

Schistosomiasis risk factors based on the infection status among school-going children in the Ndumo area, uMkhanyakude district, South Africa

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Background: Schistosomiasis remains a public health burden in South Africa, particularly in KwaZulu-Natal. The study aimed to identify the risk factors for transmission of *Schistosoma haematobium* among school-going children in the Ndumo area of uMkhanyakude district, KwaZulu-Natal.

Methods: A cross-sectional study involving 320 school-going children, aged 10–15 years, was conducted in 10 local primary schools in the Ndumo area, from May to June 2015. Data were collected using a structured questionnaire based on socio-demographic information, sanitation and water access, recreational, occupational activities, and knowledge about bilharzia. A filtration technique was used to detect *S. haematobium* eggs in 10 ml of urine. A Chi square test, bivariate and logistic regressions were performed to assess the association between variables. Odds ratios were used to determine the strength between significant predictors with 95% confidence interval and *p* value < 0.05.

Results: From the 320 participants, 120 (37.5%) were positive for *Schistosoma haematobium* infection. The risk factors associated with schistosomiasis were age, household head, poor sanitation, access to water source and knowledge about schistosomiasis.

Conclusion: The Ndumo area is considered a moderate zone for schistosomiasis endemicity according to the World Health Organisation (WHO) classification. The significant factors identified should be considered in designing an effective schistosomiasis control program.

Keywords: children, KwaZulu-Natal, Ndumo, risk factors, *Schistosoma haematobium*, Schistosomiasis, South Africa, uMkhanyakude

Introduction

Schistosomiasis, commonly known as bilharzia, is an acute and chronic tropical disease caused by trematodes of the genus *Schistosoma*.¹ The schistosome parasite is transmitted through a snail intermediate host with the human being the definitive host.² Worldwide, schistosomiasis continues to cause a public health problem with 779 million people exposed to the infection.³ The disease is present in 78 countries and endemic in 52 of those countries where an estimated 90% of people need treatment.⁴ Schistosomiasis has been successfully controlled in many countries but its burden remains high in Africa, particularly in sub-Saharan countries.^{2,5,6}

Transmission of the disease is dependent on the particular snail host, and their distribution is influenced by the environment, water development schemes and people migration.² Humans contract infection during domestic, occupational and recreation activities that involve having contact with water infested with cercariae from the intermediate host snails.^{2,4} However, the movement of people from endemic areas to non-endemic areas where the snail intermediate host is present, may introduce the disease to areas where the disease had been absent.⁶ Insufficient and erratic rains due to climate change and the construction of water development schemes to meet power and agricultural needs are usually associated with the movement of people from both endemic and non-endemic areas into the project areas,⁴ thereby introducing or exacerbating the transmission of schistosomiasis.⁷ Schistosomiasis is more prevalent among school-going children.⁸ The distribution of the disease among school-going children between 10 and 15 years of age is mainly attributed to the high frequency of contact with infested water in an endemic area. This predominance thereafter decreases with less contact with infested water in adulthood.^{9,10}

The distribution of schistosomiasis in South Africa is based on temperature suitability, which indicates that the disease is prevalent in the North West, Gauteng, Limpopo, Mpumalanga, KwaZulu-Natal and Eastern Cape provinces.¹¹ The Limpopo, Mpumalanga and KwaZulu-Natal provinces were shown to have an estimated prevalence of 70% of the national burden in South Africa.¹¹

The Ndumo area is located in the northern part of the uMkhanyakude district in the KwaZulu-Natal province. The area has the highest burden of schistosomiasis in the province.¹² A study conducted among school children in 1998 in Ingwavuma in the same study area, reported a prevalence of 68%.¹³ Another study carried out in Mtubatuba in the southern area of the district found a *Schistosoma haematobium* infection prevalence of 16.6%.¹⁴ In the Ndumo area the main source of water is surface water and families rely on rivers and dams to sustain the daily household needs for water such as bathing, washing, and gardening, which expose its population, particularly school-going children, to water infested with snail intermediate hosts. Therefore, school-going children are the most at risk of infection due to their activities which involve contact with water. Immigrants from Mozambique, one of the countries with the highest burden of schistosomiasis worldwide (13 456 367 people requiring preventive treatment in Mozambique),² are a threat to transmission in South Africa,¹⁵ particularly in the Ndumo area.

A better understanding of risk factors for schistosomiasis is important in controlling the disease among school children. We therefore aimed to investigate the schistosomiasis risk factors among school-going children aged between 10 and 15 years based on their *S. haematobium* status in the Ndumo area. The

age group chosen has always been considered the most vulnerable to *S. haematobium* infection.¹⁶

Materials and methods

Study area and population

This study was conducted between May 2015 and June 2015 in the Ndumo area located in the northernmost part of the uMkhanyakude district in the KwaZulu-Natal (KZN) province, South Africa. The district is on the northern coast of KZN and extends over 12 818 km². It is limited to the east by the Indian Ocean, to the north by Mozambique, to the northwest by Swaziland and to the south and west by the Uthungulu and Zululand districts.¹⁷ The uMkhanyakude district is a typical rural area with a sub-tropical climate, characterised by a hot and humid summer (November – February) and a cooler and drier winter (June – August). The area is also characterised by aridness. Rivers (Ingwavuma and Pongola), streams, dams (Pongola) and ponds constitute the hydrologic network. The district is one of the poorest in the province.¹⁷ The unemployment rate was 46.18% excluding housewives in 2003,¹⁷ and was reported to be 53% in 2010.¹² KZN has the highest prevalence of malaria, HIV infection and schistosomiasis infection in the country.¹² It is also the site of natural conservations, such as Ndumo reserve.¹⁷

Study design and sampling

The study was cross-sectional involving school-going children aged 10–15 years from all primary schools (10) in the Ndumo area. The study was conducted under the umbrella of a WHO/TDR funded Malaria and Bilharzia in Southern Africa (MABISA) project. The sample size was calculated using the formula as described in Naing *et al.*¹⁸ as followed:

$$N = Z^2 P (1 - P) / d^2$$

where *Z* statistic = 1.96 for the confidence level of 95%; *P* the expected proportion in our study area = 0.8 (12); *d* the precision = 0.05 for 95% confidence interval. This gave us a sample size of 246. Since there were expectations of absence of children at school during the survey and possible failures by children to return consent and assent forms, *N* was multiplied by 2.5 to have 615 as baseline sample size of our study.

School-going children were systematically sampled using school registers in a manner that represented males and females equally in each school. Only 320 out of 615 provided both parental consent and signed assent forms and were thus eligible to participate in the study.

Data collection

Parasitology survey

Eligible children (320) participated in the parasitology screening for *S. haematobium*. Samples of 10 ml of urine were collected in plastic containers during the day between 10h00 and 14h00 because that was when there was a high probability of obtaining larger loads of eggs.¹⁹ Urine samples were examined using the filtration technique for *S. haematobium* detection.^{19,20}

Questionnaire administration

School-going children who provided parasitology samples were interviewed by pre-trained community research assistants (CRAs) under our supervision using a structured questionnaire with sections that solicited information on socio-demographic

aspect, access to water and sanitation, sources of livelihood, recreational and occupational activities and knowledge about schistosomiasis. Questionnaires were prepared in English and translated to isiZulu, the main spoken local language in the area. They were pretested prior administration to ensure that content was not lost or distorted during translation. However, they were not back-translated. We relied on the experience of the translator who has been used by several other researchers within the university. The CRAs hold metric education qualifications and are proficient in both English and isiZulu.

Data management and statistical analysis

Collected data were computed and analysed using SPSS version 22 (21). *S. haematobium* infection was defined as any number of eggs greater than zero found in 10 ml of urine. Pearson Chi-square test was performed to assess the association between the status of *S. haematobium* infection and the associated risk factors.

A bivariate logistic regression analysis based on the Crude Odds Ratio (COR) and the significance of independent variables was used to predict the likelihood of *S. haematobium* infection (positive) of the 10–15 years old school going children. Risk factors that were found to be statistically significant based on the chi-square *p*-value were considered in the bivariate logistic regression model. Adjusted Odds Ratio (AOR) and *p*-value from multivariate logistic regression model were used to investigate the strength of the likelihood of children to contract schistosomiasis. Only significant predictors from bivariate model were included in the multivariate analysis. A 95% confidence interval with *p*-value < 0.05 was used at all level as the statistical significance. The dependent variable was the infection status with being positive or negative of infection as response. Independent variables were the risk factors investigated.

Ethical consideration and treatment

Ethical clearance was obtained from the Biomedical Research Ethics Committee of the University KwaZulu-Natal (BREC no: BE449/15) and gatekeeper permissions were obtained from local traditional leaders and headmasters of the targeted schools. Since the age group of our study population was between 10 and 15 years, assent and consent forms were sought and obtained respectively from school-going children and their parents. All the questionnaires and results were coded to meet the principle of confidentiality. Children found positive for *S. haematobium* infection were treated by the healthcare workers from the health department of the uMkhanyakude district.

Results

Prevalence of *S. haematobium*

From a total of 320 school-going children aged 10–15 years that participated in the study, 120 (37.5%) were infected with *S. haematobium*.

Socio-demographic information of the participants

Of the 320 participants, 199 (62.2%) were females and 121 (37.8%) were males. Out of the 120 infected school-going children, females had the higher rate of *S. haematobium* infection: 60.8% (73). School children aged 13 years were the most infected (25%). Participants whose mothers were the head of the household accounted for 37.5% (45/120) of the infection. Those whose household heads were employed represented 69.2% (83/120) infected with *S. haematobium*.

Table 1: Frequencies of *Schistosoma haematobium* infection by gender, age, and household head in the Ndumo area of the uMkhanyakude district of South Africa

Factor		Frequency	<i>S. haematobium</i> status		<i>p</i> value
			No. Positive (%)	No. Negative (%)	
Gender	Female	199	73(60.8)	126(63.0)	0.699
	Male	121	47(39.2)	74(37.0)	
Age	10 years	8	2(1.7)	6(3.0)	0.004
	11 years	84	26(21.7)	58(29.0)	
	12 years	81	20(16.7)	61(30.5)	
	13 years	67	30(25.0)	37(18.5)	
	14 years	44	22(18.3)	22(11.0)	
	15 years	36	20(16.7)	16(8.0)	
Household head	Both parents	57	18(15.0)	39(19.5)	0.008
	Mother	109	47(37.5)	64(32.0)	
	Father	76	23(19.2)	53(26.5)	
	Others	78	34(28.3)	44(22.0)	
	Total	320	120(100.0)	200(100.0)	

In the analysis, only age ($p = 0.004$), and household head ($p = 0.008$) were significantly associated with the infection, while the gender was not significant (Table 1).

Sanitation and access to water sources for the participants

Of 320 participants, 236 (73.8%) had toilet facilities at home and accounted for 76 (63%) among those carrying the infection (120). Those using pit latrines carried the biggest burden of the disease (56.7%), followed by those without toilet facilities (36.7%). Of the 200 school-going children that used toilets regularly (62.5% of the participants), 50% of these children carried the disease. During the rainy season, 218 (68.1%) children had access to clean water; but, during the dry season, 189 (59.1%) learners went to an open source of water for their domestic needs and had a 64.2% infection rate. Participants that were involved in bathing and washing clothes at the rivers and dams during the dry season (174) had the highest rate of the disease: 86/120 (71.6%). Forty-one learners (34.25%) who had a clean source of domestic water about 1 km away were more infected than those having a water source at lesser distance [less than 500 m: 28 (23.3%)].

Overall, schistosomiasis had a strong relationship with the following factors: having toilet facilities at home ($p = 0.001$), frequency of toilet use ($p = 0.001$), main source of domestic water during the rainy season ($p < 0.001$), distance of domestic water collection during the rainy season and dry season ($p < 0.001$), and bathing and washing clothes at an open source of water ($p < 0.001$).

Recreational/occupational activities

Of the 320 participants, the highest prevalence of infection was among school children not involved in swimming (83.3%). School children who reported that they fetch water as their main occupational activity (173/320) carried 61.7% (74/120) of the disease burden. A high prevalence (74.2%) was found among children who were not watering gardens. Only those fetching

Table 2: Prevalence of *Schistosoma haematobium* in school-going children by recreational and occupational activities among school-children in the Ndumo area of the uMkhanyakude, South Africa

Risk factors	No. participants	<i>S. haematobium</i> status		<i>p</i> value
		No. Positive	No. Negative	
<i>Swimming</i>				
Yes	50	20(16.6)	30(15.0)	0.422
No	270	100(83.3)	170(85.0)	
<i>Fetching water</i>				
Yes	173	74(61.7)	99(49.5)	0.034
No	147	46(38.3)	101(50.5)	
<i>Washing clothes</i>				
Yes	142	53(44.2)	89(44.9)	0.954
No	178	67(55.8)	111(55.5)	
<i>Watering gardens</i>				
Yes	89	31(25.8)	58(29.0)	0.541
No	231	89(74.2)	142(71.0)	
Total		120	200	

water had a statistical implication for schistosomiasis transmission ($p = 0.034$) (Table 2).

Knowledge about bilharzia

In this study, 295 out of the 320 participants (92.2%) had learnt about bilharzia, of which 108 (90.0%) were observed among the infected. The highest burden (45.8%) was found among those who had received the information about bilharzia at school. The number of children who did not know how one could get infected was 181 (56.6%), and accounted for 42.5% (51/120) of the disease.

Knowing how one could contract bilharzia ($p = 0.003$) and knowing its symptoms were significant ($p = 0.003$). No significance was found with others risk factors.

Logistic regression

Table 3 shows the association between schistosomiasis and the risk factors. Statistical significance was found with the following factors: school children aged 11 and 12 years, having a toilet facility at home, type of toilet (pit latrine), using a toilet every time, using piped/clean water for domestic needs during the rainy season, distance to open source of water during both seasons, fetching water as occupational activity, bathing/washing clothes at home, swimming in infested water as a mode of transmission, and knowing urinating blood (haematuria) as a symptom of schistosomiasis.

In the multivariate logistic regression analysis (Table 4), the risk factors that remained associated with schistosomiasis were the 12 year old age category, distance to open source of water less than 500 m during the dry season, and swimming in infested water as a way of contracting the disease. Participants whose homesteads were close to open water sources (less than 500 m away) were three times more likely to contract schistosomiasis [AOR 95% CI: 3.273(1.216–8.807)] during the dry season. Those that were aware that they could contract schistosomiasis infections by swimming in water infested with schistosomes were twice as likely to contract the disease [AOR 95% CI: 2.147(1.213–3.799)]. In the multivariate model, no statistical significance ($p > 0.05$) was found for the following factors: age of

Table 3: Bivariate logistic regression analysis of the significant risk factors associated with *S. haematobium* in the Ndumo area, uMkhanyakude district

Variable	<i>S. haematobium</i> status		<i>p</i> value	Bivariate logistic analysis COR** (95% CI)
	Positive (%)	Negative (%)		
Age				
10 years	2(1.7)	6(3.0)	0.004	0.267(0.047–0.504)
11 years	26(21.7)	58(29.0)		0.359(0.161–0.801)
12 years	20(16.7)	61(30.5)		0.262(0.114–0.601)
13 years	30(25.0)	37(18.5)		0.649(0.287–1.465)
14 years	22(18.3)	22(11.0)		0.800(0.331–1.936)
15 years	20(16.7)	16(8.0)		1
Householder head				
Both parents	18(15.0)	39(19.5)	0.008	0.585(0.280–1.220)
Mother	45(37.5)	64(32.0)		0.891(0.483–1.642)
Father	23(19.2)	53(26.5)		0.550(0.277–1.090)
Uncle /Aunt	4(3.3)	0(0.0)		0.844(0.218–3.266)
Other	30(25.0)	44(22.0)		1
Toilet facilities at home				
Yes	76(63.3)	160(80.0)	0.001	2.316(1.394–3.848)
No	44(36.7)	40(20.0)		1
Type of toilet				
Pit latrine	68(56.7)	156(78.0)	0.001	0.397(0.238–0.661)
Ventilated latrine	5(4.2)	1(0.5)		4.556(0.511–40.637)
Other type	3(2.5)	2(1.0)		0.911(0.123–6.767)
No toilet (N/A)	44(36.7)	44(36.6)		1
Frequency of using toilet				
Sometimes	20(16.7)	23(11.5)	0.000	0.804(0.3813–1.699)
Every time	60(50.0)	140(70.0)		0.396(0.231–0.680)
Do not use toilet	40(33.3)	37(18.5)		1
Main source of domestic water during the rainy season				
Piped/safe water sources (tap, bore-hole)	67(55.8)	151(75.5)	0.000	0.410(0.253–0.665)
Open water sources (river, dam, spring)	53(44.2)	49(24.5)		1
Distance to the open source of water during the rainy season				
Less than 1 km	28(23.3)	44(22.0)	0.000	2.227(1.170–4.240)
About 1 km away	41(34.2)	43(21.5)		3.337(1.812–6.146)
More than 1 km away	25(20.8)	22(11.0)		3.977(1.936–8.170)
At home	26(21.7)	91(45.5)		1
Place for bathing and washing clothes during the dry season				
At home	48(40.0)	135(67.5)	0.000	0.321(0.201–0.514)
Elsewhere (river, dam, spring, well)	72(60.0)	65(32.5)		1

(Continued)

Table 3: (Continued)

Variable	<i>S. haematobium</i> status		<i>p</i> value	Bivariate logistic analysis COR** (95% CI)
	Positive (%)	Negative (%)		
Place for bathing and washing clothes during the rainy season				
At home	34(28.3)	112(56.0)	0.000	0.311(0.191–0.505)
Elsewhere (river, dam)	86(71.7)	88(44.0)		1
Fetching water as occupational activity				
Yes	74(61.7)	99(49.5)	0.034	1.641(1.035–2.602)
No	46(38.3)	101(50.5)		1
Transmission mode of schistosomiasis				
Swimming in infested water	32(26.7)	38(19.0)	0.003	2.147(1.213–3.799)
Drinking non potable water/dirty water	4(3.3)	5(2.5)		2.039(.526–7.898)
Swimming + drinking + washing	31(25.8)	26(13.0)		3.039(1.645–5.614)
Do not know	51(42.5)	130(65.5)		1
Knowing the symptoms of schistosomiasis				
Presence of blood in the urine (haematuria)	40(33.3)	38(19.0)	0.003	2.462(1.430–4.239)
Pain while urinating (dysuria)	4(3.3)	5(2.5)		1.871(0.484–7.230)
Haematuria + Dysuria	20(16.7)	21(10.5)		2.228(1.120–4.432)
Do not know	56(46.4)	131(65.5)		1
Total	120(100.0)	200(100.0)		

**Crude Odds Ratio.

Table 4: Multivariate logistic analysis for risk factors associated with *Schistosoma haematobium* in the Ndumo area, uMkhanyakude district, South Africa

Predictor		AOR (95% CI)***
Age	10 years	1
	11 years	0.494(0.192–1.269)
	12 years	0.296(0.114–0.764)
Distance to open source of water	Less than 1 km	3.273(1.216–8.807)
	About 1 km away	1.213(0.451–3.261)
	More than 1 km	1.456(0.532–3.982)
	At home	1
Transmission mode of schistosomiasis	Swimming in infested water	2.147(1.213–3.799)
	Drinking dirty water+washing with	1

***Adjusted Odds Ratio.

11 years; having an open source of water at about 1 km away and more than 1 km; drinking dirty water and washing with dirty water as a mode of transmission.

Discussion

The findings of our study revealed an overall prevalence of 37.5% (120/320) of *S. haematobium* among school-going children aged 10–15 years in the Ndumo area of the uMkhanyakude district. The prevalence rate met the WHO classification for an endemic area.²² Referring to the previous study done in the area, there was a notable decrease in the prevalence of *S. haematobium*;¹³ however, the prevalence was higher than that found in a study conducted in the southern part of the same district (Mtubatuba).¹⁴ This could be explained by the fact that after establishing that schistosomiasis was endemic in South Africa, particularly in KwaZulu-Natal, the Department of Health of KwaZulu-Natal in collaboration with the Department of Education set up a 3-year helminth control pilot program promoting regular treatment for schistosomiasis and intestinal helminth infections in all primary schools from 1997–2000.^{23,24}

Out of the 320 participants, our study showed that females were the most affected (60.8%). A study conducted in Nigeria found similar results,²⁵ while others reported the opposite.^{5,26,27} The fact that fetching water and washing clothes are seen as being female duties in our local communities might explain the likely reason for more females being infected. In addition, the difference in the sex ratio during our sampling might have already favoured the female gender.

In our study, participants staying with their mothers as head of household were the most predisposed to develop the infection. In line with our findings, similar results were found in Tanzania.⁹ The fact that single mothers are usually the family providers, they spend less time with the children. Thus, the children are left on their own and may easily get involved in activities that expose them to the disease. Also, single mothers may only count on their children to get assistance for the domestic work, such as fetching water. The age group of 13 years was the most affected which was consistent with the theory that adolescents have a high contact with infested water, which decreases inversely with age in their adulthood.^{9,10}

From our findings, participants that had a toilet at home, particularly those having pit latrines, carried the highest burden of the infection. In contrast with our findings, a study conducted in western areas of the Ivory Coast found a high rate of the infection amongst children lacking toilet facilities at their home.²⁸ In our case, although participants had toilets at home, the open source of water (rivers and dams) remained the main source of domestic water which exposed them to the infection. Participants that had a clean source of water at their home during the rainy season were more affected (55.8%) than those without a clean source of water (44.2%). A noticeable increase of affected children without clean source of water at home was observed during the dry season (from 44.2% to 64.2). Contrary to our findings, a high rate of schistosomiasis was reported in Sudan among school children without a clean water source at their home.⁸ The water accumulation in boreholes and the storage of water in water tanks called “JoJo” tanks during the rainy season, may stop people from using the open water sources more often and this may explain our findings. However, due to the non-availability of water during the dry season, people rely on rivers and dams for their daily water needs. Most of our population (68.1%) had access to clean water during the rainy season even though the highest burden (75.5%) was reported among those using open sources of water. In contrast with the above, the number of people having clean water during the dry season decreased while the infection rate increased among those who

used open water sources. The implication of domestic water sources in *S. haematobium* infection has been reported by other researchers.^{8,29} Children with a habit of bathing and washing clothes at the rivers and dams had a high rate of the infection (71.7%). A similar observation has been reported in other studies.^{8,28} In endemic areas, rivers, dams and ponds are potential sources of infection.

Our findings suggest that people fetching water from less than 1 km away were significantly affected. In line with this, the distance to water sources has been reported as being associated with *S. haematobium* infection in many studies.^{5,8,30–32} The proximity to the open water source might increase the duration of exposure, giving high chances of contracting the parasite.

A high prevalence was not found among school children who practiced swimming contrary to other studies where most of the infections were found among swimmers.^{27,28} This may be explained by the fact that the open water sources were not appropriate for swimming compared to studies conducted in endemic areas with large surfaces of water. Most of the infected participants (61.7%) were involved in the fetching of water. Since the study area was dry with limited piped water, fetching water for domestic use might have been the main occupational activity for school-going children, particularly females, and hence might have been a source of infection.

Our findings showed that 90.0% of those infected had knowledge about bilharzia. This was in line with the study conducted in Ethiopia²⁷ where, even though children were aware of the disease, the environment in which they lived remained a threat to them. They do not have a better option.

Children at puberty, toilet facilities, the main source of water, the distance to the open source of water, bathing and washing clothes at open water sources and fetching water were significantly associated with *Schistosoma* transmission. In accordance with our findings, previous studies reported similar observations.^{5,8,27,29,30,33,34} Young children living in poverty under tropical to subtropical climate have high risk to contract schistosomiasis.

Conclusion

Our study area falls into the zone with moderate risk according to the WHO classification. The population of the Ndumo area live in conditions that predispose them to contracting *S. haematobium* infection.

Improving the sanitation and access to clean water accompanied with treatment with praziquantel once every 2 years, remain the key measures for controlling the disease in the Ndumo area, uMkhanyakude district, KwaZulu-Natal, South Africa.

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