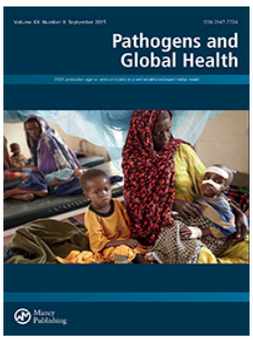

Pathogens and Global Health

ISSN: 2047-7724 (Print) 2047-7732 (Online) Journal homepage: http://www.tandfonline.com/loi/ypgh20

Performance of three rapid screening methods in the detection of Schistosoma haematobium infection in school-age children in Southeastern Nigeria

Ogochukwu Caroline Okeke & Patience Obiageli Ubachukwu

To cite this article: Ogochukwu Caroline Okeke & Patience Obiageli Ubachukwu (2014) Performance of three rapid screening methods in the detection of Schistosoma haematobium infection in school-age children in Southeastern Nigeria, Pathogens and Global Health, 108:2, 111-117, DOI: 10.1179/2047773214Y.0000000128

To link to this article: https://doi.org/10.1179/2047773214Y.0000000128

Published online: 04 Mar 2014.

Short Communication

Performance of three rapid screening methods in the detection of *Schistosoma haematobium* infection in school-age children in Southeastern Nigeria

Ogochukwu Caroline Okeke, Patience Obiageli Ubachukwu

Department of Zoology and Environmental Biology, Parasitology Unit, University of Nigeria, Nsukka, Enugu, Nigeria

Background: A cross-sectional study of primary school children was conducted to evaluate and compare the performance of some rapid screening methods in the detection of *Schistosoma haematobium* infection in Nigeria Cement Factory (NigerCem) and Nike Lake areas of Southeastern Nigeria.
Methods: Urine samples of school children were examined for macro-haematuria and tested for micro-haematuria and proteinuria using reagent strips followed by egg microscopy. Self-reported haematuria was assessed using simple questionnaire. The performances of these rapid diagnoses singly and in combination were calculated using egg microscopy as gold standard.
Results: The prevalence of the infection was 26.6% in NigerCem and 5.1% in Nike Lake area, classifying these areas as moderate- and low-prevalence areas (MPA and LPA); while in the subsample used for self-reported haematuria, the prevalence was 27.2 and 4.2% in MPA and LPA, respectively. The positive predictive value (PPV) of micro-haematuria was comparable in MPA (55.26%) and LPA (57.89%). Overall PPV of macro-haematuria was 87.50% in MPA and 66.70% in LPA while in the detection of heavy infection; PPV was higher in LPA (75%) than in MPA (66.67%). In LPA and MPA, combination of micro-haematuria and proteinuria, and concomitant presence of macro-haematuria, micro-haematuria, and proteinuria had PPV of 83.33 and 63.16%, and 100 versus 66.67%, respectively. Generally, the rapid screening tests had lower negative predictive values (NPVs) in MPA than in LPA. The use of simple questionnaire increased the PPV of heavy infection in MPA (77.78%). This was further increased to 80% when self-reported haematuria was combined with micro-haematuria.
Conclusion: The result suggests that in MPA with chronic infections, combination of self-reported haematuria and micro-haematuria may reduce the chance of missing those who should be treated.

Keywords: *Schistosoma haematobium*, Macro-haematuria, Reagent strip, Questionnaire method, Predictive values

Introduction

Urinary schistosomiasis, caused by *Schistosoma haematobium* is prevalent in Sub-Saharan Africa. Of the world's 207 million estimated cases of schistosomiasis, 93% occur in Sub-Saharan Africa, with the largest number in Nigeria.[1] The current control strategy recommended by World Health Organization (WHO) is mass drug administration (MDA) with praziquantel, to reduce morbidity due to schistosomiasis; targetting mainly school-age children and adults at risk.[2] School-age children are an important high-risk group for schistosomiasis because children are more susceptible; the infection impairs their growth and significantly diminishes their learning capacities. They also lack awareness of the need for good personal hygiene, and like to play in water.[3]

To ensure success of MDA programme, there is a need to update information regarding the prevalence and distribution of *S. haematobium* infection.[4] For many years, microscopy has been the only tool available for the detection of *S. haematobium* in urine samples. However, sample preparation for direct observation using microscopy is time-consuming, labour intensive, and proper diagnosis depends on qualified laboratory technicians.[5] Rapid and cost-effective screening methods have been proposed as alternatives in the diagnosis of *S. haematobium* infection. Examples of such rapid diagnostic methods are the use of macro-haematuria, reagent strips for detection of micro-haematuria and proteinuria, and self-reported haematuria.

Correspondence to: Ogochukwu Caroline Okeke, University of Nigeria, Nsukka, Enugu, Nigeria. Email: lovelymatters@yahoo.com

DOI 10.1179/2047773214Y.0000000128

The clinical usefulness of a diagnostic test is largely determined by the accuracy with which it identifies its target disorder. Accuracy measures, examples of which are sensitivity (SS), specificity (SP), and predictive values (positive and negative), are determined by calculating indices of agreement using egg microscopy as gold standard.[6,7] The predictive value of a test is determined by the test's SS and SP and varies with changing prevalence and intensity of disease.[7,8] Studies in southern Sudan and Tanzania have shown that the positive predictive value (PPV) increases with prevalence of infection and is affected by the SP of the test.[9,10] Negative predictive value (NPV) is affected by the SS of the test and high NPV provides reasonable exclusion criteria for treatment.[6]

In the present study, we report the diagnostic performance of reagent strip, macro-haematuria, and simple questionnaire used singly and in combination in the detection of *S. haematobium* infection in primary school children in moderate- and low-prevalence areas (MPA and LPA) in Southeastern Nigeria.

Materials and Methods

Study area

The study was conducted in Ishielu and Enugu East Local Government Areas (LGA) of Ebonyi and Enugu States, respectively. Ishielu LGA lies between longitudes 7° 45′ and 7° 50′E and latitudes 6° 31′ and 6° 35′N, with ecologically homogeneous soil and climate. The vegetation is of the typical guinea savanna mosaic type with gently undulating rocky lowland composed mostly of limestone.[11] Farming and petty trading are the major occupations of the inhabitants of the area. The second study area, Enugu East LGA, lies between longitudes 7° 36′ and 7° 41′E and latitudes 6° 31′ and 6° 36′N. It has tropical rain forest vegetation and the climate is humid, with humidity being highest between March and November. One characteristic geographical feature of this study area is the presence of a natural Lake called Nike Lake. Petty trading, civil service, and farming are the main occupations of those living in the area.

Study population and sampling method

The study population is primary school children between the ages of 5–13 years. Multi-stage sampling technique was used to select areas studied. From the 17 autonomous communities in Ishielu LGA, Nkalagu a rural community was selected and in Nkalagu, a small community of distressed factory workers living around the abandoned Nigeria Cement Factory (NigerCem) was selected. One community primary school was randomly selected from the two community primary school and one mission primary school in the area. Multistage sampling technique was also used to select two communities (Nike-Uno and Mbulu Owehe) from the four communities that make up Enugu East LGA. Two suburbanized villages (Amorji and Ibagwa) were randomly drawn from the five in Nike-Uno because this community has more population than other communities. In MbuluOwehe, Amokpo (a suburban village) was randomly drawn. Each village had one community primary school and this was used for the sampling. The communities selected for sampling were referred to as Nike Lake area in this study. Drug intervention programme have been conducted in 1987 and 1995 in NigerCem while in Nike there had been no MDA.

Data collection

School children were interviewed by trained school teachers using a questionnaire adapted from the Red Urine Study group.[12] Questions were assessed using dichotomous response of 'yes or no'. Questions were read and translated in native language to each student by a teacher and the response ticked by the teacher without any attempt to influence response. Each questionnaire also recorded sex and age of the interviewed student.

In addition to the questionnaire interview, urine samples were collected from school children in well labelled, clean, wide mouthed sample containers between 10:00am and 2:00pm. Samples were immediately moved to the laboratory of the Parasitology Unit of the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka, for analysis.

Parasitological analysis

Urine samples were inspected for macro-haematuria followed by the screening for micro-haematuria and proteinuria using reagent strips (Medi-test Combi-9, manufactured by Machery-Hagel, Duren, Germany). Each urine sample was processed using sedimentation technique. After sedimentation, 10 ml of urine was screened for schistosome eggs. Cases of schistosomiasis were defined as children with at least one *S. haematobium* egg on microscopic examination of urine.

Ethical consideration

Ethical clearance was obtained from the Ministry of Health, Ebonyi State and Enugu State Educational Board for the two study areas, respectively. Consent to collect urine samples of children were obtained from parents or guardians of the school children 1 week before sample collection. Infected children were treated with 40 mg/kg praziquantel.

Data analysis

Data were entered into SPSS version 17.0 for windows software. Prevalence of infection by microscopy, reagent strips, and questionnaire response was

calculated. Spearman's rank-correlation was used to determine the relationship among prevalence of infection by simple reagent strip method, questionnaire response, and the result obtained by microscopic examination of urine. The diagnostic accuracy of reagent strip, macro-haematuria, and questionnaire response were evaluated by computing their SS, SP, and predictive values using microscopic examination as the 'gold' standard method. In the calculation of the diagnostic accuracy of the questionnaire method, children older than 10 years were excluded in order to avoid false positives due to menstrual blood from girls and increase the validity of the test. This analysis was considered significant at $P<0.05$.

Results

The mean age (SD) of the 184 primary school children sampled in NigerCem (8.68 ± 2.49) and the 296 in Nike Lake area (9.11 ± 2.54) was not significantly different. In NigerCem and Nike Lake area, girls accounted for 59.3 and 50.3% of the study population while boys were 40.8 and 49.4%, respectively.

The prevalence of *S. haematobium* infection in NigerCem and Nike Lake area using different diagnostic tools is presented in Table 1. Egg microscopy had a prevalence of 26.6% in NigerCem and 5.1% in Nike Lake area. This classifies NigerCem as MPA and Nike Lake area as LPA. The prevalence of micro-haematuria, proteinuria, and self-reported haematuria when compared to prevalence of egg microscopy was lower in MPA than in LPA. Macro-haematuria had a prevalence of 4.3% in MPA compared to its 2.0% prevalence in LPA. Using Spearman's rank-correlation test, it was observed that the prevalence of *S. haematobium* infection had positive and significant correlations with micro- and macro-haematuria, and proteinuria in both study areas. However, the correlation between egg microscopy and self-reported haematuria was only significant in MPA (Table 2).

Table 3 summarizes the general performance of the different diagnostic tools in the detection of *S. haematobium* infection in both study areas. The PPV of micro-haematuria was comparable in both settings. However, its SS, SP, and NPV in LPA were higher. Proteinuria had higher SS and SP in LPA but its PPV was higher in MPA. Macro-haematuria had low SS in both study areas, higher PPV in MPA, and higher NPV in LPA. Combination of micro-haematuria and proteinuria had low SS but the SP, PPV, and NPV improved when compared with the performance of these diagnostic tools singly. Comparing the two locations, the diagnostic values of the combination of micro-haematuria and proteinuria was higher in LPA than in MPA. The concomitant presence of macro-haematuria, micro-haematuria, and proteinuria had low SS in both areas. It had 100% SP and PPV, and very high NPV in LPA but these diagnostic indices were lower in MPA.

Micro-haematuria had high SS, SP, and NPV but poor PPV for light infections in LPA while in the detection of heavy infection it had 100% SS and NPV. In MPA, micro-haematuria had very poor SS and PPV for heavy infection and moderate SS and PPV for light infection. Its NPV was also lower than the NPV in LPA. Proteinuria in both settings for both heavy and light infections had low SS and PPV, and high SP and NPV. Compared to the aforementioned tests, macro-haematuria had higher diagnostic accuracy for heavy infection in both study areas, with its diagnostic indices for heavy infection higher in LPA than in MPA. Combination of micro-haematuria and proteinuria had poor SS for heavy and light infections, poor PPV for heavy infection, and high SP and NPV for light infection in both study areas. Except for its poor SS, the diagnostic values of the combination of macro-haematuria, micro-haematuria, and proteinuria in detecting light and heavy infections had higher diagnostic values in LPA than in MPA (Table 4).

Self-reported haematuria and its combination with micro-haematuria had 0% SS and PPV generally and in the different intensities of infection in LPA. It had high SP and NPV except in heavy infection where its SP and NPV were 0 and 33.33%, respectively. In MPA, self-reported haematuria and its combination with micro-haematuria had poor SS. Its PPV when combined with micro-haematuria was higher than when self-reported haematuria was assessed alone

Table 1 Prevalence of *Schistosoma haematobium* infection as detected by different diagnostic tools in Nigeria Cement Factory (NigerCem) and Nike Lake area

Diagnostic tools (%) (95% CI)	MPA *n* =184	LPA *n* =296
Egg microscopy	26.6 (20.22–32.98)	5.1 (2.59–7.61)
Micro-haematuria	20.7 (14.85–26.55)	6.4 (3.61–9.19)
Proteinuria	17.9 (12.36–23.44)	24.3 (19.41–29.19)
Macro-haematuria	4.3 (1.37–7.23)	2.0 (0.41–3.59)
	(*n* = 136)	(*n* = 190)
Self-reported haematuria	16.9 (10-60-23.20)	17.9 (12.45–23.35)
Egg microscopy	27.2 (19.72–34.68)	4.2 (1.35–7.05)

MPA: moderate prevalence area; LPA: low prevalence area.

Table 2 Spearman's rank-correlation analysis of the prevalence of egg microscopy and other diagnostic tests

	Prevalence of egg microscopy	
Diagnostic tools	MPA	LPA
Micro-haematuria	0.330**	0.631**
Proteinuria	0.199**	0.156**
Macro-haematuria	0.294**	0.404**
Self-reported haematuria	0.294*	-0.098^{ns}

**Correlation is significant at 0.01 level.
*Correlation is significant at 0.05 level.
[ns] Correlation is not significant ($P>0.05$).
MPA: moderate prevalence area; LPA: low prevalence area.

except for light infection. In the detection of heavy infection, self-reported haematuria and its combination with micro-haematuria had high PPV and NPV than the other diagnostic tests (Table 5).

Discussion

The classification of NigerCem area as MPA and Nike Lake area as LPA was based on the WHO disease specific thresholds.[13] The prevalence of *S. haematobium* infection in these study areas agrees with the result of the mapping of schistosomiasis in Nigeria, which shows that most states in Nigeria are characterized by either low or moderate risk; although high risk communities with prevalence in excess of 50% can be found in some states.[14] However, the low prevalence of infection reported in the Lake area contradicts the high prevalence of *S. haematobium* infection identified with lake environments. In natural lakes, of which Nike Lake is an example, high prevalence of infection is attributed to high fishing activity reducing the population of molluscivorous fishes, close proximity of residents to lake shore, high water contact activities, and damming of lakes for water projects.[15,16] The low prevalence of infection in Nike Lake area may be as a result of the following reasons: (1) Fishing is not common in this Lake because of pollution by sewage (from the resort built close to the lake), oil (from automobile mechanics), and fertilisers (from farming activities). Farming, which is the main occupation of the residents, is carried out on the shore of the lake. Farming is only during dry season as the lake overflows in the rainy season. Irrigation of crops by farmers is through the use of pumping machines. This method of irrigation dislodges snails from their attachments and settles them on crops. Since dry season favours quick evaporation of water on surfaces, desiccation and death of snails follow. (2) Residential areas are not in close proximity to the Lake and the Lake is not the only water source in the area. This suggests that apart from those involved in farming along the lake shore, there is low human water contact activity in the area.

In line with many previous reports,[17,18] micro-haematuria, proteinuria, and macro-haematuria were positively correlated with the prevalence of *S. haematobium* infection in both MPA and LPA. Hence, these disease markers are regarded as alternative tests in the rapid diagnosis of *S. haematobium* infection. Compared to other published results from Nigeria,[7,18,19] micro-haematuria had low SS in MPA. However, this low SS was similar to the 41% SS of micro-haematuria reported in Imo State, a south-eastern State in Nigeria.[20] Proteinuria in the present study had poor performance when compared to the reports of other authors in Nigeria.[17,18,19] On the contrary, proteinuria is considered less sensitive and

Table 3 Overall performance of some diagnostic tools in detecting *S. haematobium* infection in moderate- and low-prevalence areas (MPA and LPA)

Diagnostic tool	Diagnostic indices (%) (95% CI)	MPA (n = 184)	LPA (n = 296)
Micro-haematuria	SS	42.86 (35.71–50.01)	73.33 (68.29–78.37)
	SP	87.41 (82.62–92.20)	97.15 (95.25–99.05)
	PPV	55.26 (48.08–62.44)	57.89 (52.27–63.51)
	NPV	80.82 (75.13–86.51)	98.56 (97.20–99.92)
Proteinuria	SS	30.61 (23.95–37.27)	53.33 (47.65–59.01)
	SP	86.67 (81.76–91.58)	96.88 (94.90–98.86)
	PPV	45.45 (38.26–52.64)	11.11 (7.53–14.69)
	NPV	77.48 (71.44–83.52)	77.22 (72.44–82.00)
Macro-haematuria	SS	14.29 (9.23–19.35)	26.67 (21.63–31.71)
	SP	99.25 (98.00–100.00)	99.29 (98.33–100.00)
	PPV	87.50 (82.72–92.28)	66.67 (61.30–72.04)
	NPV	76.14 (69.98–82.30)	96.21 (94.03–98.39)
Micro-haematuria and proteinuria	SS	24.49 (18.18–30.70)	33.33 (27.96–38.70)
	SP	94.81 (91.60–98.02)	99.64 (98.96–100.00)
	PPV	63.16 (56.19–70.13)	83.33 (79.08–87.58)
	NPV	77.58 (71.55–83.61)	96.55 (94.47–100.00)
Macro-haematuria, micro-haematuria, and proteinuria	SS	32.65 (25.87–39.43)	13.33 (9.46–17.20)
	SP	94.07 (90.66–97.48)	100.00 (100.00–100.00)
	PPV	66.67 (59.86–73.48)	100.00 (100.00–100.00)
	NPV	79.38 (75.53–85.23)	95.58 (93.24–97.92)

MPA: moderate prevalence area; LPA: low prevalence area; SS: Sensitivity; SP: Specificity; PPV: positive predictive value; NPV: negative predictive value; CI: confidence interval.

Table 4 Performance of different diagnostic tools in the detection of heavy and light infections in moderate- and low-prevalence areas (MPA and LPA)

Diagnostic test	Diagnostic indices (%) (95% CI)	Heavy infection (≥50 eggs/10 ml urine)		Light infection (<50 eggs/10 ml urine)	
		MPA (n = 12)	LPA (n = 3)	MPA (n = 37)	LPA (n = 12)
Micro-haematuria	SS	33.33 (26.52–40.14)	100 (100–100)	45.95 (38.75–53.15)	73.67 (68.65–78.69)
	SP	54.05 (46.85–61.25)	33.00 (27.64–38.36)	85.71 (80.65–90.77)	96.13 (93.93–98.33)
	PPV	19.04 (13.37–24.71)	27.00 (21.94–32.06)	44.74 (37.56–51.92)	42.11 (36.49–47.73)
	NPV	71.43 (65.90–77.76)	100 (100–100)	86.30 (81.33–91.27)	98.56 (97.20–99.72)
Proteinuria	SS	16.67 (11.28–22.06)	33.33 (27.96–38.70)	35.13 (28.23–40.03)	58.33 (52.71–63.95)
	SP	61.88 (61.86–75.23)	41.67 (36.05–47.29)	86.39 (81.44–91.34)	77.11 (72.32–81.90)
	PPV	15.38 (10.17–20.59)	12.50 (8.73–16.27)	39.40 (32.34–46.46)	9.72 (6.35–13.90)
	NPV	70.59 (64.01–77.17)	71.43 (66.28–76.58)	84.11 (78.83–89.39)	97.77 (96.09–99.45)
Macro-haematuria	SS	33.33 (26.52–40.14)	100 (100–100)	5.41 (2.14–8.68)	8.33 (5.18–11.48)
	SP	94.44 (91.13–97.75)	91.67 (88.52–94.82)	95.92 (93.06–98.78)	98.23 (96.73–99.73)
	PPV	66.67 (59.86–73.48)	75.00 (70.07–79.93)	25.00 (18.74–31.26)	16.67 (12.42–20.92)
	NPV	80.95 (75.28–86.62)	100 (100–100)	80.11 (74.34–85.88)	96.89 (94.91–98.87)
Micro-haematuria and proteinuria	SS	16.67 (11.28–22.06)	33.33 (27.96–38.70)	27.03 (20.61–33.45)	33.33 (27.96–38.70)
	SP	70.58 (64.01–77.16)	63.64 (58.16–69.12)	93.20 (89.56–96.84)	99.29 (98.30–100)
	PPV	16.67 (11.28–22.06)	20.0 (15.44–24.56)	52.63 (45.42–59.84)	66.67 (61.30–72.04)
	NPV	70.59 (64.01–77.17)	77.78 (73.04–82.52)	83.03 (77.61–88.45)	94.00 (91.29–96.71)
Macro-haematuria, micro-haematuria, and proteinuria	SS	41.67 (34.55–48.77)	33.00 (27.64–38.36)	29.73 (23.13–36.33)	8.3 (5.16–11.44)
	SP	70.27 (63.67–76.87)	91.67 (88.52–94.82)	91.16 (87.06–95.26)	99.65 (98.98–100)
	PPV	31.25 (24.55–37.95)	50.00 (44.70–55.70)	45.83 (38.63–53.03)	50.00 (44.30–55.70)
	NPV	78.79 (73.10–84.88)	84.62 (80.51–88.73)	78.82 (72.92–84.72)	96.26 (94.10–98.42)

MPA: moderate prevalence area; LPA: low prevalence area; SS: Sensitivity; SP: Specificity; PPV: positive predictive value; NPV: negative predictive value; CI: confidence interval.

specific than micro-haematuria because it is also found in small quantities in the urine of healthy persons.[7,21] Macro-haematuria was useful in the detection of heavy infection in this study but its PPV was lower than the findings of Mafe[22] and Ugbomoiko *et al.*[7]

In southern Sudan and Tanzania,[9,10] the PPV of micro-haematuria has been shown to be higher in MPA and high-prevalence areas than in LPA. In our study, micro-haematuria had low and similar PPV in the different prevalence areas. For macro-haematuria, the PPV was higher in MPA when the overall performance was considered while with heavy and light infections, the PPV was comparable in both locations. Combinations of diagnostic tests have been employed in urinary schistosomiasis endemic areas to improve the performance of rapid diagnosis.[23,24] Combination of micro-haematuria and proteinuria in MPA and LPA improved PPV generally and in the detection of light infection. When this combination was used on those with heavy infection, the PPV obtained was not better than when these disease markers were used singly. Comparing the PPV of this combination to those already published,[7,21] it was

Table 5 Performance of self-reported haematuria and its combination with micro-haematuria in moderate- and low-prevalence areas (MPA and LPA)

(%) (95% CI)	Self-reported haematuria		Micro-haematuria and self-reported haematuria	
	MPA (n = 136)	LPA (n = 190)	MPA (n = 136)	LPA (n = 190)
General				
Sensitivity	29.73 (22.05–37.41)	0 (0–0)	13.51 (7.76–19.26)	0 (0–0)
Specificity	87.89 (82.41–93.37)	81.31 (75.77–86.85)	97.80 (95.33–100)	99.45 (98.40–100)
PPV	47.83 (39.43–56.23)	0 (0–0)	71.43 (63.84–79.02)	0 (0–0)
NPV	76.99 (69.92–84.06)	94.87 (91.73–98.01)	75.19 (67.93–82.45)	95.77 (92.91–98.63)
Heavy infection (>50 eggs/10 ml urine)				
Sensitivity	63.64 (55.56–71.72)	0 (0–0)	44.00 (35.66–52.34)	0 (0–0)
Specificity	92.91 (87.83–96.79)	0 (0–0)	96.43 (93.31–99.55)	0 (0–0)
PPV	77.78 (70.79–84.77)	0 (0–0)	80.00 (73.28–86.72)	0 (0–0)
NPV	85.71 (79.83–91.59)	33.33 (26.63–40.03)	84.38 (78.28–90.48)	33.33 (26.63–40.03)
Light infection (≤50 eggs/10 ml urine)				
Sensitivity	14.29 (8.41–20.17)	0 (0–0)	3.57 (0.45–6.69)	0 (0–0)
Specificity	82.41 (76.01–88.81)	81.52 (76.00–87.04)	94.44 (90.59–98.29)	99.45 (98.40–100)
PPV	17.39 (11.02–23.76)	0 (0–0)	14.29 (8.41–20.17)	0 (0–0)
NPV	76.79 (69.92–84.06)	96.15 (93.41–98.89)	79.07 (72.23–85.91)	96.82 (94.32–99.32)

MPA: moderate prevalence area; LPA: low prevalence area.

lower. Combining the disease marker information obtained from reagent strip and macro-haematuria has been reported to have high and similar PPV as when macro-haematuria is used alone in school children living in a highly endemic area.[7] Using this approach in our MPA, we obtained a lower PPV even in the detection of those heavily infected. However, in LPA we observed that the overall PPV of this method was 100% but in the detection of heavy and light infections, a lower PPV was obtained. In addition, the PPV of the combined method was higher in LPA than in MPA. Deducing from the PPVs of these diagnostic tests, there is indication that school-age children in LPA are also at risk of urinary schistosomiasis. Evidence has also shown that those with light infections are still at significant risk of schistosomiasis-associated disease because the strength of an individual's immune response to parasite eggs, more than intensity of infection, determines risk of severe tissue inflammation in schistosomiasis.[25]

The NPVs of the micro-haematuria, proteinuria, and macro-haematuria were within the range previously reported.[18,19] When tests were combined, the NPVs were higher than those already published.[7] Overall, higher NPVs were obtained in LPA than in MPA. In the detection of heavy infection, higher NPV was also observed in LPA but outstandingly with micro-and macro-haematuria. World Health Organization[26] recommends that school-age children in LPA should be treated on entry and exit of primary school while only suspected adults should be given treatment. However, because these children and adults have high chance of infection despite the high NPV that warrants an exclusion from treatment,[6] we suggest treating every member of the community at least once every 2 years.

The lower NPV in MPA is as a result of the low SS of the diagnostic test, which is a consequence of high number of false negatives. High number of false negatives would indicate that most individuals in this community have chronic form of urinary schistosomiasis. The implication is that those who need treatment, will be considered normal and remain untreated.[10] According to WHO,[26] school-age children and adults of special risk group in MPA should be treated every 2 years but there is a growing discussion that adults in general contribute to community transmission of schistosomiasis and should be included in mass treatment.[27] More important is the fact that this MPA has been known to be endemic for schistosomiasis since 1986–1987.[28] Chemotherapeutic control was given in 1987 and 1995 and since then no mass treatment had been done in the area. Reports have it that in endemic areas, once mass treatment with praziquantel treatment is stopped, there is severe rebound morbidity.[29] This suggests that adults that were school-age children at the time when treatments were given could be suffering from schistosomiasis-associated morbidities that occur late in infection. Therefore, treatment in this area would also handle morbidity if the general community is treated again. In addition to control using praziquantel, other control measures such as the molluscicides, improved sanitation, and health education should also be employed.

In line with the findings of Lengeler *et al.*,[30] self-reported haematuria in urine had significant positive correlation with the overall prevalence of *S. haematobium* infection in MPA. The poor correlation between self-reported haematuria and the infection prevalence in LPA as evidenced by the 0% SS and PPV contradicts the result of the study conducted in a low prevalence community in Ghana,[31] where the SS of self-reported haematuria was 53%. The PPV and NPV of self-reported haematuria in MPA are within the range reported.[30] In the performance of self-reported haematuria in MPA, the PPV of self-reported haematuria was lower compared to that of other diagnostic tests. However, in the detection of those with heavy infection, the PPV was greatly improved, probably as a result of the vivid memory of seeing blood in urine. This implies that in the use of the questionnaire method, more positive cases who suffer from urinary schistosomiasis would be identified and treated. Furthermore, combining the result of micro-haematuria and questionnaire method improved the overall detection of *S. haematobium* infection in MPA and boosted the detection of heavy infection in school children. This agrees with the result obtained in Yemeni school children where the performance of reagent strip was enhanced when combined with interview technique, although reagent strip had better performance than interview method.[24] The improved diagnostic performance of questionnaire method alone and in combination with micro-haematuria, especially in the detection of heavy infection, confirms that there is chronic infection in MPA as earlier suggested. This strengthens our earlier recommendation of mass community treatment instead of selective drug distribution in this area.

Disclaimer Statements

Contributors The collection of samples was assisted by Mr S. Ali of the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka. Access to NigerCem was made possible by the community head, Mr Demo.

Funding The study was funded by Chief Poly Emenike (MON), CEO of Neros Pharmaceuticals.

Conflicts of interest The authors declare that they have no conflicts of interest.

Ethics approval Ethical clearance was obtained from the Ministry of Health, Ebonyi State and Enugu

State Educational Board for the two study areas, respectively. Consent to collect urine samples of children were obtained from parent or guardian of the school children 1 week before sample collection. However, urine samples were only collected from school children who cooperated despite the consent sought from parents. Infected children were treated with 40 mg/kg Praziquantel.

Acknowledgements

We are grateful to Chief Poly Emenike (MON), CEO of Neros Pharmaceuticals, who provided funds for the study. We are also grateful to Engr. and Dr (Mrs) S. N. Chikwendu for their encouragement during the survey. We acknowledge the parents, head teachers, and teachers of community primary schools involved in the study. We also appreciate the school children involved in the study for their consent.

References

1 Hotez PJ, Kamath A. Neglected tropical diseases in sub-Saharan Africa: review of their prevalence, distribution, and disease burden. PloS Negl Trop Dis. 2009;3:e412.
2 World Health Organization (WHO). Helminth control in school age children: a guide for managers of control programmes, 2nd edn. Geneva: World Health Organization; 2011.
3 Zang Y, MacArthur C, Mubila L, Baker S. Control of neglected tropical diseases needs a long-term commitment. BMC Med. 2010;8:67.
4 Nduka FO, Nwosu EC. Validation of the World Health Organization's Rapid Assessment method for urinary schistosomiasis in Southeastern Nigeria. J Parasitol. 2008;94:533–6.
5 Shiff C. The importance of definitive diagnosis is in chronic schistosomiasis, with reference to *Schistosoma haematobium*. J Parasitol Res. 2012;2012:4.
6 Hammad TA, Gabr NS, Talaat MM, Orieby AS, Shawky E, Strickland GT. Haematuria and proteinuria as predictors of *Schistosoma haematobium* infection. Am J Trop Med Hyg. 1997;57:363–7.
7 Ugbomoiko US, Dalumo V, Ariza L, Bezerra FS, Heukelbauch J. A simple approach improving the performance of urine reagent strips for rapid reagent strips for rapid diagnosis of urinary schistosomiasis in Nigerian school children. Mem Inst Oswaldo Cruz. 2009;104:456–61.
8 Akobeng AK. Understanding diagnostic test 1: sensitivity, specificity and predictive values. Acta Paediatr. 2006;96:338–41.
9 Robinson E, Picon D, Sturrock HJ, Sabasio A, Lado M, Kolaczineki J, *et al*. The performance of haematuria reagent strips for the rapid mapping of urinary schistosomiasis: field experience from Sudan. Trop Med Int Health. 2009;14:1484–7.
10 Poggense G, Krantz ZI, Kiwelu I, Feldmeier H. Screening of Tanzanian women of childbearing age for urinary schistosomiasis: validity of urine reagent strip readings and self-reported symptoms. Bull World Health Organ. 2000;78:542–8.
11 Ivoke N. A coprological survey of geohelminth infections among school children in rural Ebonyi State, Nigeria. Anim Res Int. 2007;4:653–61.
12 Red Urine Group. Identification of high risk communities for schistosomiasis in Africa: a multicountry study. Social and Economic Research Project Reports, No. 15. Tropical Disease Research, Geneva: World Health Organization.
13 Tcheum Tchunte LA, Kamwa Ngassam IR, Sumo L, Ngassam P, Dongmo Noumedem C, Nzu DD *et al*. Mapping of schistosomiasis and soil-transmitted helminthiasis in the regions of centre, East and West Cameroon. PloS Negl Trop Dis. 2012;6:e1553.
14 Ekpo UF, Hulimann E, Schur N, Oluwole AS, Abe EM, Mafe MA, *et al*. Mapping and prediction of schistosomiasis in Nigeria using compiled survey data and Bayesian geospatial modelling. Geospat Health. 2013;7:355–66.
15 Madsen H, Stauffer JR, Bloch P, Konings A, McKaye KR, Likongwe JS. Schistosomiasis in Lake Malawi. Afr J Aquat Sci. 2004;29:117–9.
16 Webbe G. The transmission of *Schistosoma haematobium* in an area of Lake Province of Tanganyika. Bull World Health Organ. 1962;27:59–85.
17 Mott KE, Dixon A, Osei-Tutu E, England EC, Ekue K, Tekle, A. Evaluation of reagent strips in urine test for detection of *Schistosoma haematobium* infection: a comparative study in Ghana and Zambia. Bull World Health Organ. 1985;63:125–33.
18 Ugbomoiko US, Obiezue RN, Oguniyi TA, Ofoezie IE. Diagnostic accuracy of different urine dipsticks to detect urinary schistosomiasis: a comparative study in five endemic communities in Osun and Ogun State, Nigeria. J Helminthol. 2009;83:203–9.
19 Houmsou RS, Kela SL, Suleiman MM. Performance of microhaematuria and proteinuria as measured by reagent strip in estimating intensity and prevalence of *Schistosoma haematobium* infection in Nigeria. Asian Pac J Trop Med. 2011;4:997–1000.
20 Anosike JC, Nwoke BE, Njoku AJ. The validity of haematuria in the community diagnosis of urinary schistosomiasis infection. J Helminthol. 2001;75:223–5.
21 Stephenson LS, Latham MC, Kinoti SN, Odour ML. Sensitivity and specificity of reagent strip in screening of Kenyan children for *Schistosoma haematobium* infection. Am J Trop Med Hyg. 1984;33:862–71.
22 Mafe MA. The diagnostic potential of three indirect tests for urinary schistosomiasis in Nigeria. Acta Trop. 1997;68:227–84.
23 Takougan I, Meli J, Fosto S, Angwafo F 3rd, Kamageu R, Ndumbe PM. Haematuria and dysuria in the self-diagnosis of urinary schistosomiasis among school-children in Northern Cameroon. Afr J Health Sci. 2004;11:3–4.
24 Ahmed BA. Two practical and cost effective methods for urinary schistosomiasis screening in Yemeni school children. Iran J Public Health. 2009;38:78–83.
25 King CH, Sturrock RF, Kariuki HC, Hamburger J. Transmission control of schistosomiasis – why it matters now. Trends Parasitol. 2006;22:575–82.
26 World Health Organization. Preventive chemotherapy in human helminthiasis. Coordinated use of anthelminthic drugs in control interventions: a manual for health professionals and programme managers. Geneva: World Health Organization; 2006.
27 Evans DS, King JD, Eigege A, Umaru J, Adamani W, Alphonsus K, *et al*. Assessing the WHO 50% prevalence threshold in school-aged children as indication for treatment of urogenital schistosomiasis in adults in central Nigeria. Am J Trop Med Hyg. 2013;18:441–5.
28 Anya AO, Okafor FC. Prevalence of *Schistosoma haematobium* infections in Anambra State, Nigeria. Bull de l' IFAN.1986–1987;46:321–32.
29 Gray DJ, McManus DP, Li Y, William GM, Bergquist R, Ross AG. Schistosomiasis elimination: lessons from the past guide the future. Lancet Infect Dis. 2010;10:733–6.
30 Lengeler C, Utzinger J, Tanner M. Questionnaire for the rapid screening of schistosomiasis in sub-Saharan Africa. Bull World Health Organ. 2002;80:235–42.
31 Bogoch II, Andrews JR, Dadzie Ephraim RK, Utzinger J. Simple questionnaire and urine reagent strips compared to microscopy for the diagnosis of *Schistosoma haematobium* in a community in northern Ghana. Trop Med Int Health. 2012;17:1217–21.