WORLD HEALTH & POPULATION

Public Health Implication of Bacteriuria and Antibiotic Susceptibility of Bacteria Isolates in Schistosoma haematobium-Infected School Pupils in Southeast Nigeria

C.J. Uneke, Department of Medical Microbiology/Parasitology, Faculty of Clinical Medicine, Ebonyi State University

C.D.C. Ugwuoru, Department of Medical Microbiology/Parasitology, Faculty of Clinical Medicine, Ebonyi State University

B.A.F. Ngwu, Department of Medical Microbiology/Parasitology, Faculty of Clinical Medicine, Ebonyi State University

O. Ogbu, Department of Applied Microbiology, Faculty of Applied and Natural Sciences, Ebonyi State University

C.U. Agala, Department of Applied Microbiology, Faculty of Applied and Natural Sciences, Ebonyi State University

Correspondence: C.J. Uneke, Department of Medical Microbiology/Parasitology, Faculty of Clinical Medicine, Ebonyi State University, P.M.B. 053 Abakaliki- Nigeria Tel: 234-08038928597; Fax: 234-04300222; E-mail: unekecj@ yahoo.com

Abstract

Schistosoma haematobium infection prevalence of 57% was observed among primary school pupils, with males more infected than females (60.3% vs. 49.5%). Light infection (78.9%) was higher than heavy infection (21.1%). Prevalence of bacteriuria was 88.4% in infected individuals. *Escherichia coli* (20.5%), *Salmonella* spp (16.1%), and *Staphylococcus aureus* (16.1%) were major isolates. A 100% bacterial susceptibility to ciprofloxacin and taravid, was observed and up to 100% resistance with tetracycline, cotrimoxazole and nitrofuratoin. Systematic schistosomicidal/antimicrobial treatment advocated.

Introduction

Urinary tract infection (UTI) is one of the most common diseases, occurring from the neonate up to geriatric age groups throughout the world. UTI defines a condition in which the urinary tract is infected with a pathogen causing inflammation (Franz and Horl 1999). Though the etiology and clinical presentation of infections are similar in industrialized and developing countries, it is evident that persons with these infections in resource-constrained tropical areas of the world often present for care with more severe illness and often only after complications have developed (Latif 2004).

Urinary schistosomiasis caused by *Schistosoma haematobium* and transmitted by bulinid water snails is a very important parasitic UTI, which constitutes a major public health problem in many tropical and sub-tropical countries (Michaud et al. 2003). *S. haematobium* is reportedly endemic in 53 countries in the Middle East and most of the African continent (Chitsulo et al. 2000). Although infection with schistosomes does not always result in clinical disease, and many infections are asymptomatic, *S. haematobium* infection, however, could cause haematuria, dysuria, nutritional deficiencies, lesion of the bladder, kidney failure, an elevated risk of bladder cancer and – in children – growth retardation (Mostafa et al. 1999; Vennervald 2000). Accordingly, the estimates for morbidity and mortality in affected populations are high, with school-aged children usually presenting with the highest prevalence and intensity of infection (WHO 2002; Saathoff et al. 2004).

Studies in Nigeria among school aged children in various parts of the country and in both rural and urban environments have shown that *S. haematobium* is clearly a problem of this age group. Prevalence among school-aged children ranges from 20–40% in typical communities (Okoli and Odaibo 1999; Odaibo et al. 2004; Okoli and Iwuala 2004; Umar and Parakoyi 2005), but can be as high as 50–70% in areas where environmental changes occur due to constructions such as human-made dams and quarries (Mafiana et al. 2003; Nduka et al. 2006).

The prevalence of bacteria infection as a consequence of urinary schistosomiasis has been assessed in different epidemiological, clinical and experimental studies to determine if there is a link between the two conditions (Laughlin et al. 1978; El-Hawey et al. 1989; Adeyeba and Ojeaga 2002). Although bacteria prevalence values vary from one area to another, and even from one report to another in the same country, they are generally much higher than those documented in the area with no *S. haematobium* endemic infection (Laughlin et al. 1978; Pugh and Gilles 1979). With high levels of bacterial and *S. haematobium* infection, it seems most probable that children who are regularly exposed to contaminated water are occasionally infected simultaneously with the schistosome parasite and pathogenic bacteria. This is of great importance in the health of many populations in developing countries where the frequency of infection is a general indication of the local level of hygiene and sanitation (WHO 2002).

Information is very scanty on the bacteria/schistosoma co-infection in many endemic areas of sub-Saharan Africa, including Nigeria. Although Ejezie et al. (1989) claimed that schistosomiasis is not associated with bacteriuria in Nigeria, Kassim (1989) documented in Epe, Lagos State, that bacteriuria was found in 8.5% of schistosoma-infected children, compared with 5.2% of the control group. *Streptococcus faecalis* and *E. coli* were the two bacteria isolated from the urine specimens. This dearth of information has adversely affected adequate patient evaluation and management, control programs and identification of drug resistance in many rural communities (Gibodat and Bergquist 2000; WHO 1998). This study was therefore necessitated by the enormous medical and socio-economic implication of the concomitant infection with bacteriuria and urinary schistosomiasis in the face of the unprecedented upsurge in drug failure of both antibacterial and antischistosomal drugs in use in this part of the world (WHO 2000; Brindley 1994).

The objectives of this study were twofold; first, to determine the prevalence and intensity of urinary schistosomiasis in primary school pupils; second, the assessment of bacteriuria and antibiotic susceptibility patterns of bacteria isolates among pupils with urinary schistosomiasis. The overall goal of the study was to highlight the public health implications of bacteriuria and *S. haematobium* co-infection. This study constituted part of the preliminary investigations that contributed scientific data for development of community-based effective control and management strategies for schistosomiasis and other UTIs in Southeast Nigeria.

Materials and Methods

Study Area

This study was conducted from May 2004 through June 2005 in the rural district of Ikwo Local Government Area (LGA) in Ebonyi State, Southeast Nigeria. The climate is tropical and the vegetation characteristic is predominantly the rain forest with an average annual rainfall of about 1600 mm and average atmospheric temperature of 30°C. There are two distinct seasons: the wet season and the dry season. The former takes place between April and October; the latter occurs from November to March. The area is traversed by a number of streams and rivers, which constitute the major source of water supply to all the communities in the area. Agriculture, especially swamp rice cultivation and fishing are the mainstay of the economy. The educational status of most of the inhabitants is generally very low. Systematic schistosomicidal treatment had never been applied in the area.

Study Population

The study population comprised of 300 primary school pupils aged 5–20 years, the majority of whom were in the fourth, fifth, or sixth grade. Of interest is the fact that individuals up to 20 years of age are often in primary schools as pupils in the area because of the current free basic education policy of the state government; hence, individuals who could not afford basic education in their early life took advantage of the policy to gain basic education. The major primary schools in the area (Community Primary School, CPS, Ndiagu-Echara and Community Central School, CCS, Enyibichiri) were selected for the study, with 150 individuals enrolled from each school. Primary school pupils were selected for this study because: (1) schools are accessible without much difficulty, (2) the peak of prevalence of schistosomiasis is to be found in this group (Bundy et al. 1992) and (3) experience shows that there is general good compliance from children and parents (Montresor et al. 1998).

Ethical Consideration

Ethical clearance was obtained from the Ethical Committee of the Faculty of Clinical Medicine (Infection Disease Research), Ebonyi State University. The study was also approved by the Ikwo Local Government Council, the Local Government Health Department and the Parent-Teachers Association (PTA) of each of the schools studied. Informed consent was obtained from each of the pupils before inclusion in the study. In the course of the study, 11 pupils declined participation and were excluded from the study. Demographic information such as age and water contact activities was obtained through interviews with each participant.

Sampling Technique

About 20 ml of clean-catch, midstream urine samples were collected in 50 ml capacity, autoclaved, wide-mouthed, leak-proof universal containers by subjects themselves, who were previously carefully instructed with illustration aids. This was to avoid any possible contamination during collection. Samples were obtained between 10:00hrs and 14:00hrs (WHO 2003a) from pupils whose last micturation was at least two hours old (Engbaek et al. 1995) to accommodate bacteria analysis. Samples with visible haematuria were noted. Each sample collected was divided into two fractions. About 10 ml of each urine sample (fraction A) was investigated for the presence of *S. haematobium* ova. The remaining 10 ml (fraction B) was investigated for bacteriuria for cases with presence of *S. haematobium* ova. The specimens were appropriately labeled with identification numbers and placed in a cold box with ice packs, immediately after collection. They were processed within two to three hours of collection. In situations where delay in transportation of specimens to the laboratory was inevitable, 0.2 ml of household bleach was added to each fraction A (10 ml urine) (to preserve any schistosome ova present), while 0.1 g of boric acid was added to each fraction B (10 ml urine) (to arrest bacteria multiplication) (WHO 2003a; Cheesbrough 1998).

Laboratory Investigations

The urine sedimentation technique described previously (Cheesbrough 1998) was used to detect the presence of *S. haematobium* ova in the urine samples and to determine the intensity of the infection in each case. Intensity was reported as the number of ova/10 ml of urine and was categorized as light (≤ 50 ova/10 ml of urine) and heavy (≥50 ova/10 ml of urine). A few drops of saponin solution were added to samples with visible haematuria to enhance clarity in microscopy (Cheesbrough 1998).

Fraction B of the urine samples that contained *S. haematobium* ova were aseptically cultured (as soon as they were identified) on blood agar (BA) medium and cystine lactose electrolyte deficiency (CLED) medium according to standard protocol described by Cheesbrough (2000). The pairs of culture plates were incubated aerobically at 37°C for 24 hours. Colonial characteristics, gram reaction, catalase and coagulase tests, haemolysis on BA medium, lactose fermentation on CLED medium and other biochemical tests, such as indole production, citrate utilization, urase activity, triple sugar iron (TSI) agar test (for glucose, sucrose and lactose fermentation), gas and hydrogen sulphide production and oxidase test, were conducted as described by Cheesbrough (2000) for bacterial isolation.

The bacteria isolates made were subjected to antibiotic susceptibility analysis using disc diffusion method (Cheesbrough 2000; WHO 2003b). Known local strains of *E. coli* and *S. aureus* obtained from the bacteriology laboratory of Ebonyi State University Teaching Hospital (EBSUTH), were used as the control organisms.

The following antibiotics were employed for the sensitivity analysis: ampicillin, augmentin, chloramphenicol, ciprofloxacin, cloxacillin, cotrimoxazole, erythromycin, gentamycin, nalidixin acid, nitrofuratoin, penicillin, streptomycin, taravid and tetracycline. Their selection was based on local prescribing policies and availability. They were sourced from government approved pharmacies.

Statistical Analysis

Differences in proportion were evaluated using the Chi-square test. Statistical significance was achieved at $P < 0.05$.

Results

Of the 300 pupils examined, 171 (57.0%, 95% CI., 49.58–68.42) were infected with S. haematobium, with the males more infected than the females (60.3% vs. 49.5%). The prevalence of *S. haematobium* was significantly higher in the Community Central School (CCS) (51.3%, 95% CI., 40.10–62.50) ($\chi^2 = 3.930$, $P< 0.05$). Individuals of age group 16–20 years were significantly more infected (84.3%, 95% CI., 74.65–93.35) than those of age groups 11–15 years (60.8%, 95% CI., 52.24–69.36) and 5–10 years (34.3%, 95% CI., 25.22–43.38) ($\chi^2 = 44.102$, $P< 0.05$) (see Table 1).

Out of the 171 individuals with *S. haematobium* infection, 135 (78.9%) had light infection, while 36 (21.1%) had heavy infection. The prevalence of heavy infection was higher among the males (18.1%) than the females (2.9%), and heavy infection was highest among individuals of 11–15 years age group (9.4%). No significant difference was observed in the association between intensity and sex ($\chi^2 = 3.67$, $P<0.05$), or intensity and age ($\chi^2 = 0.906$, $P<0.05$) (see Table 2). A total of nine haematuric cases comprising seven males and two females were observed, and all cases were found to have heavy infection. Prevalence of heavy infection was however significantly higher in CPS (15.2%) than in CCS (5.8%) ($\chi^2 = 5.464$, $P< 0.05$) (Table 2).

Analysis for bacteria was done on the first 112 urine samples out of the 171 identified with *S. haematobium* infection. The remaining 59 samples could not be analyzed due to logistical problems. Ninety-nine isolates (88.4%, 95% CI., 82.47–94.33) were made comprising of 10 different bacteria species (Table 3). The highest number of isolates was *E. coli* (20.5%), *Salmonella* species (16.1%) and *S. aureus* (16.1%); the least isolates were *Proteus* species (4.5%), *Pseudomonas*, *aeruginosa* (3.6%) and *Enterococcus faecalis* (2.7%). Other bacteria isolated included *Klebsiella pneumoniae* (8.0%), *Citrobacter* species (6.3%), *Enterobacter* species (5.4%) and *Staphylococcus saprophy- ticus* (5.4%).

The antibiotic susceptibility patterns of the bacterial isolates are shown in Table 4. Results indicated that *Citrobacter* species *E. coli*, *Enterobacter* species and *S. aureus* exhibited 100% susceptibility to ciprofloxacin and taravid. *Proteus* species and *Pseudomonas aeruginosa* exhibited the highest antibiotic resistance to up to five of the antibiotics tested, including cotrimoxazole, nitrofuratoin and tetracycline. Highest antibiotic resistance was observed with tetracycline, where *Enterobacter* species, *Klebsiella pneumoniae*, *Proteus* species, *Pseudomonas aeruginosa* and *S. aureus* exhibited 100% resistance to it.

Table 1. Prevalence of *S. haematobium* infection among school pupils in Ikwo LGA, Ebonyi State, Southeast Nigeria

Parameter	Male		Female		Overall Total		
	Number Examined.	Number (%) Infected	Number Examined	Number (%) Infected	Number Examined.	Number (%) Infected	95 (%) Confidence Interval
Age							
5–10	79	31 (39.2)	26	5 (19.2)	105	36 (34.3)	25.22–43.38
11–15	91	62 (68.1)	34	14 (41.2)	125	76 (60.8)	52.24–69.36
16–20	39	33 (84.6)	31	26 (83.9)	70	59 (84.3)	74.65–93.35
Total	209	126 (60.3)	91	45 (49.5)	300	171 (57.0)	49.59–64.42
School							
CPS Ndiagu-Echara	108	73 (67.6)	42	12 (50.0)	150	94 (62.7)	52.92–72.48
CCS Enyibichiri	101	53 (52.5)	49	24 (49.0)	150	77 (51.3)	40.10–62.50
Total	209	126 (60.3)	91	45 (49.5)	300	171 (57.0)	49.58–46.42

Table 2. Intensity of *S. haematobium* infection among school pupils in Ikwo LGA, Ebonyi State, Southeast Nigeria

Parameter	Light Infection (<50 eggs/ 10 ml urine) Number (%)	Heavy Infection (≥50 eggs/ 10 ml urine) Number (%)	Overall Total Number (%)	95 (%) Confidence Interval
Sex				
Male	95 (55.6)	31 (18.1)	126 (73.7)	67.10–80.3
Female	40 (23.4)	5 (2.9)	45 (26.3)	19.70–32.90
Total	135 (78.9)	36(21.1)	171(57.0)	49.59–64.42
Age				
5–10	27 (15.8)	9 (5.3)	36 (21.1)	14.98–27.22
11–15	60 (35.1)	16 (9.4)	76 (44.4)	36.95–51.85
16–20	48 (28.1)	11 (6.4)	59 (34.5)	27.38 –41.62
Total	135 (78.9)	36 (21.1)	171 (57.0)	49.59–64.42
School				
CPS Ndiagu-Echara	68 (39.8)	26 (15.2)	94 (55.0)	47.54–62.46
CCS Enyibichiri	67 (39.2)	10 (5.8)	77 (45.0)	37.54–52.46
Total	135 (78.9)	36 (21.1)	171 (57.0)	49.59–64.42

Table 3. Prevalence of bacteriuria in *S. haematobium*-infected school pupils in Ikwo LGA, Ebonyi State, Southeast Nigeria (N=112)

Bacteria agents	Number of Isolates	Percentage	95% Confidence Interval
Citrobacter species	7	6.3	1.80–10.80
Enterobacter species	6	5.4	1.20–9.60
Enterococcus faecalis	3	2.7	0.30–5.70
Escherichia coli	23	8.0	2.98–13.02
Klebsiella pneumoniae	9	8.0	2.98–13.02
Proteus species	5	4.5	0.66–8.34
Pseudomonas aeruginosa	4	3.6	0.15–7.05
Salmonella species	18	16.1	9.29–22.91
Staphylococcus aureus	18	16.1	9.29–22.91
Staphylococcus saprophitics	3	5.4	1.20–9.60
Total	99	88.4	82.47–94.33

Table 4. Antibiotic susceptibility patterns of bacterial isolates from *S. haematobium*-infected school pupils in Ikwo LGA, Ebonyi State, Southeast Nigeria

	Percentage Susceptibility									
Antibiotics *Tested*	*Citrobacter* species	*Enterobacter* species	*Escherichia coli*	*Klebsiella pneumoniae*	*Proteus* species	*Pseudomonas aeruginosa*	*Salmonella* species	*Staphylococcus aureus*	*Enterococcus faecalis*	*Staphylococcus saprophyticus*
Ampicillin	0	66.7	20.0	60.0	0	faNA	77.8	27.3	72.7	50.0
Augmentin	0	66.7	0	100.0	100.0	0	NA	80.0	NA	NA
Chloramphericol	0	0	35.3	25.0	0	100.0	85.7	27.3	41.7	58.3
Ciprofloxacin	100.0	100.0	100.0	100.0	50.0	NA	71.4	100.0	90.9	92.3
Cloxacillin	NA	NA	NA	NA	NA	NA	NA	75.0	81.8	33.3
Co-trimoxazole	80.0	0	28.6	25.0	0	0	40.0	28.6	64.3	73.3
Erytenomycin	NA	NA	NA	NA	NA	NA	NA	61.5	100.0	83.3
Gentamicin	75.0	0	92.9	83.3	50.0	0	63.6	81.8	54.4	88.9
Nalidixin acid	NA	100.0	NA	100.0	NA	NA	25.0	NA	NA	NA
Nitroturatoin	100.0	33.3	60.0	NA	0	0	0	NA	NA	NA
Penicillin	NA	NA	NA	NA	NA	NA	NA	0	0	66.7
Streptomycin	75.0	33.3	71.4	66.7	50.0	50.0	NA	0	30.0	28.6
Taravid	100.0	100.0	100.0	20.0	100.0	100.0	20.4	100.0	50.0	30.0
Tetracycline	20.0	0	28.6	0	0	0	40.0	0	50.0	33.3

NA= Antibiotics not applied (not available at time of testing)

Discussion

The prevalence of infection due to *S. haematobium* (57%) observed in this study falls within the WHO classification as endemic (WHO 2002). This is in conformity with a number of other findings that showed that *S. haematobium* is endemic in many parts of Nigeria particularly among school children (Attah et al. 2002; Mafe et al. 2005). This finding supports reports that, of the world's serious parasitic diseases, schistosomiasis still ranks second only to malaria in the number of people infected and the extent of areas where the disease is endemic (Chitsulo et al.2000). It is well established that the chronic character and steady increase in morbidity in infected individuals in such endemic areas result in diminished working capacity and prolonged suffering. Morel (2000) indicated that lifelong disability looms if treatment with anti-schistosomal drug, such as praziquantel, cannot be provided and more so early on when the pathology is still reversible. This is perhaps one of major reasons why urinary schistosomiasis remains a matter of public health concern in many parts of developing tropical countries including Nigeria.

Our results showed that the males were more infected and with higher intensity than the females, with the older pupils significantly more infected ($P < 0.05$). This is presumably due to higher water contact activities by male pupils of the older age group who were particularly more into swamp rice farming and fishing as well as swimming and bathing in cercariae-infested rivers. In addition, females are generally restricted from swimming and bathing in the rivers on religious and socio-cultural grounds. This is similar to the observations made by Ndyomugyenyi and Minjas (2001) in Tanzania, Okoli and Odaibo (1999) in Southwest Nigeria, as well as Nduka et al. (1995) in another part of Southeast Nigeria. These factors not only make the males the more vulnerable group to urinary schistosomiasis but also powerful amplifiers of the infection in the area as indiscriminate passing out of urine (containing *S. haematobium* ova by infected individuals) during swimming or bathing in the rivers is a common phenomenon, thus increasing the availability of miracidia hatched from the ova and enhancing the infectivity of the snail intermediate hosts within which they transform into the infective cercariae. Sturrock (1987) had, however, demonstrated that the infectivity of a cercariae-infested water body in an endemic area is largely influenced by the dynamics of snail infections at any one time period and also by the volume of the water body. The implication of this is that snail vector control must be appreciated and made an indispensable component of the disease-control efforts because of the central role that the vectors play in the epidemiology of urinary schistosomiasis (Gibodat and Bergquist 2000).

We observed from this study that the percentage of pupils with heavy infection was considerably lower than those with light infection (21.1% vs. 78.9%). Mahmoud (2000) had earlier noted that the distribution of schistosomiasis in endemic communities fits a negative binomial curve, with most infected persons harboring low worm burdens and only a small proportion having heavy infections. This may explain the trend we have observed. However, the aggregation of worm burden in a small proportion of infected individuals may have multiple explanations including genetic susceptibility (Secor et al. 1996).

The prevalence of bacteria among the pupils with proven *S. haematobium* infection in this study appeared very high (88.4%). Reports from other community-based epidemiological surveys revealed bacteria prevalence of 25.8% in Egypt (Mostafa et al. 1999), 10.0% in Tanzania (Forsyth and Bradley 1966), 6.6% in Gambia (Wilkins 1977) and up to 75.4% in Southwest Nigeria (Adeyeba and Ojeaga 2002) among persons with *S. haematobium*. The relatively higher levels of bacteria and *S. haematobium* co-infection observed in this study, seemed to have resulted from the swamp rice farming, fishing and other water contact activities by the pupils, which regularly exposed them simultaneously to cercariae-infested and bacteria-contaminated water. It is probable that, at this juncture, the speculated association between bacteria and schistosome infection is enhanced. Penaud et al. (1983) and LoVerde et al. (1980) had earlier indicated that infection with schistosomes in endemic areas could bring about increased susceptibility to urinary tract bacterial infection. This is in addition to an earlier finding by Pugh and Gilles (1979) in a urinary schistosomiasis low endemic area of Malumfashi, Northwest Nigeria, where they concluded that the lack of association between urinary bacterial infection and schistosomiasis in their study probably reflects the low intensity of *S. haematobium* in the area. The public health significance of this finding cannot be overstated as it strengthens the argument that, by adequately controlling urinary schistosomiasis, a considerable reduction in bacteria-associated UTIs may be achieved.

Up to 10 different bacterial agents were identified in association with *S. haematobium* infection in this study. The majority of the isolates being *E. coli*, *Salmonella* spp, *S. aureus* and *Klebsiella pneumoniae*. Similar isolates were earlier made in related studies by Arinola and Salimonu (1999), El-Aaser et al. (1982) and Hicks et al. (1982). The health implications of this bacterio-schistosomal interaction have been established. Some of these organisms isolated particularly *S. aureus*, *Klebsiella pneumoniae*, *Proteus spp* and *E. coli* are nitrate-reducing bacteria (Mostafa et al. 1994) and are thought to play a significant role in the endogenous formation of carcinogenic alkylating agents (e.g., N-nitrosamines), which greatly increase the risk of urinary bladder cancer and other cancers (Mostafa et al. 1999). Adding to this, bacterial infection in urinary schistosomiasis has been

suggested in being responsible for an increased transport into the urogenital tract of cells harboring HIV-1 (e.g., mononuclear cells) and to enhance the rate of viral replication and release into semen (Leutschet et al. 2000). Bouree et al. (2002) also noted that a decreased host immune response following schistosomiasis enhances a delayed or prolonged infection with *Salmonella*. These discoveries underscore the necessity for the integration of antimicrobial agents as important components of chemotherapy in communities endemic for urinary schistosomiasis (Stamm and Hooton 1993).

It is worth noting that one outcome of the increased availability and usage of antimicrobial agents for symptomatic treatment of illness has been the emergence of antimicrobial resistance. This was clearly evident from this study. Up to 100% resistance was observed in three to five antibiotics by *Citrobacter* spp, *S. aureus* and *Klebsiella pneumoniae*, *Enterobacter* spp, *Proteus* spp and *Pseudomonas aeruginosa*, particularly tetracycline, cotrimoxazole and nitrofurantoin. A similar finding was made by Obi et al. (1996) in Zimbabwe. This is of particular concern in the developing world, including Nigeria, because fewer affordable, appropriate and effective treatment options, such as ciprofloxacin and tarvid, are readily available in most rural communities where scistosomiasis is endemic. It has become increasingly important to monitor patterns of resistance as the antimicrobial susceptibility of bacterial pathogens, which contributes significantly to the burden of *S. haematobium* infection and other UTIs, has declined. Because antimicrobial susceptibility testing is resource-intensive and is not easily afforded in many developing countries, the WHO recommends that only one or two reference laboratories in a country perform these tests (WHO 2003b). Many wealthy developed countries have exclusively focused efforts on fighting diseases within their own borders, while failing to help eliminate them globally. Proliferating elsewhere, many bacteria, viruses and parasites mutate, become drug resistant and venture back to wealthy countries via modern transportation (WHO 2000). The importance of continuous concerted global efforts in the control of infections can not be overstated. The sustainability of such control programs depends to a large extent on grant supports to resource-poor endemic tropical regions to strengthen the efforts to reduce morbidity due to diseases of major public health significance as schistosomiasis. The success of schistosomiasis control and prevention programs in endemic communities also depends to a large extent on the level of commitment of the governments of affected countries and other stakeholders in public health. It should be seen as a component part of the entire health system but with a nucleus of professional expertise.

In conclusion, this study highlights the importance of *S. haematobium* infection and its endemicity in Southeast Nigeria as well as the possible potential for interaction between urinary schistosomiasis and bacteruria. It advocates an urgent systematic schistosomicidal/antimicrobial treatment in the area. The control of urinary schistosomiasis among school aged children in the rural areas in an integrated and inter-sectoral manner is advocated. Regular antibiotic sensitivity surveillance and public health interventions, such as access to safe water, improved sanitation, immunizations, education, health communication and access to acute medical care with appropriate case management, would contribute to improvement in public health in schistosomiasis-endemic resource-scarce settings of the tropics.

References

Adeyeba, O.A. and S.G.T. Ojeaga. 2002. "Urinary Schistosomsis and Concomitant Urinary Tract Pathogens Among School Children in Metropolitan Ibadan, Nigeria." *African Journal of Biomedical Research* 5(3): 103–107.

Arinola, O.G. and L.S. Salimonu. 1999. "Concurrent Infections and Neutrophil Phagocytic Function in Nigerians with Urinary Schistosmiasis." *African Journal of Medical Sciences* 28(1-2): 101–105.

Attah, D.D., D.A. Dakul, T. Adamu, C.J. Uneke and D. Kumbak. 2002. "Prevalence of Schistosomiasis in the Former Zuru Emirate Council, Kebbi State, Nigeria." *Nigeria Journal of Experimental and Applied Biology* 3: 195–99.

Bouree, P, F.D. Bottered and S. Romand. 2002. "Delayed Salmonella Bacteriuria in a Patient Infected with Schistosoma haematobium." *Journal of Egyptian Society for Parasitology* 32: 355–360.

Brindley, P.J. 1994. "Drug Resistance to Schistosomicides and other Anthelmintics of Medical Significance." *Acta Tropica* 56: 213–31.

Bundy, D.A.P., A. Hall, G.F. Medley and L. Savioli. 1992. "Evaluating Measures to Control Intestinal Parasitic Infections." *World Health Statistics Quarterly* 45: 168–79.

Cheesbrough, M. 1998. *District Laboratory Practice in Tropical Countries* Part 1 (pp. 178–306). UK: Cambridge University Press.

Cheesbrough, M. 2000. *District Laboratory Practice in Tropical Countries* Part 2 (pp. 34–243) UK: Cambridge University Press.

Chitsulo, L., D. Engels, A. Montresor and L. Savioli. 2000. "The Global Status of Schistosomiasis and Its Control." Acta Tropica 77: 41–51.

Ejezie, G.C., E.I. Gemade and S.J. Utsalo. 1989. "The Schistosomiasis Problem in Nigeria." *J Hyg Epidemiol Microbiol Immunol* 33(2): 169–79.

EL-Aaser, A.A., M.M. EL-Merzabani, N.A. Higgy and A.E. EL-Habet. 1982. "A Study on the Etiological Factors of Bilharzial Bladder Cancer in Egypt. 6. The Possible Role of Urinary Bacteria." *Tumori* 64: 23–28.

EL-Hawey, A.A., D. Massoud, D. Badr, A. Waheeb and S. Abdel-Hamid. 1989. "Bacterial Flora in Hepatic Encephalopathy in Bilharzial and Non-bilharzial Patients." *Journal of Egyptian Society for Parasitology* 19: 79–804.

Engbaek, K., M.N. EL-Nageh and J. Groen. 1995. "Specimen Collection and Transport for Microbiological Investigation." WHO Regional publications, Eastern Mediterranean, Series No 8. viii, pp. 125–30.

Forsyth, D.M. and D.J. Bradley. 1966. "The Consequences of Bilharziasis, Medical and Public Health Importance in North-west Tanzania." *Bulletin of World Health Organization* 34: 715–35.

Franz, M. and W.H. Horl. 1999. "Common Errors in Diagnosis and Management of Urinary Tract Infection. I: Pathophysiology and Diagnostic Techniques." *Nephrolgy Dialysis and Transplant* 14: 2746–753.

Gibodat, M. and N.R. Bergquist. 2000. "Post-transmission Schistosomiasis: A New Agenda." *Acta Tropica* 77: 3–7.

Hicks, R. M., M.M. Ismail, C.L. Walters, M. T. Beecham and M.A. E L-Alamy. 1982. "Association of Bacteiuria and Urinary Nitrosamine Formation with Schistomaiasis Haematobium Infection in Qalyub Area of Egypt." *Transaction of the Royal Society for Tropical Medicine and Hygiene* 75: 519–27.

Hopkins, D.R., A. Eigege, E.S. Miri, I. Gontor, G. Ogah, J. Umaru, C.C. Gwomkudu, W. Mathai, M. Jinadu, S. Amadiegwu, O.K. Oyenekan, K. Korve, F.O. Richards Jr. 2002 (September). "Lymphatic Filariasis Elimination and Schistosomiasis Control in Combination with Onchocerciasis Control in Nigeria." *Am J Trop Med Hyg* 67(3): 266–72.

Kassim, O.O. 1989. "Proteinuria and Haematuria as Predictors of Schistosomiasis in Children." *Ann Trop Paediatr* 9(3): 156–60.

Latif, A.S. 2004. "Urinogenital Infections in the Tropics (pp. 8.1–8.10)." The Australasian College of Tropical medicine. Retrieved May 5, 2005. <http://www.google.co.uk/search?hl=en&q=Latif%2C+A.S.+2004.+%E2%80%9CUrinogenital+Infections+in+the+Tropics+&btnG=Google+Search&meta=> <www.tromped.org/primer/chapter08.pdf>.

Laughlin, L.W., Z. Farid Jr., N. Mansour, D.C. Edman and G.I. Higashi. 1978. "Bacteiuria in Urinary Schistosmiasis in Egypt a Prevalence Survey." *American Journal of Tropical Medicine and Hygiene* 27: 916–18.

Lehman, J.S., Z. Farid Jr., Z. Smith, J. H. Basily and N.A. E L-Masry. 1973. "Urinary Schistosmiasis in Egypt: Clinical, Radiological, Bacteriological and Parasitological Correlation." *Transaction of the Royal Society for Tropical Medicine and Hygiene* 67: 384–99.

Leutschet, P., C.M. Reimert, N.O. Chirstenson and B.J. Vennervald. 2000. "Male Genital Schistosmiasis (M G S) – A Neglected Risk Factor for HIV Transmission in Sub-Saharan Africa?" International conference on AIDS July 9–14, 13 (53) (Abstract no. Lb Pe C 7079).

LoVerde, P.T., C. Amento and G.I. Higashi. 1980. "Parasite-Parasite Interaction of Salmonella typhimurim and Schistosoma." Journal of Infection Diseases 141: 177–85.

Mafe, M.A., B. Appelt, B. Adewale, E.T. Idowu, O.P. Akinwale, A.K. Adeneye, O.U. Manafa, M.A. Sulyman, O.D. Akande and B.D. Omotola. 2005. "Effectiveness of Different Approaches to Mass Delivery of Praziquantel Among School-Aged Children in Rural Communities in Nigeria." *Acta Tropica* 93: 181–90

Mafiana, C.F., U.F. Ekpo D.A. Ojo. 2003 (January). "Urinary Schistosomiasis in Preschool Children in Settlements Around Oyan Reservoir in Ogun State, Nigeria: Implications for Control." *Trop Med Int Health* 8(1): 78–82.

Mahmoud, A.A.F. 2000. "Trematodes (Schistosmiasis) and other Flukes." In Mandell, Douglas and Bennett, eds., *Principles and Practice of Infectioous Disease*, 5th ed. Vol. 2, (p. 2956). New York: Churchill Livingston.

Michaud, C.M., W.S. Gorden and M.R. Reich. 2003. "The Global Burden of Diseases due to Schistosomiasis (pp. 1–40)." D C P P Working Paper 19, Cambridge. Retrieved May 5, 2005. <http://www.dcp2.org/file/34/wp19.pdf>)

Miegeville, M., M. Marijote and C. Vermeil. 1979. "Interaction Between Salmonella and Schistosomes Scanning Electron Microscopy." *Bulletin of Society Pathol Exof Filiales* 72: 107–11.

Montresor, A., D.W.T. Crompton, D.A.P. Bundy, A. Hall and L. Savioli. 1998. "Guidelines for the Evaluation of Soil Transmitted Helminthiasis and Schistosomiasis at Community Level (pp. 1–45)." Geneva: World Health Organization.

Morel, C. 2000. (October) "Schistosomiasis in the post-transmission phase: Foreword." *Acta Tropica* 77(3):1

Mostafa, M.H., S. Helimi, A.F. Badawi, A.R. Tricker, B. Spiegelhalder and R. Preussman. 1994. "Nitrate, Nitrate and Volatile N-nitroso Compounds in the Urine of *Schistosoma mansoni* Infected Patients." *Carcinogenesis* 15: 619–25.

Mostafa, M.H., S.A. Sheweita and P.J. O'Connor. 1999. "Relationship Between Schistosomiasis and Bladder Cancer." *Clinical Microbiology Review* 12: 97–111.

Nduka, F.O., C.M. Ajaero and B.E. Nwoke. 1995. "Urinary Schistosomiasis Among School Children in an Endemic Community in South Eastern Nigeria." *Aplied Parasitology* 36: 34–40.

Nduka, F.O., P.E. Etusim, V.O. Nwaugo and R.M. Oguariri. 2006. "The Effects of Quarry Mining on the epidemiology of Schistosoma haematobium in schoolchildren, in Ishiagu, South-eastern Nigeria." *Ann Trop Med Parasitol* 100(2): 155–61.

Ndyomugyenyi, R. and J.N. Minjas. 2001. "Urinary Schistosomiasis in School Children in Dar-es-salam, Tazania and the Factors Influencing its Transmission." *Annals of Tropical Medicine and Parasitology* 95: 697–706.

Nmorsi, O., N. Ukwandu, O. Egwungenya, N. Obhiemi. 2005. "Evaluation of CD4+/CD8+ Status and Urinary Tract Infections Associated with Urinary Schistosomiasis Among some Rural Nigerians." *Afr Health Sci* 5(2): 126–30.

Nwaorgu, O.C., J. Okeibunor, E. Madu, U. Amazigo, N. Onyegegbu and D. Evans. 1998. "A School-Based Schistosomiasis and Intestinal Helminthiasis Control Programme in Nigeria: Acceptability to Community members." *Trop Med Int Health* 3(10): 842–49.

Obi, C.L., A. Tarupiwa and C. Simango. 1996. "Scope of Urinary Pathogen Isolated in the Public Health Laboratory Harare: Antibiotic Susceptibility Patterns of Isolates and Incidence of Haemolytic Bacteria." *Central African Journal of Medicine* 43: 26–27.

Odaibo, A.B., C.O. Adewunmi, F.O. Olorunmola, F.B. Adewoyin, L.K. Olofintoye, T.A. Adewunmi, M.O. Adetula, C.O. Awe and F. Akinyemi. 23004. "Preliminary Studies on the Prevalence and Distribution of Urinary Schistosomiasis in Ondo State, Nigeria." *Afr J Med Sci* 33(3): 219–24.

Okoli, C.G. and M.O. Iwuala. 2004. "The Prevalence, Intensity and Clinical Signs of Urinary Schistosomiasis in Imo state, Nigeria." *J Helminthol* 78(4): 337–42.

Okoli, E.I. and A.B. Odaibo. 1999. "Urinary Schistosomiasis Among School Children in Ibadan, an Urban Community in South-western Nigeria." *Tropical Medicine and International Health* 4: 308–15.

Otten, H. and C. Dickerson. 1972. "Studies on the Effects of Bacteria on Experimental Schistosome Infections in Animals." *Transactions of the Royal society of Tropic Medicine and Hygiene* 66: 85–107.

Penaud, A., J. Mourrit, P. Chapoy, P. Alessandrini, E. Louchet and R.M. Nieoli. 1983. "Bacterio-Parasitic Interaction. Enterobacteria and Schistosomes (salmonella-schistosome association)." *Med Trop (Mars)* 43: 331–40.

Pugh, R.N. and H.M. Gilles. 1979. "Malumfashi Endemic Disease Research Project, X Schistosoma haematobium and Bacteriuria in the Malumfashi Area." *Annals of Tropical Medicine and Parasitology* 73: 349–54.

Saathoff, E., A. Olsen, P. Magnussen, J.C. Kvalsving, W. Becker and C.C. Appleton. 2004. "Patterns of Schistosoma haematobium Infection, Impact of Praziquantel Treatment and Re-Infection after Treatment in a Cohort of School Children from Rural Kwazulu-Natal/South African." *BMC Infection Diseases* 4: 40

Secor, W.E., H. del Cerral and M.G. dos Reis et al. 1996. "Association of Hepatosplenic Schistosoniasis with HLA – DOB1* 0201." *Journal of Infections Disease* 174: 1331–1335.

Stamm, W.E. and T.M. Hooton. 1993. "Management of Urinary Tract Infections in Adults. *N Engl J Med* 329(18):1328-3234.

Sturrock, R.F. 1987. "Biology and Ecology of Human Schistosomes. In A.A.F. Mahmoud, ed., *Clinical Tropical Medicine and Communicable Diseases* (pp. 249–66). London: Bailliere-Tindall.

Umar, A.S. and D.B. Parakoyi. 2005 (September). "The Prevalence and Intensity of Urinary Schistoso-miasis Among School Children Living along the Bakalori Dam, Nigeria." *Niger Postgrad Med J* 12(3): 168–72.

Useh, M.F. G.C. Ejezie. 1999 (July-August). "School-Based Schistosomiasis Control Programmes: A Comparative Study on the Prevalence and Intensity of Urinary Schistosomiasis Among Nigerian School-Age Children in and out of School." *Trans R Soc Trop Med Hyg* 93(4): 387–91.

Vennervald, B.J. A.I. Kahama and C.M Reimert. 2000 (October). "Assessment of Morbidity in *Schistosoma haematobium* Infection: Current Methods and Future Tools." *Acta Trop* 77(3):81-89.

Wilkins, H.A. 1977. (June) "*Schistosoma haematobium* in a Gambian Community. III. The Prevalence of Bacteriuria and of Hypertension". *Ann Trop Med Parasitol.* 71(2):179-186.

World Health Organization. 1998. Report of the WHO Informal Consultation on Monitoring of Drug Efficacy in the Control of Schistosomiasis and Intestinal Nematodes (pp. 1–45). WHO/CDS/CPC /SIP 199.1. Geneva.

World Health Organization. 2000. "Overcoming Antimicrobial Resistance (pp. 1–33)." WHO Report on Infections Disease. WHO/CDS 2000.2. Geneva.

World Health Organization. 2002. "Prevention and Control of Schistosomiasis and Soil Transmitted Helminthiasis (pp.1–57)." WHO Technical Report Services, 912: i-vi. Geneva: Author.

World Health Organization. 2003a. Manual of Basic Techniques for a Health Laboratory, 2nd ed. (pp. 249–51). Geneva: Author.

World Health Organization. 2003b. Manual for the Laboratory Identification and Antimicrobial Susceptibility Testing of Bacterial Pathogens of Public Heath Importance in the Developing World (pp. 103–20). WHO/DCS/CSR/RMD/2003.6. Geneva: Author.