (63.7%)
Makes excuse to avoid sexual intercourse	302 (66.1%)
Decrease in quality or frequency of sexual relations	242 (53.0%)
Worry that partner will have sexual relations outside of relationship	187 (40.9%)
Score on depression scale	
No depression (0–4 points)	48 (10.5%)
Mild depression (5–9 points)	259 (56.7%)
Moderate depression (10–14 points)	85 (18.6%)
Moderately severe or severe depression (≥ 15 points)	7 (1.5%)

* Percentages were calculated using a denominator of the total sample size (457) to capture existing symptoms. Depression score was missing for 58 women, whereas less than 5.5% of data was missing for all other variables.

† Includes women that answered that they were somewhat or very much bothered by the symptom.

‡ Includes women that answered I agree or I agree completely that they experience the symptom.

S. mansoni infection, by contrast, was only detected among women living in northern villages near the lake. Among 337 women living in northern lakeside villages, 31 (12.2%) were infected with *S. mansoni*, and among 120 women in southern inland villages, none were infected ($P < 0.0001$).

Prevalence of other infections. Of the 457 women examined, 33 had bacterial vaginosis (7.2%), 22 had candidiasis (4.8%), and 15 had trichomoniasis (3.3%). Twenty-seven women were HIV-infected (5.9%), and 33 had reactive syphilis serology (7.2%).

Prevalence of gynecologic symptoms, sexual dysfunction, and depression. Gynecologic symptoms reported most commonly by women included abdominopelvic pain (75.5%), menorrhagia (56.0%), genital itching (54.5%), dysmenorrhea (54.3%), dyspareunia (42.9%), and foul-smelling discharge (31.1%) (Table 3). The majority of women stated that they made excuses to avoid sexual intercourse (66.1%), and 40.9% of women were worried that their partner would have sexual relations outside of the relationship. Notably, 77% of women met criteria for depression based on the PHQ-9 scale. Of the 457 women, 259 (57%) were mildly depressed, and 92 (20%) had moderate to severe depression.

Factors associated with FUS. We examined associations between baseline characteristics, other infectious diseases, and female urogenital schistosomiasis. Younger age was significantly associated with FUS (Table 4). As a continuous variable, age in years showed an OR of 0.92 (95% CI = 0.86–0.98), which may be interpreted as approximately an 8% decrease in odds of disease per 1 year increase in age. As a categorized variable, age had an OR of 5.5 (95% CI = 1.2–26.3) for women who were younger than 25 years old, 8.2 (95% CI = 1.7–38.4) for those who were 25–29 years old, and 1.2 (95% CI = 0.16–8.4) for those who were 30–34 years old compared with women who were 35 years old or older (reference group).

HIV was also significantly associated with FUS, with an OR of 4.0 (95% CI = 1.2–13.5). Of the 23 women with FUS, 4 (17.4%) were HIV-infected compared with 23 (5.3%) of 434 women without FUS. There were no significant differences among women with and without FUS in the overall rates of other vaginal or sexually transmitted infections including candidiasis, trichomoniasis, bacterial vaginosis, or syphilis, and there were no other significant differences in other variables. The final regression model with the two risk factors—age and HIV status—resulted in AUC of 0.732 (age as continuous variable) and AUC of 0.72 (age as categorical variable), which are much higher than null value of AUC = 0.5.

FIGURE 1. Map of the Mwanza region in Tanzania's Lake Victoria region with village locations. Northern villages nearer to Lake Victoria, with lower rates of *S. haematobium* and higher rates of *S. mansoni*, are depicted with yellow dots. Southern villages, with higher rates of *S. haematobium* and no *S. mansoni* infection detected, are depicted with red dots.

DISCUSSION

FUS affects young women, is associated with HIV infection, and is prevalent in inland villages of the Lake Victoria region of Tanzania. Our study builds on the findings of a previous study in Zimbabwe, which showed an association between HIV infection and *S. haematobium* detected in cervical specimens, with an OR of 2.9 (95% CI = 1.2–3.5).⁷ The authors of the earlier study postulated that genital schistosomiasis may pre-dispose to HIV infection. Our work extends this finding by showing an association between HIV infection and the newly expanded WHO case definition of urogenital schistosomiasis. This finding, in light of the high prevalence of FUS in women of reproductive age, may have important public health implications for prevention of HIV infection.

Although a causal association between FUS and HIV infection will require a prospective longitudinal study, a number of factors support the hypothesis that the risk of HIV acquisition is augmented by the presence of FUS. First, schistosomal infection is generally acquired during childhood, before the commencement of sexual activity. Second, it has been pointed out that genital schistosomiasis may increase the risk of HIV infection through its disruption of the genital-tract epithelium.⁸ Third, schistosomiasis can stimulate a Th-2-type

immune response similar to other chronic parasitic infections. This produces changes in cytokines and an accompanying up-regulation of the HIV coreceptors CC chemokine receptor 5 (CCR5) and CXC chemokine receptor 4 (CXCR4) on monocytes and lymphocytes, with an overall shift in the body's immune response away from the Th-1 immunity that provides early initial control in HIV infection.^{16,17} Fourth, the inflammatory reaction to schistosomal eggs in genital lesions may increase the numbers of lymphocytes and activated macrophages in the cervical tissue; these are target cells for HIV infection. Finally, HIV-positive patients with helminth coinfections seem to have higher viral loads than those without coinfections and therefore may experience both higher rates of HIV transmission and more rapid HIV progression.^{17,18} For all of these reasons, the WHO and others have suggested that mass treatment of FUS may be an effective strategy for decreasing HIV transmission in sexually active women in Africa.^{1,9}

The association of FUS with younger age of 18–29 years is consistent with the natural history of schistosomiasis, and it has important public health ramifications. The age of peak prevalence for *S. haematobium* infection is between 8 and 15 years old, with peaks in the later end of this spectrum occurring in communities with lower prevalence of disease.^{19–21} Repeated exposure to the parasite over time leads to the development of at least partial immunity in later adulthood.^{19,21} Our findings show that, in communities in which the prevalence of disease is at least moderate in children (50–90% in a previous study),¹⁰ women continue to have urogenital schistosomiasis throughout their teens and twenties. This is also the age at highest risk for HIV transmission.²² Women between the ages of 18 and 29 years are not a focus of school-based anti-schistosomal treatment campaigns in sub-Saharan Africa, but the substantial burden of FUS in this age group argues strongly for targeted FUS treatment.

Our study suggests that, although *S. mansoni* may be geographically isolated near the Lake shores, *S. haematobium* may be more widespread in inland villages throughout the region, placing more women at risk for urogenital schistosomiasis and

TABLE 4
Factors associated with female urogenital schistosomiasis

Predictive factor	Number (%) in FUS group (n = 23)	Number (%) in non-FUS group (n = 434)	Odds ratio (95% CI)	P value
Age (years)				
< 25	9	109	5.5 (1.2–26.3)	0.03
25–29	10	80	8.2 (1.7–38.4)	0.008*
30–34	2	108	1.2 (0.16–8.4)	0.887
≥ 35	2	131	1	
HIV status				
Positive	4	23	4.0 (1.2–13.5)	0.024
Negative or unknown	19	411	1	

*Area under the receiver-operating characteristic curve (AUC) = 0.72. When we fitted the same model using age as a continuous variable, P value for age was 0.082, and AUC was 0.732.

potentially, increased HIV transmission. A school-based survey in central Sudan reported a comparable marked variation in the prevalence and intensity of both infections, even over short distances within the same province.²³ A compilation of over 2,000 studies conducted in East Africa between 1980 and 2009 revealed starkly distinct distributions for *S. mansoni* and *S. haematobium*, including the observation that *S. mansoni* is most prevalent along the shores of large lakes, including Lake Victoria.²⁴ Near Lake Victoria in Tanzania, studies in school-children have similarly found that the prevalence of *S. mansoni* decreased and the prevalence of *S. haematobium* increased with increasing distance from the lake.^{10,25} Thus, although our designation of northern and southern villages was not chosen *a priori*, our finding of significantly distinct parasite distributions in each of these regions is supported by other studies in the region.

This clustering has been attributed to differences in the ecology preferred by the intermediate snail vectors *Biomphalaria* spp. (for *S. mansoni*) and *Bulinus* spp. (for *S. haematobium*). *Bulinus* snails are capable of aestivation and thus are able to colonize and survive in temporary water sources that dry up for months of the year. In contrast, *Biomphalaria* snails do not aestivate and therefore require large permanent bodies of water with at least moderate aquatic vegetation for survival.²⁶ Because of these characteristics, transmission of *S. haematobium* is generally more widespread than *S. mansoni*, but it is also more seasonal, with highest transmission occurring after the rainy season when snails are not dormant.^{25,26}

Another important finding from this study was the high prevalence of depression among these women in rural villages. We found that 20% of women scored 10 or above on the PHQ-9 scale, consistent with moderate to severe depression. A PHQ-9 score above 10 is 88% sensitive and 88% specific for major depression as defined by the DSM-IV criteria.¹⁵ Other community-based studies in sub-Saharan Africa have reported a similar, although slightly lower, prevalence of major depression by DSM-IV criteria in 5–15% of women, with a higher prevalence in those living in rural settings.^{27,28} Thus, our findings highlight an additional prevalent healthcare need that affects rural women in sub-Saharan Africa.

This work underscores the significant burden and breadth of diseases—including parasitic, sexually transmitted, and mental health-related—in women of reproductive age living in rural northwest Tanzania. Because of resource constraints, we relied on single urine and stool samples to estimate prevalence of intestinal and urogenital schistosomiasis. In all likelihood, had we analyzed urine and stool samples on 3 consecutive days, the prevalence of these infections would have been even higher than those that we observed. Schistosomiasis in women of reproductive age is not currently a focus of public health screening or treatment, but the infection is common and widespread among this population. It has been pointed out that control of FUS, and possibly, the opportunity to curtail new HIV infections, may cost as little as 32 cents per woman.⁹

In conclusion, FUS is a geographically clustered infection that disproportionately affects women younger than 30 years of age and is significantly associated with HIV infection. These young women, who also have the highest risk for incident HIV infection and in whom genital lesions may be reversible if treated early, should be the focus of public health interventions aimed to reduce the prevalence of *S. haematobium* infection.

Received October 15, 2010. Accepted for publication December 6, 2010.

Acknowledgments: The authors thank Bugando Medical Centre, Weill-Bugando University College of Health Sciences, and the National Institute for Medical Research—Mwanza Research Centre for their invaluable support in the design and conduct of this study.

Financial support: This study was supported by the 2009 Merle A. Sande/Pfizer Fellowship Award in International Infectious Diseases, which is awarded annually by the Infectious Diseases Society of America Education and Research Foundation and the National Foundation for Infectious Diseases. This work was supported by Grant T32 HS000066 from the Agency for Healthcare Research and Quality (AHRQ) and by the Clinical and Translational Science Center Grant UL1-RR024996 (REDCap).

Authors' addresses: Jennifer A. Downs, Warren D. Johnson Jr., and Daniel W. Fitzgerald, Center for Global Health, Weill-Cornell Medical College, New York, NY, E-mails: jna2002@med.cornell.edu, wdjohnso@med.cornell.edu, and dfitzgerald@gheskio.org. Charles Mguta, Weill-Bugando University College of Health Sciences, Mwanza, Tanzania, E-mail: majanihopes@yahoo.com. Godfrey M. Kaatano and John M. Changalucha, National Institute for Medical Research—Mwanza Research Centre, Mwanza, Tanzania, E-mails: gmkaatano@yahoo.com and jchangalucha@yahoo.com. Katrina B. Mitchell, Department of Surgery, New York Presbyterian Hospital Weill-Cornell Medical Center, New York, NY, E-mail: invernness78@gmail.com. Heejung Bang, Department of Public Health, Weill-Cornell Medical College, New York, NY, E-mail: heb2013@med.cornell.edu. Harusha Simplicie, Sengerma District Hospital, Sengerema, Tanzania, E-mail: hsimplice@yahoo.co.uk. Samuel E. Kalluvya, Weill-Bugando University College of Health Sciences and Bugando Medical Centre, Mwanza, Tanzania, E-mail: samuelkalluvya@yahoo.com.

REFERENCES

1. World Health Organization WHO Working Group on Urogenital Schistosomiasis and HIV Transmission, 2009. *World Health Organization Neglected Tropical Diseases Website*. Available at: http://www.who.int/neglected_diseases/integrated_media_urogenital_schistosomiasis/en/index.html. Accessed August 3, 2010.
2. Kjetland EF, Kurewa EN, Ndhlovu PD, Midzi N, Gwanzura L, Mason PR, Gomo E, Sandvik L, Mduluza T, Friis H, Gundersen SG, 2008. Female genital schistosomiasis—a differential diagnosis to sexually transmitted disease: genital itch and vaginal discharge as indicators of genital *Schistosoma haematobium* morbidity in a cross-sectional study in endemic rural Zimbabwe. *Trop Med Int Health* 13: 1509–1517.
3. Poggensee G, Kiwelu I, Weger V, Goppner D, Diedrich T, Krantz I, Feldmeier H, 2000. Female genital schistosomiasis of the lower genital tract: prevalence and disease-associated morbidity in northern Tanzania. *J Infect Dis* 181: 1210–1213.
4. Leutscher PDC, Ramarokoto CE, Hoffmann S, Jensen JS, Ramaniraka V, Randrianasolo B, Raharisolo C, Migliani R, Christensen N, 2008. Coexistence of urogenital schistosomiasis and sexually transmitted infection in women and men living in an area where *Schistosoma haematobium* is endemic. *Clin Infect Dis* 47: 775–782.
5. Kjetland EF, Poggensee G, Helling-Giese G, Richter J, Sjaastad A, Chitsulo L, Kumwenda N, Gundersen SG, Krantz I, Feldmeier H, 1996. Female genital schistosomiasis due to *Schistosoma haematobium*. Clinical and parasitological findings in women in rural Malawi. *Acta Trop* 62: 239–255.
6. Poggensee G, Feldmeier H, 2001. Female genital schistosomiasis: facts and hypotheses. *Acta Trop* 79: 193–210.
7. Kjetland EF, Ndhlovu PD, Gomo E, Mduluza T, Midzi N, Gwanzura L, Mason PR, Sandvik L, Friis H, Gundersen SG, 2006. Association between genital schistosomiasis and HIV in rural Zimbabwean women. *AIDS* 20: 593–600.
8. Feldmeier H, Krantz I, Poggensee G, 1994. Female genital schistosomiasis as a risk factor for the transmission of HIV. *Int J STD AIDS* 5: 368–372.
9. Hotez PJ, Fenwick A, Kjetland EF, 2009. Africa's 32 cents solution for HIV/AIDS. *PLoS Negl Trop Dis* 3: e430.

10. Clements ACA, Lwambo NJ, Blair L, Nyandindi U, Kaatano G, Kinung'hi S, Webster JP, Fenwick A, Brooker S, 2006. Bayesian spatial analysis and disease mapping: tools to enhance planning and implementation of a schistosomiasis control programme in Tanzania. *Trop Med Int Health* 11: 490–503.
11. Amsel R, Totten PA, Spiegel CA, Chen KC, Eschenbach D, Holmes KK, 1983. Non-specific vaginitis: diagnostic criteria and microbial and epidemiologic associations. *Am J Med* 74: 14–22.
12. Feldmeier H, Zwingenberger K, Steiner A, Dietrich M, 1981. Diagnostic value of rectal biopsy and concentration methods in schistosomiasis intercalctum: quantitative comparison of three techniques. *Trop Med Parasitol* 32: 243–246.
13. Omoro SAO, Fann JR, Weymuller EA, Macharia IM, Yueh B, 2006. Swahili translation and validation of the Patient Health Questionnaire-9 depression scale in the Kenyan head and neck cancer patient population. *Int J Psychiatry Med* 36: 367–381.
14. Monahan PO, Shacham E, Reece M, Kroenke K, Ong'or WO, Omollo O, Yebei VN, Ojwang C, 2009. Validity/reliability of PHQ-9 and PHQ-2 depression scales among adults living with HIV/AIDS in western Kenya. *J Gen Intern Med* 24: 189–197.
15. Kroenke K, Spitzer RL, Williams JBW, 2001. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med* 16: 606–613.
16. Secor WE, 2006. Interactions between schistosomiasis and infection with HIV-1. *Parasite Immunol* 28: 597–603.
17. Modjarrad K, Vermund SH, 2010. Effect of treating co-infections on HIV-1 viral load: a systematic review. *Lancet Infect Dis* 10: 455–463.
18. Modjarrad K, Chamot E, Vermund SH, 2008. Impact of small reductions in plasma HIV RNA levels on the risk of heterosexual transmission and disease progression. *AIDS* 22: 2179–2185.
19. Woolhouse MEJ, Taylor P, Matanhire D, Chandiwana SK, 1991. Acquired immunity and epidemiology of *Schistosoma haematobium*. *Nature* 351: 757–759.
20. Huang Y, Manderson L, 1992. Schistosomiasis and the social patterning of infection. *Acta Trop* 51: 175–194.
21. Woolhouse MEJ, 1998. Patterns in parasite epidemiology: the peak shift. *Parasitol Today* 14: 428–434.
22. Joint United Nations Program on HIV/AIDS (UNAIDS), 2008. *2008 Report on the Global AIDS Epidemic*. Available at: http://www.unaids.org/en/knowledgecentre/hivdata/globalreport/2008/2008_global_report.asp. Accessed September 15, 2010.
23. Ahmed EF, Daffalla A, Christensen NO, Madsen H, 1996. Patterns of infection and transmission of human schistosomiasis haematobium in White Nile Province, Sudan. *Ann Trop Med Parasitol* 90: 173–180.
24. Brooker S, Kabatereine NB, Smith JL, Mupfasoni D, Mwanje MT, Ndayishimiye O, Lwambo NJ, Mbotha D, Karanja P, Mwandawiro C, Muchiri E, Clements AC, Bundy DA, Snow RW, 2009. An updated atlas of human helminth infections: the example of East Africa. *Int J Health Geogr* 8: 42.
25. Lwambo NJS, Siza JE, Brooker S, Bundy DAP, Guyatt H, 1999. Patterns on concurrent hookworm infection and schistosomiasis in schoolchildren in Tanzania. *Trans R Soc Trop Med Hyg* 93: 497–502.
26. Webbe G, 1962. The transmission of *Schistosoma haematobium* in an area of Lake Province, Tanganyika. *Bull World Health Organ* 27: 59–85.
27. Amoran O, Lawoyin T, Lasebikan V, 2007. Prevalence of depression among adults in Oyo State, Nigeria: a comparative study of rural and urban communities. *Aust J Rural Health* 15: 211–215.
28. Chipimo PJ, Fylkesnes K, 2009. Mental distress in the general population in Zambia: impact of HIV and social factors. *BMC Public Health* 9: 298.