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SCHISTOSOMIASIS AMONG SCHOOL-AGED CHILDREN AFTER MASS PRAZIQUANTEL ADMINISTRATION: PREVALENCE AND RELATIVE INDEX OF POTENTIAL CONTAMINATION IN KATSINA-ALA, BENUE STATE, NIGERIA

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ABSTRACT

Mass drug administration (MDA) of praziquantel is an intervention used in the treatment and control of schistosomiasis. This longitudinal study assessed the prevalence of Schistosoma haematobium infection and the relative index of potential contamination among school children in Katsina-Ala Local Government Area, Benue State, Nigeria, at three, six and nine months after mass administration of praziquantel. A total of 3,810 children aged 5–19 years were examined at the first survey, 3,612 at the second survey and 2,918 in the ward-level for the third survey. Urine samples collected between 10:00 and 14:00 h were examined by reagent-strip testing and microscopy following sedimentation. At three months, 468/3,810 (12.28%) children were infected; at six months, 275/3,612 (7.61%) were infected; and at nine months, 248/2,918 (8.50%) were infected. Mbatyula recorded the highest prevalence at three months (25.0%) and remained among the highest-prevalence wards at six and nine months (14.9% at each survey). The Rel. IPC for the 5–9, 10–14 and 15–19-year age groups was 15.45%, 61.32% and 23.22%, respectively, at three months; 14.48%, 61.85% and 23.67% at six months; and 14.06%, 63.38% and 22.55% at nine months. The 10–14-year age group therefore contributed the largest proportion of estimated environmental contamination throughout follow-up. The findings indicate persistent transmission after praziquantel administration and support continued surveillance, repeated treatment where indicated, improved access to safe water and sanitation, and targeted health education in high-risk communities.

KEYWORDS*:* Schistosomiasis, Prevalence, Continued Infection Praziquantel Administration, Benue State

INTRODUCTION

Schistosomiasis is a chronic and debilitating neglected tropical disease affecting poor rural communities in sub-Saharan Africa where local populations seek water for cooking, drinking, washing and bathing at schistosomiasis transmission sites (Abubakar *et al.,* 2022). Over 280, 000 deaths per year in Africa is due to schistosomiasis of which 150,000 and 130,000 deaths are due to urinary schistosomiasis and intestinal schistosomiasis, respectively. *Schistosoma haematobium* is a parasite that is responsible for urogenital schistosomiasis in different localities of Nigeria particularly in the riverine areas where human-water contact activities are inevitable (Okete *et al.*,2021).

To encourage effective management of helminth diseases including schistosomiasis, the 54th World Health Assembly (WHA) endorsed resolution 54.19 in 2001 which was to encourage member States to treat all school-aged children with praziquantel. Consequently, many sponsors including NGOs and governments in endemic regions are now paying keen interest to schistosomiais and other neglected tropical diseases (NTD) control (Guyatt *et al.,* 1999). For instance, mass drug administration of praziquantel was implemented in Uganda and Tanzania in 2003 and Nigeria in 2017 (Onwuma *et al.,* 2024). According to Bowie *et al* (2004), a cost-effective approach in the delivery of praziquantel through the schools was adopted in all these Countries. However, elimination or reduction of the disease through this school-based method of treatment has been challenged by re-infection since other members of community who may habour the infection and potential sources of contamination or transmission are left out (Tadesse e*t al.,* 2010)

Nigeria is a signatory to the 54th World Health Assembly Resolution 54.19 which encourages affiliated states to treat 75-100% of all school aged children, pregnant women and other vulnerable groups by 2020 (Richards, 2020). Interestingly, part of the mandate of this resolution which was praziquantel mass administration in school has commenced fully in many states of the federation. To strengthen this objective, estimation of prevalence and intensity and index of potential contamination of urinogenital schistosomiasis in areas where mass drug administration of praziquantel has been implemented is key. This would ascertain the age groups that are contribution the bulk of schistosoma eggs, thereby polluting the environment so that treatment can be implemented in a cost-effective manner.

This study was conducted amongst school aged children because they are usually the highly vulnerable group given the importance of the microbiome to them (Celia *et al.,* 2024). Many studies have assessed what factors impact the composition, abundance, and diversity of the prevalence and intensity of schistosomiasis in school children but yet to evaluate the IPC and thus, should be first targeted group for intervention because of the detrimental effects the disease has on their growth and development Afikwu *et al.,* 2019; Jozef *et al.,* 2021. Furthermore, they represent the infection status in the population as they consistently have highest prevalence and transmission of schistosomiasis and treatment via schools is also feasible and cost effective (Opara *et al.,* 2021).

Index of potential contamination (IPC) is most powerful predictive methodology and relevant epidemiological measures to identify the relative potential of different age groups at higher risk of infection and responsible for the transmission and spread of this disease in particular area than the use of prevalence and/or intensity (Olorunniyi *et al.,* 2024).

The identification of risk factors for *S. haematobium* infection contributes to a better understanding of the transmission process and for the definition of control programs in particular localities (King *et al.*, 2012; Shun *et al.*, 2024)

Although several epidemiological studies for urogenital schistosomiasis due to *S. haematobium* infection were carried out in different parts of Nigeria, none of them yet estimated the IPC of this disease (Eigege *et al.*, 2020; Eigege *et al.*, 2017). Moreover, there is no updated information on the infection profiles and transmission potential of urogenital schistosomiasis in the current study site except a study conducted few years ago by Okete *et al*, (2018).

However, health strategy for attainment of effective parasitic disease control programs demand knowledge on the magnitude of the disease and their changes in course of time with ecological, cultural, behavior and other factors. Therefore, the present study aimed to provide epidemiological data on the magnitude, intensity of infection, and potential transmission of *S. haematobium infections* among school children in different council wards in Katsina-Ala, Benue, Nigeria.

MATERIALS AND METHODS

Description of the study area

The study area was Katsina-Ala Local Government Area (Figure 3). Katsina-Ala is one of the largest Local Government Areas in Benue State. It has an area of 2,402km^2 and a total population of 224,718 people (Benue State population census, 2018). The administrative capital of Katsina-Ala Local Government Area is Katsina-Ala which has the Tiv and Itulos as the indigenous people. However, there are other ethnic groups including the Akweya and Nifon, Jukun, Haousa, Igbo and Igala people that are residing in the area.

Katsina-Ala Local Government Area lies within the lower river Benue trough in the middle-belt region of Nigeria. It lies between longitude 7.33^o E and 9.0 ^{o} E East of the Greenwich meridian and latitude 7.33^o N and 9.05^o N North of the equator and borders with five other Local Government Areas of Benue State: Ukum -North, Logo, Kwande - South, and Ushongo - West. It experiences two weather conditions; "a warm humid rainy season and a blistering dry season. In between the two seasons, there is a brief harmathan, occasioned by the West East Trade winds, with the main feature of dust haze, intensified by coldness and dryness". The rainy season begins from April to October with an annual rainfall in the range of 100-200 mm when the temperature reaches 28-30^o C, and night time hovers around 24-25^o C. In the dry season, the day time temperature can drop to 19^o C.

Katsina-Ala is a cosmopolitan settlement on the North Bank of the river from which the town takes its name. The people of Katsina-Ala Local predominantly farmers. Over 75% of the population engages in agriculture, making agriculture the mainstay of economy of the people.

Study design and sample size

These studies employed longitudinal survey methods; which were conducted in three successive phases with the same pupils (aged 5-19 years old) surveyed at each point of time. The sample size for this study was calculated using normal distribution formula ($N=Ɛ^2\ pq/i^2$) where

N= the desired sample size

Ɛ = the normal Z score corresponding to the risk of error α=5%

p =baseline prevalence of schistosomiasis in the study area (40.1%) (CDC, Benue state chapter preliminary report, 2018)

q =1-p; I = the precision, fixed at 5%.

$N = (1.96)^2\ (0.401)\ (1\text{-}0.401)/0.05^2 = 363.$

We considered the cluster effect, such that children from the same community attending the same school could acquire equal risk of the disease and expected attritions. Hence, N (363) was multiplied by 5% and added to the sample size, N to approximate the baseline sample size to 381 for each council ward. Therefore, the total sample size at baseline was 3,810 school children.

Selection of communities and schools

Communities and schools were selected using information on previous schistosomiasis prevalence and praziquantel treatment obtained from the community-directed distributors and the Neglected Tropical Diseases programme. Additional considerations included accessibility and safety, proximity to freshwater bodies, evidence of freshwater snail habitats and previous reports of *Schistosoma* infection.

Ethical approval and informed consent:

Ethical approval was obtained from the Research and Ethics Committee of the Benue State Ministry of Health and Human Services (Ref. No. MOH/STA/204/VOL.1/71). Permission to conduct the survey was obtained from the relevant educational authorities and participating schools. Written informed consent was obtained from parents or guardians of participating children, and assent was obtained from the children. Participants aged 18 years and above provided informed consent. The research was strictly conducted in line with ethical guidelines recommended by World Health Organization, 2018), with little modification as stipulated in the ethical clearance guidelines.

Praziquantel administration

Mass administration of praziquantel was conducted by the Neglected Tropical Diseases programme, Benue State. Praziquantel was administered at the recommended dose of 40 mg/kg body weight to eligible school children. The administration was conducted through the participating schools with the assistance of the Local Government NTD coordinator and teachers.

Urine collection and reagent-strip examination

Each participant was provided with a labelled sterile universal specimen container and instructed to provide approximately 15 mL of mid-stream urine. Urine samples were collected between 10:00 and 14:00 h according to (Ben *et al.,* (2017). Each sample was examined macroscopically and subsequently divided into portions for reagent-strip testing and parasitological examination.

Assessment of haematuria

Microhaematuria was assessed in the field using Medi-Test Combi 9 reagent strips (Macherey-Nagel GmbH & Co. KG, Germany). The reagent strip was immersed in the urine specimen according to the manufacturer's instructions, removed and allowed to develop before the colour reaction was compared with the manufacturer's reference scale. Blood result was recorded according to the corresponding reagent-strip categories (Chitsulo *et al.,* 2004).

Laboratory determination of Prevalence and intensity of urogenital schistosomiais

The other sub samples of urine were preserved with two drops of 40 % formaldehyde tightly covered, labelled and transported to Benue Diagnostic Laboratory, Katsina-Ala for a quantitative parasitological examination. Laboratory examination of urine samples using sedimentation methods was carried out in line with the procedures

outlined by Cheesbrough (2005) and employed by Babatunde *et al* (2013). Ten (10 mls) of each urine sample was transferred into 15 ml conical centrifuge tube and was spun at 350 rpm for 15minutes. The supernatant was decanted manually leaving about 0.5 ml of the fluid with the sediment at the bottom of the tube. The sediment was thoroughly mixed, and then a drop of the mixture was transferred to a microscopic slide. A drop of 40 % lugol iodine was added to stain the eggs if present, and the slide was covered with a cover slip and examined under a light microscope using x 10 objective lenses. The eggs of Schistosome *present* were identified by their distinctive characteristics, as seen under the microscope and recorded in confirmation of the result of reagent strips as positive for prevalence study while actual egg count was done per 10 ml of urine for intensity study. Based on the number of egg present/ 10 ml of urine, urine samples were classified as follow: 0 egg/10 ml - no infection; 1-49 eggs/10 ml- light infection; 50-199 eggs / 10 ml - moderate infection and 200 and above eggs/ 10 ml - heavy infection (Emily *et al.,* 2022).

Calculation of prevalence and relative index of potential contamination re infectivity

Prevalence/intensity and relative index of potential contamination was calculated as described by [24] Prevalence of infection was calculated and expressed as a percentage with the formula below:

$$\text{Prevalence} = \frac{Number\ of\ postive\ sample}{Total\ number\ of\ sample\ examined} \times 100$$

The relative index of potential contamination was used to estimate the relative contribution of each age group to environmental contamination with *S. haematobium* eggs. The calculation was based on the contribution of each age group to the total estimated egg output using the formula

$$\text{Relative Index of Potential Contamination} = \frac{Agegroup \times Population\ structure \times prevalence\ for\ eachage\ group}{SumofIndex\ of\ P\ otential\ Contamination\ forallagegroup} \times 100$$

Statistical analysis

Data were entered into Microsoft Excel and analyzed using SPSS. Descriptive statistics were used to summarized prevalence and infection intensity. Associations between infection status and categorical variables such as age and sex were assessed using the chi-square test. Statistical significance was set at $P < 0.05$.

RESULTS

Prevalence of urogenital schistosomiasis by council wards and follow-up perids

A total of 3,810 children were examined at three months, 3,612 at six months and 2,918 in the ward-level dataset at nine months after praziquantel administration. *S. haematobium* infection was detected in most participating wards during all follow-up surveys. Michile had no recorded infection at nine months. Mbatyula consistently recorded one of the highest prevalence estimates, with 24.9% at three months and 14.9% at both six and nine months. Overall prevalence in the ward-level dataset was 12.28% at three months, 7.61% at six months and 8.50% at nine months (Table 1). There was a significant difference ($P < 0.05$) in prevalence among the different phases of the surveys. Eggs of *S.*

haematobium were found in all the samples except in few cases where there was mixed infection of S. *haematobium* with *S.mansoni* (Plate 1).

Table 1: Prevalence of urogenital schistosomiasis by council ward and post-treatment survey period in Katsina-Ala, Benue State, Nigeria.

Council ward	3 months: examined	3 months: infected (%)	6 months: examined	6 months: infected (%)	9 months: examined	9 months: infected (%)
Iwar	340	23 (6.8)	325	15 (4.6)	340	30 (8.8)
Ikurav-Tiev I	226	30 (13.3)	220	20 (9.1)	221	27 (12.2)
Mbatyula	257	64 (24.9)	215	32 (14.9)	215	32 (14.9)
Mbacha	220	45 (20.5)	202	25 (12.4)	202	25 (12.4)
Michile	310	71 (22.9)	301	30 (10.0)	310	0 (0.0)
Mbayongu	434	29 (6.7)	415	12 (2.9)	410	2 (0.5)
Katsina-Ala	1103	102 (9.2)	1065	80 (7.5)	351	35 (10.0)
Yooyo	385	62 (16.1)	351	27 (7.7)	351	35 (10.0)
Utange	205	19 (9.3)	200	18 (9.0)	200	27 (13.5)
Ikurav-Tiev II	330	23 (7.0)	318	16 (5.0)	318	35 (11.0)
Total	**3810**	**468 (12.28)**	**3612**	**275 (7.61)**	**2918**	**248 (8.50)**



PLATE 1: Eggs of schistosoma haematobium with a characteristic terminal spine as recovered from found in urine of study subjects

Prevalence by age and sex

At three months, 3,810 children were examined, comprising 2,447 males and 1,363 females. Infection prevalence was 14.0% among males and 9.4% among females. The highest prevalence was observed among males aged 10–14 years (16.58%) and females aged 15–19 years (10.78%). At six months, 3,612 children were examined, comprising 2,112 males and 1,500 females; prevalence was 9.40% in males and 5.13% in females. At nine months, the age/sex dataset contained 2,918 children (1,730 males and 1,188 females), with prevalence of 12.49% among males and 2.69% among females.

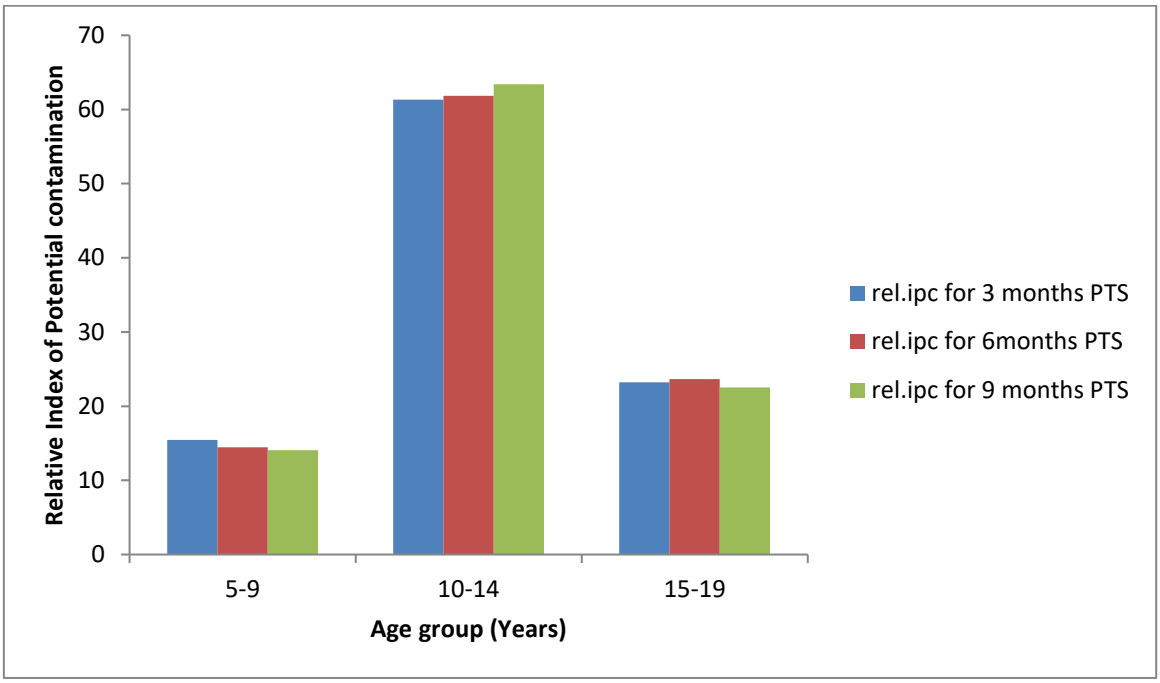
Table 2: Prevalence of schistosomiasis after a 3-months interval post treatment survey based on sex and age of school children

Age	Sex

Months of post treatment survey	Group	Male		Female		Both sexes	
		Number examined	Number infected %	Number examined	Number infected (%)	Number examined	Number infected (%)
3 months	5-9	420	40 (9.52)	236	16 (6.78)	656	56 (8.54)
	10-14	1212	201 (16.58)	515	46 (8.93)	1727	247 (14.30)
	15-19	815	102 (12.52)	612	66 (10.78)	1427	168 (11.8)
	Total	**2,447**	**343 (14.0)**	**1363**	**128 (9.4)**	**3,810**	**471 (12.36)**
6 months	5-9	420	34 (8.10)	236	13 (5.51)	656	47 (7.16)
	10-14	912	98 (10.01)	710	34 (4.79)	1622	132 (8.14)
	15-19	780	66 (8.46)	554	30 (5.42)	1334	96 (7.20)
	Total	**2,112**	**198 (9.40)**	**1500**	**77 (5.13)**	**3,612**	**275 (7.6)**
9 months	5-9	415	38 (9.16)	233	24 (10.30)	648	62 (9.57)
	10-14	910	102 (11.21)	273	56 (7.75)	1633	158 (9.67)
	15-19	800	76 (9.50)	556	39 (7.01)	1356	115 (8.48)
	Total	**2,125**	**216(10.16)**	**1,512**	**119 (5.13)**	**3,637**	**335 (9.21)**

Relative index of potential contamination (Rel. IPC)

The potential relative contribution of each age group in polluting the snail habitat with *schistosoma* eggs, thus, enabling transmission, often expressed as Relative Index of Potential Contamination (Rel.IPC) is shown in Fig 2. The 10–14-year age group had the greatest Rel. IPC throughout the follow-up period. At three months, the Rel. IPC values for the 5–9, 10–14 and 15–19-year groups were 15.45%, 61.32% and 23.22%, respectively. At six months, the corresponding values were 14.48%, 61.85% and 23.67%, while at nine months they were 14.06%, 63.38% and 22.55%, respectively.



Rel.ipc for 3 months PTS = Relative Index of Potential Contamination for three months post treatment survey

Rel.ipc for 6 months PTS = Relative Index of Potential Contamination for six months post treatment survey

Rel.ipc for 9 months PTS = Relative Index of Potential Contamination for nine months post treatment survey

FIG 2: Relative index of potential contamination (rel.ipc) by age groups of pupils based on one round of mass administration of praziquantel in the study area

DISCUSSION

The present study demonstrates persistent schistosomiasis among school children following praziquantel administration in Katsina-Ala LGA. Although the relationship between reinfection and water contact was not investigated in this present study, this persistent infection may be partly related to continued exposure to sources of infection and possible reinfection (Adewale *et al.*, 2018). More so, Praziquantel is highly effective against established schistosome infections and remains the mainstay of schistosomiasis control but does not provide lasting protection against a new infection. Individuals who return to contaminated freshwater after treatment may become infected again if cercariae are still being released from infected intermediate-host snails. This is one of the major limitations of relying on chemotherapy alone and is why the World Health Organization (WHO) recommends combining periodic praziquantel treatment with interventions such as safe water, sanitation and hygiene (WASH), snail control, health education and behaviour change (WHO, 2022; WHO, 2026).

In the ward-level, prevalence declined from 12.28% at three months to 7.61% at six months and was 8.50% at nine months. The reduction after treatment is consistent with the expected effect of praziquantel on established infections, while the subsequent persistence of infection suggests continued exposure and possible reinfection. Praziquantel treatment alone

does not prevent renewed infection when children continue to contact contaminated freshwater (Aribodor *et al.,* 2019).

Marked spatial heterogeneity was observed. Mbatyula recorded the highest prevalence at three months (24.9%) and remained at 14.9% at both subsequent surveys. Such persistence suggests that particular communities may function as transmission foci and may require more intensive surveillance and complementary interventions. Differences between wards are probably related to variation in freshwater exposure, sanitation, snail habitats, treatment coverage and human behaviour (Ekanem *et al.,* 2017). However, these factors were not directly measured in the present study and therefore should not be interpreted as demonstrated causal determinants.

Prevalence also varied by age and sex. The 10–14-year group generally showed high infection prevalence, especially among males at three and six months. The higher prevalence recorded among males in the first two surveys may reflect differences in water-contact activities, although such behavioural exposure was not quantified in this study. At nine months, the age/sex prevalence showed a different pattern, with females having a slightly higher overall prevalence than males

The Relative Index of Potential Contamination (IPC) findings provide an additional perspective on transmission. The 10–14-year group contributed 61.32%, 61.85% and 63.38% of the estimated potential contamination at three, six and nine months, respectively. This consistent predominance indicates that this age group may be particularly important for maintaining environmental contamination with *S. haematobium* eggs. Similar use of IPC to identify groups contributing disproportionately to transmission has been described in schistosomiasis epidemiology (Ayodele *et al.,* 2024).

Overall, this present study demonstrated that schistosomiasis persisted among school children after praziquantel administration in Katsina-Ala, with marked variation among council wards. The 10–14-year age group consistently had the highest relative index of potential contamination and may therefore represent an important group for targeted surveillance and health education. Sustained control should combine praziquantel treatment with access to safe water, improved sanitation, reduction of risky freshwater contact and community-based health education. Even though infection persisted in different wards in this present study, it cannot be correctly interpreted as reinfections because the study did not directly assess individual water-contact behaviour, snail abundance or snail infection status during the follow-up period. According to World Health Organization (2022), persistent *schistosoma* infection after praziquatel administration could be due to factors like incomplete cure, treatment non-adherence, infections missed during earlier assessments, limitations in diagnostic sensitivity, and genuinely new infections, may also have contributed to the observed pattern.

DECLARATIONS

Ethics Approval and Informed Consent

Ethical approval for the study was obtained from the Research and Ethics Committee of the Benue State Ministry of Health and Human Services (Ref. No. MOH/STA/204/VOL.1/71). Permission to conduct the study was obtained from the relevant educational authorities and participating schools. Informed consent was obtained from parents/guardians of participating minors, while assent was obtained from the participating children.

Participants aged 18 years and above provided informed consent.

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