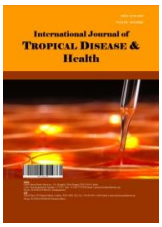

International Journal of TROPICAL DISEASE & Health

41(15): 18-32, 2020; Article no.IJTDH.61600
ISSN: 2278–1005, NLM ID: 101632866

Impact of Mass Drug Administration on Prevalence of Schistosomiasis in Eight Riverine Communities in the Asuogyaman District of the Eastern Region, Ghana

Quartey Abass[1], John Yao Bedzo[1] and Stephen Manortey[1*]

[1]Ensign College of Public Health, Kpong, Eastern Region, Ghana.

Authors' contributions

This work was carried out in collaboration among all authors. Authors QA, JYB and SM participated in conceiving the study and in the development of data collection tools. Author QA carried out data collection. Authors QA, JYB and SM participated in the data analysis and drafting of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJTDH/2020/v41i1530355
Editor(s):
(1) Dr. Giuseppe Murdaca, University of Genoa, Italy.
Reviewers:
(1) Rashika El Ridi, Cairo University, Egypt.
(2) Obiora O. Ikpeze, Nnamdi Azikiwe University, Nigeria.
(3) Gihan Mostafa Tawfeek Saber, Ain Shams University, Egypt.
Complete Peer review History: http://www.sdiarticle4.com/review-history/61600

Original Research Article

Received 20 July 2020
Accepted 27 September 2020
Published 14 October 2020

ABSTRACT

Background: The incidence of schistosomiasis in Ghana and more specifically in the Asuogyaman District had become a noticeable record following the creation of the Akosombo Dam in the early 1960s. This has inevitably since placed an enormous burden on the health service delivery systems in the geographical area. Mass Drug Administration (MDA) of Praziquantel has been used worldwide as a preventive and treatment intervention measure for the disease, and the study area is no exception. The study, therefore, aimed to assess the impact of MDA on the prevalence and associated risk factors of schistosomiasis in eight (8) selected riverine communities within the district.

Methods: A descriptive retrospective cross-sectional study was conducted involving 896 respondents with ages ranging from 2 to 82 years and a mean age of 17±13.78 years. Data were obtained from the Volta River Authority (VRA) Public Health and Environmental Department.

**Corresponding author: Email: steve.manortey@ensign.edu.gh;*

Pearson's chi-square tests and logistic regression models were used to assess the association and predict the relationship between variables.
Findings: Out of the 896 respondents, 93 (10.4 %) tested positive for Schistosoma haematobium. Proportionally, the Nyameben community had a high prevalence of 25.8% while Mami-Waterkope, and Mangoase both had a low prevalence of 3.2 %. The average uptake of Praziquantel was 41% across the study area. From the bivariate analysis, the respondents' community of residence was noted as the only statistically significant variable contributing to infection. Respondents aged 13-39 were 1.68 times more likely to be infected compared to their younger counterparts after controlling for all other covariates in the predictive model.
Conclusion: Mass Drug Administration had a tremendous effect on reducing the prevalence of urinary schistosomiasis to the present level of 10.4%. However, some "hotspots" like the Nyameben community will require special attention to reduce the high prevalence disease rate. Communities with low uptake of Praziquantel had a relatively high prevalence of schistosomiasis.

Keywords: Mass drug administration; schistosomiasis; Asuogyaman district; Ghana.

1. INTRODUCTION

Mass Drug Administration (MDA) is the treatment of the entire population in a geographic area with a curative dose without first testing for infection regardless of the presence of disease symptoms [1]. According to the principle of preventive chemotherapy, this essential drug must be safe and inexpensive [2]. The World Health Organization (WHO) regards schistosomiasis alongside some twenty other tropical diseases, namely Helminthiasis, Lymphatic filariasis, Onchocerciasis, Trachoma, Guinea Worm diseases, etc. as Neglected Tropical Diseases (NTD) [3]. According to Adenowo *et al.* (2015), NTDs are a group of diseases that cause substantial illness for more than one billion people globally and usually affecting the world's poorest people [4]. Schistosomiasis is second only to malaria in terms of the number of people infected and those at risk of infection [5]. The prevalence of schistosomiasis, at present, is still high in sub-Saharan Africa. Out of 17.5 million people treated globally for schistosomiasis in 2008, 11.7 million are from sub-Saharan Africa [4].

Since the discovery of the cause of urinary Schistosomiasis by Theodor Bilharz in 1851 [6] and the entire disease cycle by Brazilian Piraja da Silva in 1908 [7,8], the disease has moved from infectious disease status to a chronic condition due to the difficulty of completing elimination of worm and eggs from an infected person. In 2016 the WHO estimated more than 89 million people were treated out of at least 206.4 million people who required preventive treatment. Also, it was determined that at least 91.4% of those requiring treatment live in Africa, and school-age children are the most risk group because they tend to spend time swimming, bathing, or fishing in water [9]. Approximately 120 million individuals in sub-Saharan Africa have schistosomiasis-related symptoms, while about 20 million undergo hardship as a result of chronic presentations of the disease of 17.5 million people [4].

Schistosomiasis is a parasitic infection caused by digenetic blood trematode worms of the family *Schistosomatidae* and belongs to the genus *Schistosoma* [10,11]. The worms are, therefore, commonly known as schistosomes. Sexual reproduction of the schistosomes occurs in the human (definitive host), with many asexual multiplications occurring in intermediate snail host. The eggs of blood fluke leave the human body in urine or faeces, hatch in water and liberate larvae (miracidia) that penetrate freshwater snail hosts. *Schistosoma* species use freshwater snails as an intermediate host [12].

After several weeks of growth and multiplication, cercariae emerge from the snails and penetrate human skin during contaminative water contact. These cercariae then transform and subsequently migrate through the lungs to the liver, where they mature into adult worms. These adult worms move to the veins of the abdominal cavity or of the urinary tract. Most of the eggs produced are trapped in the tissues, but a proportion escapes through the bowel or urinary bladder [13,14].

The strategy for schistosomiasis control aims to prevent morbidity in later life through regular treatment with Praziquantel, which is currently the only recommended drug for the infection. Mass drug administration is prescribed for the

treatment of most of the neglected tropical diseases due to its cost-effectiveness [15]. Praziquantel is the recommended treatment for schistosomiasis at 40 mg/kg body weight [16,17]. The cost of a single 600-mg tablet is about US$ 0.08, and an average treatment is estimated to be between US$ 0.20–0.30. The combined cost of integrated NTD MDA has been calculated to be in the order of $0.50 per person per year [18]. The commencement of MDA in Ghana started in 1999 with the treatment and prevention of Onchocerciasis, but MDA for treatment of schistosomiasis began in 2008 [19]. The study, therefore, aimed at determining the impact of mass drug administration on the prevalence of schistosomiasis in eight riverine communities in the Asuogyaman District in the Eastern Region of Ghana.

2. METHODOLOGY

2.1 Study Area

The Asuogyaman District Assembly forms part of the twenty-six (26) Municipalities and Districts in the Eastern Region of Ghana. It covers a total estimated surface area of 1,507 km^2 and constitutes 5.7% of the total area of the Eastern Region. The administrative capital of the District is Atimpoku. The District shares boundaries with the Lower Manya Krobo Municipality and Upper Manya Krobo District to the west, to the east with North Tongu District, to the north with Afram Plains South, and to the south with Dangme West District. The population of the district, according to the 2010 Population and Housing Census, stood at 98,046, with 47,030 males and 51,016 females [20]. The main water bodies include the Volta River and Lake, River Adobo, River Opotoku, the Baware, Anyinase River, and the Bubuakan. The main occupation of the people in most of the communities along the river is fishing. This provides an occupational hazard to the people by increasing their risk of contracting schistosomiasis due to the relatively constant exposure to the infected water/ river. This risk is probably further heightened by the dependence on the water for drinking, cooking and recreational activities.

The study site constitutes selected riverine communities in the Asuogyaman district. The study unit was the voluntary respondent who was tested for urinal and intestinal schistosomiasis whether he or she had been tested before or not, or treated previously with Praziquantel or not.

2.2 Study Design, Sampled Population and Sample Size

The study was conducted retrospectively using secondary data obtained from the VRA Environmental and Public Health Department. Eight riverine communities along the banks of the Volta Lake (Abume, Ghanakpoe, Kokontekpedzi, Mami-Waterkope, Mangoase, Nyameben, Adjena Dornor, and Surveyline) were chosen purposively due to the relatively high prevalence rate of the disease, to ascertain the impact of Praziquantel MDA. The communities were categorized into two (2) zones; the Kpong Headpond and the Upper Volta Zones using their location in relation to the direction of the flow of the river. The study participants of 896 were selected conveniently from the eight communities. Using the estimated total population of Asuogyaman District, a 3.26 % margin of error, and the Confidence level of 95%, the sample size was calculated using Survey Monkey online software [21].

2.3 Data Analysis

The obtained data were analyzed using Microsoft Excel and STATA statistical software package (*StataCorp.2007. Stata Statistical Software. Release 14*. StataCorp LP, College Station, TX, USA). The prevalence of schistosomiasis in the various communities was deduced from the secondary data obtained. Chi-square tests were used to examine the associations of prevalence with the demographic, socioeconomic, and environmental factors. For each statistically significant factor, an Odds Ratio (OR) and a 95% confidence interval (CI) were computed where the level of statistical significance was set as $p < 0.05$.

3. RESULTS

3.1 Demographic Characteristics of Respondents

A total of 896 study records were used in this analysis involving eight (8) communities; six (6) from the lower stream area and two (2) from the upstream area of the Akosombo Dam categorized as the “Kpong Headpond” and “Upper Volta” zones respectively. The study revealed that almost 60% of the records were from Surveyline, Adjena Dornor, Ghanakpoe, and Mami-Waterkope recorded 11.8%, 15.5% and 15.3% respectively. The Nyameben community recorded the lowest (7.56%). The mean age of

the subjects was 17±13.78 years, while 50.33% were females. The majority (79.8%) of the subjects were identified as Ewes. Looking at their occupational status, more than half (68.4%) were students (Table 1).

3.2 Prevalence and Incidence Rates of Schistosomiasis

Table 2 showed that 10.4% of the total subjects tested positive, while the rest tested negative for urinary schistosomiasis. Among the subjects who tested positive in the various communities, the Nyameben community yielded the highest incidence rate of 38 per 1000, while Mami-Waterkope had a low incidence rate of 1.4 per 1000 of the population. The total incidence rate of 75 per 1000 population was estimated for the eight communities. Table 3 showed the prevalence recorded in the various communities from 2002 to 2016. This evaluation, however, was not done annually for every community. Hence the prevalence rates were not recorded in some of the communities for some particular years. Abume, Adjena Dornor, Ghanakpoe, and Mami-Waterkope recorded their highest prevalence rate of 52.9%, 72.6%, 20.4%, and 43.5% respectively in the year 2010. Kotontekpedzi and Mangoase recorded their highest prevalence rate in the year 2002 and 2003 respectively, while Surveyline recorded its lowest prevalence rate of 6.5% in the tear 2013. Nyameben recorded the highest prevalence rate of 93.5% among the eight communities, and that was in the year 2008.

Table 4 represented the bivariate analysis of factors associated with urinary schistosomiasis in the participatory communities within the Asuogyaman District. There was no observed statistical significant association between age groups, gender, occupation, ethnicity and the designated zones with urinary Schistosomiasis ($p = 0.083$), ($p = 0.325$), ($p = 0.079$), ($p = 0.664$) and ($p = 0.718$) respectively. However, the analysis revealed there was highly significant associations between urinary schistosomiasis and the community in which they live at ($p < 0.0001$).

Table 1. Demographic Characteristics of the Respondents

Variables		Indicator	Frequency (*f*)	Percentage (%)
Zone	Kpong Headpond:	Abume	113	12.6
		Ghanakpoe	139	15.5
		Kokontekpedzi	98	10.9
		Mami-Waterkope	137	15.3
		Mangoase	100	11.2
		Nyameben	48	5.4
	Upper Volta:	Adjena Dornor	106	11.8
		Surveyline	155	17.3
		Total	896	100
Age-group (years)		2 - 12	432	48.2
		13 -39	387	43.2
		40 - 82	77	8.6
		Total	85.6	100
Gender		Male	445	49.7
		Female	451	50.3
		Total	896	100
Ethnicity		Akan	57	6.4
		Ewe	715	79.8
		Others	124	13.8
		Total	896	100
Occupation		Students	613	68.4
		Traders	77	8.6
		Farmers	25	2.8
		Fisherman	45	5.0
		Others	136	15.2
		Total	896	100

Table 2. Frequency and incidence of urogenital schistosomiasis in 8 communities (2015-2016)

		Frequency (f)	Percentage (%)	Incidence rate per 1000
Urinalysis	Positive for *Schistosoma haematobium*	93	10.4	
	Negative for *S. haematobium*	803	89.6	
	Total	896	100	
Communities positive for *S. haematobium*				
Year 2015	Abume	15	16.1	10.7
	Adjena Dornor	14	15.1	10.4
	Ghanakpoe	10	10.8	3.4
	Kokontekpedzi	13	14.0	4.0
	Mangoase	3	3.2	2.4
	Nyameben	24	25.8	38.1
	Surveyline	11	11.8	4.4
Year 2016	Mami-Waterkope	3	3.2	1.4
	Total	93	100	

Table 3. Prevalence rates of schistosomiasis in eight communities studied from 2002 to 2016

Year	Studied Communities							
	Abume	**Adjena Dornor**	**Ghana-kpoe**	**Kotonte-kpedzi**	**Mami-Waterkope**	**Mangoase**	**Nyameben**	**Survey-line**
2002	-	-	-	35.9	42.8	54	92.6	-
2003	-	-	-	-		57.8	-	-
2004	-	-	-	-	33.3	-	-	-
2005	-	52.3	-	-	-	-	58.6	-
2006	-	45.5	-	-	-	-	-	-
2008	44.5	38.9	-	-	-	51.6	93.5	-
2009	-	15.6	-	-	-	-	-	-
2010	52.9	72.6	20.4	-	43.5	8.8	-	-
2011	-	-	-	-	-	-	-	-
2012	32.4	31.5	10.1	-	40.1		44.9	
2013	-	-	-	13.3	-	-	-	6.5
2014	-	-	-	-	-	-	-	-
2015	13.3	13.2	7.2	-	-	3.0	50.0	7.1
2016	-	-	-	-	2.2	-	-	-

Table 5 represented the multivariate logistic regression analysis of risk factors for urinary schistosomiasis. Subjects within age-groups 13-39 and 40-82 years were 1.83 times and 2.12 times respectively more likely to be infected with schistosomiasis compared to those aged 12 years and below, adjusting for all other variables in the model. Regarding gender, females were 1.28 times more likely to be infected with schistosomiasis compared to the males (AOR = 1.28, 95% CI 0.76-2.15) after controlling for all other covariates. Similarly, subjects living in the Upper Volta zone were 1.46 times more likely to be infected with the disease compared to residents of Kpong Headpond, holding other variables constant (AOR = 1.46, 95% CI 0.60-3.53). Communities such as Adjena Dornor, Kokontekpedzi, and Nyameben were 0.96 times, 0.25 times and 0.89 times respectively less likely to be infected with schistosomiasis compared to Abume; controlling for all other covariates. Concerning the subjects' religious beliefs, the Ewes were 3.23 times more likely to be infected with schistosomiasis compared to the Akan (AOR = 3.23, 95% CI: 0.70-14.92). In contrast, those of the "other" ethnic categories were 57.74 times more likely to be infected. Looking at the subject's occupational status, traders were 0.30 times less likely to be infected compared to the Students (AOR = 0.70, 95% CI: 0.22–2.25) but farmers and fishers were 0.63 times and 0.41 times respectively less likely (AOR = 0.37, 95% CI: 0.08–1.85) (AOR = 0.59, 95% CI: 0.17–2.11).

Subjects classified as"Others" were 2.17 times more likely to be infected, upon adjusting for other variables.

3.3 Prevalence of Intestinal Schistosomiasis and Treatment with Praziquantel

Table 6 displayed both the stool test result for intestinal schistosomiasis and treatment with Praziquantel in the district. Two (2) subjects representing 0.22% were infected with intestinal schistosomiasis, while 22.99% were not infected. The infection status of about 76.7% was not available, but 41.29% of the subjects were treated with Praziquantel while 23.66% were untreated. Since there was no data on the treatment status of 35.05% of the respondents, they were considered as those who did not receive treatment. Out of a total of 370 subjects treated with Praziquantel, 29.7% were from Mami-Waterkope, 16.8% from Surveyline and the least with 2.4% from Nyameben.

Table 7 represented the bivariate analysis on factors associated with Praziquantel treatments in the Asuogyaman District. There was no observed statistical significant association between age groups, gender, ethnicity, zone and Urogenital schistosomiasis prevalence and treatment with praziquantel ($p = 0.646$), ($p = 0.309$), ($p = 0.243$), ($p = 0.412$) and ($p = 0.75$) respectively. However, the analysis revealed there were highly significant ($p = 0.001$) associations between Praziquantel treatments and the community and occupational status of subjects.

Table 4. Bivariate analysis of risk factors for urinary schistosomiasis

Variables		Urinalysis for Schistosoma haematobium ova			
		Subjects (No).	Positive No. (%)	Negative No. (%)	P-value
Age-group (years)	2-12	432	55(12.7)	377 (87.3)	0.083
	13-39	387	31(8.0)	356 (92.0)	
	40-82	77	7 (9.1)	70 (90.9)	
	Total	896	93 (10.4)	803 (89.6)	
Gender	Male	445	51 (11.5)	394 (88.5)	0.325
	Female	451	42 (9.3)	409(90.7)	
	Total	896	93 (10.4)	803 (89.6)	
Occupations	Students	613	69 (11.3)	544 (88.7)	0.079
	Traders	77	8 (10.4)	69 (89.6)	
	Farmers	25	3 (12.0)	22 (88.0)	
	Fishermen	45	7 (15.5)	38 (84.5)	
	Others	136	6 (4.4)	130 (95.6)	
	Total	896	93 (10.4)	803 (89.6)	
Ethnicity	Akan	57	5 (8.8)	52 (91.2)	0.664
	Ewe	715	78 (10.9)	637 (89.1)	
	Others	124	10 (8.1)	114 (91.9)	
	Total	896	93 (10.4)	803 (89.6)	
Communities	Abume	113	15 (8.8)	98 (91.2)	<0.0001*
	Adjena Dornor	106	14 (13.2)	92 (86.8)	
	Ghanakpoe	139	10 (7.2)	129 (92.8)	
	Kokontekpedzi	98	13 (13.3)	85 (86.7)	
	Mami-Waterkope	137	3 (2.2)	134 (97.8)	
	Mangoase	100	3 (3.0)	97 (97.0)	
	Nyameben	48	24 (50.0)	24 (50.0)	
	Surveyline	155	11 (7.1)	144 (92.9)	
	Total	896	93 (10.4)	803 (89.6)	
Zone	Kpong Headpond	635	68 (10.7)	567 (89.3)	0.718
	Upper Volta	261	25 (9.6)	236 (90.4)	
	Total	896	93 (10.4)	803 (89.6)	

*Note: *indicates the measured association is statistically significant at $\alpha < 0.05$*

Table 5. Multivariate logistic regression analysis of risk factors for urinary schistosomiasis

Variables		P-value	COR (95% CI)	P-value	AOR (95% CI)
Age-group (years)	0-12	Reference	1		
	13-39	0.029*	1.68 (1.05-2.66)	0.064	1.83 (0.97-3.48)
	40-82	0.371	1.46 (0.64-3.34)	0.213	2.12 (0.65-6.98)
Gender	Male	Reference	1		
	Female	0.293	1.26 (0.82-1.94)	0.348	1.28 (0.76-2.15)
Zone	Kpong Headpond	Reference	1		
	Upper Volta	0.614	1.13 (0.70-1.83)	0.406	1.46 (0.60-3.53)
Community	Abume	Reference	1		
	Adjena Dornor	0.988	1.01 (0.46-2.20)	0.001	0.04 (0.01-0.26)
	Ghanakpoe	0.113	1.97 (0.85-4.58)	0.411	1.45 (0.60-3.54)
	Kokontekpedzi	0.998	1.00 (0.45-2.22)	0.605	0.75 (0.26-2.20)
	Mami-Waterkope	0.003*	6.84 (1.92-24.26)	0.007*	6.36 (1.68-4.10)
	Mangoase	0.014*	4.95 (1.39-17.64)	0.024*	7.14 (1.30-9.32)
	Nyameben	0.000*	0.15 (0.07-0.34)	0.000*	0.11 (.046-0.25)
	Surveyline	0.096	2.00 (0.88-4.55)	-	1
Ethnicity	Akan	Reference	1		
	Ewe	0.617	0.79 (0.30 -2.03)	0.133	3.23(0.70-14.92)
	Others	0.873	1.10 (0.36- 3.37)	0.000*	57.74(6.24-534.01)
Occupation	Students	Reference	1		
	Traders	0.23	1.09 (0.50-2.37)	0.552	0.70 (0.22-2.25)
	Farmers	-0.12	0.93 (0.27-3.19)	0.229	0.37 (0.076-1.85)
	Fishermen	-0.87	0.69 (0.29-1.60)	0.421	0.59 (0.17-2.11)
	Others	2.32	2.75 (1.17-6.47)	0.123	2.17(0.81-5.81)

*Note: *indicates the measured association is statistically significant at α < 0.05.*

Table 6. Stool analysis for Intestinal Schistosomiasis and Praziquantel treatment

		Frequency (f)	Percentage (%)
Stool analysis for *S. mansoni*	Positive for *S. mansoni*	2	0.22
	Negative for *S. mansoni*	206	22.99
	Not applicable	688	76.79
	Total	896	100
Praziquantel treatment	Received treatment	370	41.29
	Did not receive treatment	212	23.66
	Unknown treatment status	314	35.05
	Total	896	100
Subjects from communities with Praziquantel treatment	Abume	58	15.7
	Adjena Dornor	40	10.8
	Ghanakpoe	21	5.7
	Kokontekpedzi	26	7.0
	Mami-Waterkope	110	29.7
	Mangoase	44	11.9
	Nyameben	9	2.4
	Surveyline	62	16.8
	Total	370	100

Table 8 presented the multivariate logistic regression analysis of factors associated with Praziquantel treatment. The age, gender, zone of community, ethnicity, occupations and urogenital schistosomiasis infection were not statistically significant predictors of Praziquantel treatment in the adjusted model. Subjects within the age-groups of 13-39 and 40-82 years were 0.23 times and 0.25 times respectively less likely to go for the praziquantel compared to those 12 years and below, holding all the other variables constant (AOR= 0.77, 95% CI: 0.54–1.11) and (AOR=

0.75, 95% CI: 0.37–1.52) respectively. Females were 0.09 times less likely to go for praziquantel compared to males, holding other variables constant (AOR= 0.91, 95% CI: 0.67–1.25). An individual going for praziquantel in the upper Volta Zone was 1.6 times more likely compared to the Kpong Headpond zone, holding all other variables constant (AOR = 1.6, 95% CI: 0.93–2.74). There was an increased likelihood of Ewe respondents and other ethnic groups compared to Akan going for praziquantel both in the adjusted (AOR= 1.02, 95% CI:5.13-2.02) and (AOR=1.47, 95% CI: 0.54-3.96) and unadjusted models (COR=1.48, 95% CI:0.30-2.03) and (COR = 1.70 95% CI: 0.36-3.37), respectively.

Subjects who tested positive for urogenital schistosomiasis were 1.05 times more likely to be treated with Praziquantel compared to those who tested negative, holding all other variables constant. In the adjusted analysis, subjects in Ghanakpoe were 6.68 times, Kokontekpedzi

Table 7. Bivariate analysis of risk factors with Praziquantel treatment

Variables		Examined (No.)	Treated. No. (%)	Not treated. No. (%)	P-Value
Age group (years)	2-12	432	182 (42.1)	250 (57.9)	0.646
	13-39	387	160 (41.3)	227 (58.7)	
	40-82	77	28 (36.4)	49 (63.6)	
	Total	896	370 (41.29)	526 (58.71)	
Gender	Male	445	176 (39.5)	269 (60.5)	0.309
	Female	451	194 (43.0)	257 (57.0)	
	Total	896	370 (41.29)	526 (58.71)	
Ethnicity	Akan	57	29 (50.9)	28 (49.1)	0.243
	Ewe	715	294 (41.1)	421 (58.9)	
	Others	124	47 (37.9)	77(62.1)	
	Total	896	370 (41.29)	526 (58.71)	
Community	Abume	113	58 (51.3)	55 (48.7)	0.001*
	Adjena Dornor	106	40 (37.7)	66 (62.3)	
	Ghanakpoe	139	21 (15.1)	118 (84.9)	
	Kokontekpedzi	98	26 (26.5)	72 (73.5)	
	Mami-Waterkope	137	110 (80.3)	27 (19.8)	
	Mangoase	100	44 (44.0)	56 (56.0)	
	Nyameben	48	9 (18.8)	39 (81.3)	
	Surveyline	155	62 (40.0)	93 (60.0)	
	Total	896	370 (41.29)	526 (58.71)	
Occupation	Students	613	279 (45.5)	334 (54.5)	0.001*
	Traders	77	23 (29.9)	54 (70.1)	
	Farmers	25	12 (48.0)	13 (52.0)	
	Fishermen	45	12 (26.7)	33 (73.3)	
	Others	136	44 (32.0)	92 (68.0)	
	Total	896	370 (41.29)	526 (58.71)	
Zone	Kpong Headpond	635	268 (42.2)	367 (57.8)	0.412
	Upper Volta	261	102 (39.1)	159 (60.9)	
	Total	896	370 (41.29)	526 (58.71)	
Urogenital schistosomiasis prevalence	Positive	93	30 (32.3)	63 (67.7)	0.075
	Negative	803	340 (42.3)	463 (57.7)	
	Total	896	370(41.29)	526(58.71)	

*Note: *indicates the measured association is statistically significant at α < 0.05.*

Table 8. Multivariate logistic regression analysis of factors associated with Praziquantel treatment

Variables	P-value	COR (95% CI)	P-value	AOR (95% CI)
Age group (years)				
2-12	Reference	1		
13-39	0.820	1.03 (1.05-2.66)	0.166	0.77 (0.54-1.11)
40-82	0.344	1.2 (0.64-3.34)	0.423	0.75 (0.37-1.52)
Gender				
Male	Reference	1		
Female	0.292	0.866 (0.82-1.94)	0.560	0.91 (0.67-1.25)
Zone				
Kpong Headpond	Reference	1		
Upper Volta	0.388	1.14 (0.70-1.83)	0.089	1.60 (0.93-2.74)
Community				
Abume	Reference	1		
Adjena Dornor	0.044*	1.74 (0.46-2.20)	0.807	0.88 (0.32-2.41)
Ghanakpoe	0.001*	5.93 (0.85-4.58)	0.001*	6.68 (3.51-12.53)
Kokontekpedzi	0.001*	2.92 (0.45-2.22)	0.002*	3.13 (1.52-6.44)
Mami-Waterkope	0.286	0.26 (1.92-24.26)	0.001*	0.29 (0.16-0.52)
Mangoase	0.001*	1.34 (1.39-17.64)	0.024*	1.47 (0.77-2.82)
Nyameben	0.001*	4.57 (0.07-0.34)	0.001*	4.65 (1.98-10.91)
Surveyline	0.066	1.58 (0.88-4.55)	-	1
Ethnicity				
Akan	Reference	1		
Ewe	0.153	1.48 (0.30 -2.03)	0.960	1.02 (5.13-2.02)
Others	0.102	1.70 (0.36- 3.37)	0.450	1.47 (0.54-3.96)
Occupation				
Students		1		
Traders	0.100	1.96 (0.50-2.37)	0.934	0.70 (0.22-2.25)
Farmers	0.810	0.90 (0.27-3.19)	0.903	0.37 (0.076-1.85)
Fishermen	0.020*	2.30 (0.29-1.60)	0.387	0.59 (0.17-2.11)
Others	0.010*	1.74 (1.17-6.47)	0.563	2.17 (0.81-5.81)
Urogenital schistosomiasis prevalence				
Negative	Reference	1		
Positive	0.060	1.54	0.870	1.05 (0.62-1.75)

*Note: *indicates the measured association is statistically significant at α < 0.05*

3.13 times, Mangoase 1.47 times, and Nyameben 4.65 times more likely to go for praziquantel compared to those in the Abume community, holding all confounding variables constant. From the simple regression, those in fishing and other occupations produced statistically significant odd ratios of (COR =2.30, 95% CI: 95% CI 0.29-1.60) and (COR=1.74, 95% CI: 1.17-6.47) compared to respondents who were students.

4. DISCUSSION

Despite the relatively low prevalence (10.4%) of urinal Schistosomiasis observed in the study site, it was noted that the incidence rate varies within communities where the Nyameben community produced a high incidence rate of 38 per 1000 of the population. A general observation of the summary of the estimated annual prevalence rates for these communities since 2002 showed that there has been a decline of infection even though, for some of the years, there was a sudden spike in the prevalence. Mangoase, Nyameben, Adjena Dornor, Abume had prevalences of more than 50 % in 2002, with a dramatic reduction to about 10 %, except in Nyameben.

The national prevalence of Schistosomiasis in Ghana as at 2010 was 70.9 %, which was slightly lower the than 1986 and 2003 estimates of 72.5 % [22]. A study done in the Zenu community of Ghana by Tetteh-Quarcoo *et al.* (2013) recorded a prevalence of 30.7% [23] an indication of reduced prevalence over time. In Ethiopia, a study done among school children in the Gambella Regional State had a prevalence of 35.9 % [24]. A similar study done in Lusaka, Zambia, also among school-age population

recorded a prevalence of 20.72 %, which is much lower than what was observed in this study. A 17.8 % prevalence rate was reported among the Hausa community in Kano State, Nigeria, with no significant difference in the prevalence of urogenital Schistosomiasis (8.3%) and intestinal Schistosomiasis of 8.9 % [11].

In this study (see Table 4), individuals below 12 years old had a higher prevalence of schistosomiasis, with 55 infections out of 432 giving 12.7% which was higher than those of 13-39 years with 8.0% (31 out of 381) and 42-82 years with 9.1% (7 out of 77). Respondents below 12 years old were likely to be school children, so this prevalence rate met the WHO classification for an endemic area [18]. A 27.4 % urinary Schistosomiasis prevalence rate was reported among respondents between the ages of 11 and 12 years, and 39.1% for 13–14 years old [25]. Agnew-Blais *et al.* (2010) reported a statistically significant associated risk factor among adolescents (13–17 years old) and pre-adolescents (9–12 years old) (AOR =3.26, 95%, CI: 2.15–4.93) and (AOR= 3.33, 95% CI: 2.04–4.79) respectively [26]. Age as exposure to Schistosomiasis infection in this study was not a significant predictor. However, respondents below 18 years old were reported to be a statistically significant predictor of infection [11]. The subjects from Mangoase and Mami-Waterkope communities were 7.14 and 6.36 times, respectively, more likely to be exposed to the disease compared to their counterparts in Abume, adjusting for all the other variables.

Out of 896 respondents, males had a higher prevalence of 11.5% (51 out of 445) over females 9.3% (42 out of 451) (see Table 4). This outcome was contrary to a similar study conducted by Kabuyaya *et al.* (2017) among school-going children in the Ndumo area in South Africa, which had a prevalence of 60.8 % among females [27]. However, the finding in this study corroborated other studies among school children in Mozambique that males were more at risk [28]. Fulford *et al*. (1996) observed that in some communities, females had contracted the disease far more than males across age groups, while in other villages, both genders had almost identical patterns of infection [29]. It is likely that due to gender-role differences, exposure to Schistosoma *haematobium* differed slightly between males and females. In some Moslem communities, females are not allowed to swim or bathe in open water sources and also do not participate in fishing and irrigation activities [30]. Moreover, males were more likely to be knowledgeable of the existence of an open water source in their area compared to females, thereby leading to a higher prevalence among the males [31].

Concerning occupation, there was higher prevalence among fishermen 15.5% (7 out of 45) than farmers 12% (3 out of 25) and students 11.5% (69 out of 613) (see Table 4). Augusto *et al.* (2009) reported that farmers had a higher prevalence of infection than non-farmers, while housewives had more cases than Government employees and casual workers [28]. The result of this study also supported that of Salwa *et al.* (2016) that individuals with secondary and tertiary education had a high prevalence of 19.9% among those in education and that unemployed individuals also had a higher prevalence of 21.7 % more than the employed [11].

The Kpong Headpond zone communities had a higher prevalence rate of urinary schistosomiasis than communities within the Upper Volta Zone. Out of the positive cases, 73.1% (68 out of 93) were from within the Kpong Headpond zone while 26.9% (25 out of 93) were from within Volta zones. Kumbu *et al.* (2016) explored the prevalence of *Schistosoma mansoni* infection in Kisanthu Health zone in the Congo Democratic Republic and reported a high prevalence of schistosomiasis among children in Kipasa compared to other health areas [32]. Children in Kipasa are known to make close contact with Lassa and Kiela rivers which shelter snail, intermediate hosts of *Schistosoma* species in the area. The high prevalence in the Kpong Headpond Zone may be due to some of the characteristics studied that might have tipped the balance heavily toward the Kpong zone in terms of the prevalence. The high prevalence in this zone may be significant because the Nyameben community with the highest prevalence of urinary schistosomiasis is situated within it. There was a statistically significant difference between the prevalence of the participatory communities in the study, with Nyameben having a higher prevalence and probably posing a higher risk than the other communities. It may not be surprising because Nyameben is within the Kpong Headpond zone, which had more urinary Schistosomiasis cases. Differences in prevalence among the communities corroborated the findings by Satayathum *et al.* (2006) in Kenya that place of residence was consistently a significant

predictor for infection and re-infection. They observed that those at risk had no pipe-borne water and sanitary facilities as well as being in an area with persistently high snail and human infection rates [33]. Toilet facilities were provided in certain areas, but some residents in the study communities still practised open defecation, and in the water, which increases the risk of infection and re-infection. The availability of water and distances of homes from water sources may have played a role in this study, like in those of Pennance *et al*. (2016) and Clennon *et al.* (2004) [34,35].

Communities like Mangoase and Ghanakpoe with some settlements away from the water might have accounted for their low prevalence. Mogeni *et al.* (2020) reported that some villages with access to pipe-borne water had overall shorter and fewer water-contact activities than the residents in other villages that had only borehole, wells, and surface water as their main sources of water supply. And that those with piped water were the same ones that had the lowest risk of infection or re-infection [36].

Respondents of the Ewe ethnicity had a higher prevalence of urinary schistosomiasis 10.9% (78 out of 715) than those in the Akan ethnic groups with 8.8% (5 out of 57) and the others 8.1% (10 out of 124). These may be attributable to the fact the Ewes comprised 79.8% or 715 out of the total 896 respondents. A study by Sama *et al.* (2007) within the South West Province of Cameroon, noted ethnicity was a significant predictor for schistosomiasis infection with a p-value lesser than 0.05 [37]. Pinot De Moira *et al*. (2010) elaborated in their finding that the influence of ethnicity on infection had been linked to cercarial exposure as opposed to biological differences in susceptibility to infection [38]. In this study, a lower level of schistosomiasis infection was observed in females than males among the Ewes, but there was no clear difference in gender prevalence among the Akan ethnic group. It was reported by Chaula *et al*. (2014) that the influence of gender on the re-infection of schistosomiasis appeared to differ depending on the ethnic groups in Tanzania [39]. This observation could likely be attributed to the occupational distributions from these communities as they registered a lot of school-going children. Respondents from the other ethnic groups in this study were observed to be 57.74 times more likely to be contracting urinary schistosomiasis compared to the Akans, holding all other variables constant.

The treatment status of a significant number of respondents 314 (35.05 %) was not available while 212 (23.66 %) had no clear reason for not taking Praziquantel. The remaining 370 received Praziquantel on-the-spot during the testing and evaluation exercise in 2015 and 2016. A study done by Mogeni *et al.* (2020) shows that the treatment of schistosomiasis with praziquantel helps to boost one's natural immunity against the disease, thereby serving as a significant predictor to reduced re-infection [36]. In a study to assess the impact of mass drug administration in Bahi, Tanzania, by Chaula *et al*. (2014), it was observed that there was an increase in uptake of MDA praziquantel from 39.5% in 2011 to 43.6% in 2012, leading to a decrease in the prevalence of *S. haematobium* by 50 % from 2011 to 2012 [39]. This finding was synonymous with the observation in this study where urogenital schistosomiasis prevalence was very high in a community like Nyameben with low MDA praziquantel uptake of about 1% and approximately 19 % (using the total number of participants who received Praziquantel (370) and the total number of participants (896) in the study, as denominators respectively) and prevalence was low (2%) in communities where the uptake was comparatively higher as seen in the case of Mami-Waterkope. Using the same yardstick, the community recorded an uptake rate of 12.2 % and 80 % higher than the rest of the communities. This rate conformed with and surpassed the WHO target coverage of 75 % at the community level. The average uptake or coverage per the eight (8) communities representing the Asuogyaman district stood at 41 %, which is relatively lower than the WHO target coverage of 75 % at the community level. In a study done in the Koome Islands, Central Uganda, Tuhebwe *et al*. (2015) observed that uptake of MDA was more likely if the respondent was knowledgeable about schistosomiasis transmission and prevention, and reported a sub-optimal uptake of schistosomiasis of 44.7 % [40].

5. CONCLUSION

The prevalence rate of schistosomiasis in eight (8) selected communities in the Asuogyaman District of the Eastern Region of Ghana was very high. Urinary Schistosomiasis was more prevalent in some "hotspot" communities like Nyameben, compared to the rest of the communities, and it was more in males than females by 10 %. The study also revealed that there are more cases in the Kpong Headpond Zone as compared to the Upper Volta zone. The

prevalence rate of urinary schistosomiasis by the occupation status of the subjects also revealed the rate was much higher among students compared to those in other occupations. The risk factors that were statistically associated with urinary schistosomiasis were the communities of residence of positive cases (Mangoase, Nyameben, and Mami-Waterkope) and ethnic groups other than Akan and Ewe. The Mami-Waterkope with high uptake of Praziquantel had low prevalence while Nyameben with low uptake had a high prevalence of urinary schistosomiasis.

The Ministry of Health, Regional, and District Health Directorates should integrate Praziquantel administration into their health-care delivery programmes, as well as intensify public education on the modes of disease transmission among residents of riverine communities to sustain community-wide treatment. Despite the advantages of MDA, the effect is often short-lived with the possibility of reinfection. It is, therefore, the total adherence to personal hygiene and the strict avoidance of getting in contact with infected water bodies that will reduce the infection rate. Hence the need to intensify public education on the mode of transmission of the disease within the riverine communities.

Findings from this work will contribute knowledge to science and help inform stakeholders/ policymakers on the prevalence of the disease within the participatory communities which could guide further strategies to eradicate the disease. Future research work should consider exploring a qualitative approach to help unearth the prevailing factors influencing the low uptake of the prescribed treatment among residents.

CONSENT

It is not applicable.

ETHICAL APPROVAL

Administrative approvals from the Asuogyaman Directorate of Health Service and VRA Public Health and Environmental Department were respectively sought prior to the gathering of the needed data. Names of participants were expunged from hospital records for confidentiality. Ethical approval was also given by the Ethics Review Board of Ensign College of Public Health. Finally, all documents cited in the text were acknowledged in the references.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Prevention-CDC 'CDC - Malaria - Malaria Worldwide - How Can Malaria Cases and Deaths Be Reduced? - Mass Drug Administration and Mass Fever Treatment'; 2015.
   Available:https://www.cdc.gov/malaria/malaria_worldwide/reduction/mda_mft.html
2. Joanne P Webster, David H Molyneux, Peter J Hotez, Alan Fenwick. 'The contribution of mass drug administration to global health : Past, present and future. Philosophical Transaction of Royal Society B. 2014:369.
   Available:https://doi.org/10.1098/rstb.2013.0434
3. Bodimeade C, Marks M, Mabey D. Neglected tropical diseases: elimination and eradication. Clinical Medicine. 2019;19(2):157-160.
   Available:https://doi.org/10.7861/clinmedicine.19-2-157
4. Adenowo AF, Oyinloye BE, Ogunyinka BI, Kappo AP. 'Impact of human schistosomiasis in sub-Saharan Africa', The Brazilian Journal of Infectious Diseases. 2015;1(92):196–205.
   Available:https://doi.org/10.1016/j.bjid.2014.11.004.
5. Barakat RMR. 'Epidemiology of Schistosomiasis in Egypt: Travel through Time: Review', Journal of Advanced Research, 2013;4:425–432.
   Available:https://doi.org/10.1016/j.jare.2012.07.003
6. Di Bella S, Riccardi N, Giacobbe DR, Luzzati R. History of schistosomiasis (bilharziasis) in humans: from Egyptian medical papyri to molecular biology on mummies. Pathogens and Global Health. 2018;112(5):268-273.
   Available:https://doi.org/10.1080/20477724.2018.1495357.
7. Jordan P. Schistosomiasis: The St Lucia Project - Peter Jordan - Google Books, Cambridge: Cambridge University Press; 1985.
   Available:https://doi.org/10.1017/S0025727300045865.
8. Droz J. Tropical Hemato-Oncology - Google Books; 2015.

Available:https://books.google.com.gh/books/about/Tropical_Hemato_Oncology.html?id=g1UwCgAAQBAJ&redir_esc=y.

9. Schistosomiasis [InternetAvailable: https://www.who.int/news-room/fact-sheets/detail/schistosomiasis. [cited 2020 Mar 14].
10. Jamieson BGM. Schistosoma : Biology, pathology, and control; 2017. ISBN:9781498744256. Available:https://www.crcpress.com/Schistosoma-Biology-Pathology-and-Control/Jamieson/p/book/9781498744256
11. Salwa D, Hesham MA, Init I, Jamaiah I, Awatif MA, Abdulhamid A, Hany S, Wahib MA, MAA, Fatin NE, Nabil Ahmed N, Johari S. 'Prevalence and risk factors of schistosomiasis among Hausa communities in Kano State, Nigeria'. Rev. Inst. Med. Trop. S. Paulo. 2016;56. Available:https://doi.org/10.1590/S1678-9946201658054
12. WHO. Crossing the billion. Lymphatic filariasis, onchocerciasis, schistosomiasis, soil-transmitted helminthiases and trachoma: Preventive chemotherapy for neglected tropical diseases; 2017. Available:https://www.who.int/neglected_diseases/resources/9789240696471/en/
13. Wikipedia; 2018. Available:https://en.wikipedia.org/wiki/Schistosoma_mansoni.
14. Manuela Ciddio Lorenzo Mari, Susanne H Sokolow, Giulio A De Leo, Renato Casagrandiand MarinoGatto. The spatial spread of Schistosomiasis: A multidimensional network model applied to Saint-Louis region, Senegal. Advances in Water Resources. 2016;108:406-415. Available:https://doi.org/10.1016/j.advwatres.2016.10.012
15. WHO. 'WHO | Epidemiological situation', WHO. World Health Organization; 2016. Available:https://www.who.int/gho/publications/world_health_statistics/2016/Annex_B/en/
16. Turner HC, Truscott JE, Hollingsworth, TD. Cost and cost-effectiveness of soil-transmitted helminth treatment programmes: Systematic review and research needs. Parasites Vectors. 2015;8:355 Available:https://doi.org/10.1186/s13071-015-0885-3
17. Crompton DWT. (David WT, WHO). Preventive chemotherapy in human helminthiasis : Coordinated use of anthelminthic drugs in control interventions : A manual for health professionals and programme managers. World Health Organization; 2006. Available:https://apps.who.int/iris/bitstream/handle/10665/43545/9241547103_eng.pdf?sequence=1
18. Joanne P Webster, David H. Molyneux, Peter J Hotez, Alan Fenwick. 'The contribution of mass drug administration to global health: past, present and future'. Philosophical Transaction of Royal Society-Biological Sciences. 2014;19:369. Available:https://doi.org/10.1098/rstb.2013.0434
19. Cunningham LJ, Campbell SJ, Armoo S, Koukounari A, Watson V, Selormey P, Stothard JR, Idun B, Asiedu M, Ashong Y, Adams ER, Osei-Atweneboana MY. Assessing expanded community-wide treatment for schistosomiasis: Baseline infection status and self-reported risk factors in three communities from the Greater Accra Region, Ghana. PLoS Neglected Tropical Diseases. 2020;14(4):e0007973. Available:https://doi.org/10.1371/journal.pntd.0007973
20. Population and Housing Census Asuogyaman District; 2010). Available:https://new-ndpc static1.s3.amazonaws.com/CACHES/PUBLICATIONS/2016/06/06/Asuogyaman+2010PHC.pdf
21. Survey Monkey. Sample Size Calculator: Understanding Sample Sizes | Survey Monkey; 2018. Available:https://www.surveymonkey.com/mp/sample-size-calculator/
22. Susanne S. 'History of Schistosomiasis Control in Ghana'; 2015. Available:https://schisto.stanford.edu/pdf/Ghana.pdf
23. Patience B Tetteh-Quarcoo, Simon K Attah, Eric S Donkor, Marian Nyako, Andrew A Minamor Emmanuel Afutu, Edward T Hervie, Patrick F, Ayeh-Kumi. 'Urinary Schistosomiasis in Children—Still a Concern in Part of the Ghanaian Capital City', Open Journal of Medical Microbiology, 2013;3:151-158. Available:https://doi.org/10.4236/ojmm.2013.33023.
24. Alemu A, Tegegne Y, Damte D, et al. Schistosoma mansoni and soil-transmitted helminths among preschool-

aged children in Chuahit, Dembia district, Northwest Ethiopia: Prevalence, intensity of infection and associated risk factors. BMC Public Health. 2016;422. Available:https://doi.org/10.1186/s12889-016-2864-9

25. Geleta S, Alemu A, Getie S. Prevalence of urinary schistosomiasis and associated risk factors among Abobo Primary School children in Gambella Regional State, southwestern Ethiopia: A cross-sectional study. Parasites Vectors. 2015;8:215. Available:https://doi.org/10.1186/s13071-015-0822-5
26. Agnew-Blais J, Carnevale J, Gropper A, Shilika E, Bail R, Ngoma M. 'Schistosomiasis Haematobium Prevalence and Risk Factors in a School-age Population of Peri-urban Lusaka, Zambia'. Journal of Tropical Pediatrics, 2010;56(4):247-253. Available:https://doi.org/10.1093/tropej/fmp106
27. Muhubiri Kabuyaya, Moses J Chimbari, Tawanda Manyangadze, Samson Mukaratirwa. 'Schistosomiasis risk factors based on the infection status among school-going children in the Ndumo area, Mkhanyakude district, South Africa', Southern African Journal of Infectious Disease. 2017;32(2):67–72. Available:https://doi.org/10.1080/23120053.2016.1266139
28. Gerito Augusto, Rassul Nalá, Verónica Casmo, Acácio Sabonete, Lourenço Mapaco, Judite Monteiro. 'Geographic Distribution and Prevalence of Schistosomiasis and Soil-Transmitted Helminths among Schoolchildren in Mozambique', The American Journal of Tropical Medicine and Hygiene. 2009;81(5):799–803. Available:https://doi.org/10.4269/ajtmh.2009.08-0344
29. Fulford AJC, Ouma JH, Kariuki HC, Thiongo FW. 'Water contact observations in Kenyan communities endemic for schistosomiasis: methodology and patterns of behaviour', Parasitology. 1996;113(3):223–241. Available:https://doi.org/10.1017/S0031182000082007
30. Hany Sady, Hesham M Al-Mekhlafi, Mohammed A K Mahdy, Yvonne A L Lim, Rohela Mahmud, Johari Surin. 'Prevalence and Associated Factors of Schistosomiasis among Children in Yemen: Implications for an Effective Control Programme', PLoS Neglected Tropical Diseases. 2013; 7(8):e2377. Available:https://doi.org/10.1371/journal.pntd.0002377
31. Atupele P Kapito-Tembo, Victor Mwapasa, Steven R Meshnick, Young Samanyika, Dan Banda, Cameron Bowie, Sarah Radke. 'Prevalence Distribution and Risk Factors for Schistosoma hematobium Infection among School Children in Blantyre, Malawi', PLoS Neglected Tropical Diseases. 2009;3(1):e361. Available:https://doi.org/10.1371/journal.pntd.0000361
32. Kumbu RK, Makola KM, Bin L. 'Prevalence of Schistosoma mansoni Infection in Four Health Areas of Kisantu Health Zone, Democratic Republic of the Congo', Hindawi- Advances in Medicine. 2016;5. Available:https://doi.org/10.1155/2016/6596095
33. Satayathum SA, Muchiri EM, Ouma JH, Whalen CC, King CH. 'Factors affecting infection or re-infection with Schistosoma haematobium in Coastal Kenya: Survival analysis during a nine-year,school-based treatment program', American Journal of Tropical Medicine and Hygiene. 2006;75(1):83–92. Available:https://www.ncbi.nlm.nih.gov/pubmed/16837713
34. Pennance T, Person B, Muhsin MA, Khamis AN, Muhsin J, Khamis IS, Mohammed KA, Kabole F, Rollinson D Knopp S. Urogenital schistosomiasis transmission on Unguja Island, Zanzibar: characterisation of persistent hot-spots. Parasites & Vectors. 2016;9:646. Available:https://doi.org/10.1186/s13071-016-1847-0
35. Julie A Clennon, Charles H King, Eric M Muchiri, H Curtis Kariuki, John H Ouma, Peter Mungai, Uriel Kitron. 'Spatial patterns of urinary schistosomiasis infection in a highly endemic area of coastal Kenya.', The American Journal of Tropical Medicine and Hygiene. 2004;70(4):443–448. Available:https://doi.org/10.4269/ajtmh.2004.70.443
36. Mogeni P, Vandormael A, Cuadros D, Appleton C, Tanser F. Impact of community piped water coverage on re-infection with urogenital schistosomiasis in rural South Africa. eLife. 2020;9: e54012.

Available:https://doi.org/10.7554/elife.54012

37. Sama MT, Oyono E, Ratard RC. High-risk behaviours and schistosomiasis infection in Kumba, South-West Province, Cameroon.', International Journal of Environmental Research and Public Health. 2007;4(2): 101-105.
Available:https://doi.org/10.3390/ijerph2007040003

38. Pinot De Moira, Fulford AJC, Kabatereine NB, Ouma JH, Booth M, Dunne DW. Analysis of Complex Patterns of Human Exposure and Immunity to Schistosomiasis mansoni: The Influence of Age, Sex, Ethnicity and IgE. PLOS Neglected Tropical Diseases. 2010;4(9): e820.
Available:https://doi.org/10.1371/journal.pntd.0000820

39. Chaula SA, Tarimo DS. 'Impact of praziquantel mass drug administration campaign on prevalence and intensity of Schistosoma haemamtobium among schoolchildren in Bahi district, Tanzania', Tanzania Journal of Health Research. 2014;16(1).
Available:https://doi.org/10.4314/thrb.v16i1.1

40. Tuhebwe D, Bagonza J, Ekirapa Kiracho E, Yeka A, Elliott AM, Nuwaha F. 'Uptake of Mass Drug Administration Programme for Schistosomiasis Control in Koome Island, Central Uganda', PloS ONE 2015;10(4):e0123673.
Available:https://doi.org/10.1371/journal.pone.0123673

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/61600