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Urogenital schistosomiasis situation in school-age children after a decade of mass praziquantel treatment in the region of Kayes, Mali

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ABSTRACT

Praziquantel is the basic drug recommended for Mass Drug Administration (MDA) by the World Health Organization (WHO). However, its impact on the prevalence of infection has not been updated after a decade of MDA in Mali. This study aimed to assess the prevalence and intensity of urogenital schistosomiasis in school-age children in the Kayes region. A community-based cross-sectional study was conducted in three health districts of Kayes (Bafoulabe, Diema, and Oussoubidiagnan) from June to August 2022. School-age children ranging from 5 to 14 years were enrolled at home after obtaining parental consent. Urine was filtered and examined for eggs. A total of 2658 children were examined. The prevalence of infection was 37.67%; 40.79% and 34.37% in Bafoulabe, Diema, and Oussoubidiagnan, respectively ($p=0.02$). There was a significant difference between boys and girls in the district of Bafoulabe (42.6% vs. 33%) and Oussoubidiagnan (38.9% vs. 29.4%). However, in Diema, the percentage of boys and girls respective were comparable (39.9% vs. 41.5%). In addition, the egg excretion rate was 28.95%; 17.81%, and 13.10% in Diema, Bafoulabe, and Oussoubidiagnan, respectively ($p<0.001$). After a decade of MDA, the prevalence and intensity of infection remain high in the three health districts of Kayes.

Keywords: Prevalence, Intensity, MDA, Urogenital schistosomiasis, School-age children.

INTRODUCTION

Schistosomiasis is a worldwide public health problem (World Health Organization, 2022). It is the second most deadly parasitic disease after malaria and is still endemic in 74 countries. More than 261 million people are infected throughout the world, and nearly 800 million people are exposed (Freer et al., 2018). Sub-Saharan Africa is the most affected region, accounting for 90% of infections (World Health Organization, 2022). Schistosomiasis is considered a disease of poverty and unequally affects the world's poorest people (Karunamoorthi et al., 2018).

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Infection can occur when humans come into contact with cercariae released by snails called intermediate host mollusks in infested freshwater (World Health Organization, 2015). Safe water supply, and improved sanitation combined with preventive chemotherapy using praziquantel are considered the basic strategies for reducing the burden of schistosomiasis (World Health Organization, 2015). Environmental concerns and the high costs associated with the control of intermediate host mollusks have hindered the realization of a successful global schistosomiasis control strategy (Fenwick et al., 2009).

Because of the importance and, above all, the impact of this parasite on the health of populations, particularly women (genital lesions, dyspareunia, vaginal hemorrhage and sterility due to damage to the genital organs) and children (World Health Organization, 2022), the WHO has made the fight against neglected tropical diseases (NTDs), including schistosomiasis, a recommendation for achieving the Millennium Development Goals (World Health Organization, 2005). It aims to reduce the morbidity of the disease, its main strategy being based on mass chemotherapy with praziquantel (PZQ) at a single dose of 40 mg/kg, the molecule of choice also used in many endemic countries (World Health Organization, 2013). Thus, in 2001, the 54th World Health Assembly (WHA 54.19) officially considered large-scale chemotherapy to be an essential public health strategy for combating schistosomiasis in all endemic areas (World Health Organization, 2001). This resolution aimed to ensure, as a minimum, the regular administration of chemotherapy (PZQ, Albendazole (ALB) or Mebendazole (MEB)) to at least 75%, and up to 100%, of all school-age children (SAC) at risk of morbidity, from 2001 to 2010 (World Health Organization, 2001).

In Mali, schistosomiasis is still a public health problem, present in almost all regions, with prevalence varying according to eco-climatic zone (Traore et al., 2007). Mass drug administration (MDA) PZQ-based was definitively implemented in Mali in 2007 (Dembélé et al., 2012). Since then, an annual or biannual treatment campaign has been carried out in endemic areas of regions (Ségou, Mopti, Koulikoro, and Kayes) based on the current prevalence threshold (1-49 egg moderate and >= 50 egg high) as recommended by the WHO (World Health Organization, 2013). Prevalence surveys carried out at the national level had shown that the Senegal River basin area in the Kayes region constitutes the second most important area of bilharzia endemicity after the Office du Niger (Traore et al., 2007).

However, little information exists on the epidemiology and impact of treatment on the prevalence and intensity of schistosomiasis infection in the upper valley of the Senegal River basin in Mali (Traore et al., 2007). Mali is committed to the goal of controlling and eliminating schistosomiasis and soil-transmitted diseases as far as possible by 2025. Nevertheless, the impact of treatment needs to be regularly assessed, particularly in endemic areas. With this in mind, the present study was carried out to assess the prevalence and intensity of urogenital schistosomiasis after more than a decade of MDA among school-age children in the three health districts of the Kayes region.

MATERIALS AND METHODS

Type and period of study

The study was cross-sectional, with a single run from June to August 2022.

Study site

The present study was carried out in the schistosomiasis endemic health districts of Bafoulabe, Diema, and Oussoubidiagna in the Kayes region.

Bafoulabe health district

The climate is pre-Guinean to the south and Sahelian to the north. The population of the Bafoulabe health district was estimated at 186,735 in 2021 (source: updated RGPH 2009). In 2019, the treatment coverage rate was 101%.

Oussoubidiagna health district

The Oussoubidiagna health district, which resulted from the splitting of the Bafoulabe cercle into two (2) health districts, had an estimated population of 152,784 in 2021 (source: RGPH 2009 update). It is irrigated by the Bakoye for around 50 km. In 2019, the treatment coverage rate was 95%.

The climate is pre-Guinean in the south and Sahelian in the north. An alternating cold season from November to February, a hot season from mid-February to mid-June and a rainy season (wintering) from June to October. Average annual rainfall is 900 mm.

It is the most watered cercle in the Kayes region, with the Senegal River, formed by the Bafing and Bakoye rivers at Bafoulabe, crossing it for 33 km, 87 km, and 80 km respectively. In addition to the rivers, the circle is also home to several important torrential and intermittent marigots, the most important of which are the Kétiou, Samanbo, Dounanko, Kankauto, and Bélin. The cercle of Bafoulabe is also home to the Manantali dam.

Cercle of Diema

Diema health district

The cercle makes up the Diema health district. In 2019, the treatment coverage rate was 94%. In 2021, the population of the Diema health district was estimated at 307,732 (source: updated RGPH 2009).

Climate is of the Sudano-Sahelian type, with three (3) alternating seasons: A cold and dry season, a hot season, and a rainy season. Rainfall varies between 400 and 800 mm per year.

Hydrography is made up of numerous ponds and marigots, whose regime is often linked to that of rainfall. The most important watercourses in the health district are Bilibani, Fangouné, Tinkaré (in the commune of Diema), Débo (in the commune of Diangounté Camara), Foulabougou (in the commune of Dianguirdé), Lakamané, Dioumara, Koungo (in the commune of Bema) and Dioba (in the commune of Fassoudebe). There are also some ephemeral rivers and ponds, which disappear after the rains.

Sample technique and size

For this study, cluster sampling at three levels (villages, neighborhoods, and households) was used. The first level of sampling consisted of selecting villages (or clusters). All clusters had an equal probability of being selected. If a selected village was inaccessible, another village sharing the same geography was drawn to replace it. The second level of sampling was the division of the selected village into segments. The village was segmented into existing neighborhoods or according to natural boundaries (road, river, market, etc.). One segment in each village was selected at random. The third level of sampling involved selecting households from the segments. Modified compact segments refer to groups of around fifty households. Only households in the selected segment were included in the study, and all children in the target age group (5 to 14 years) within these households were asked to take part in the survey. In the village where the number of households selected was less than forty, the survey was conducted in all households in the segment. (Valliant et al., 2014). To minimize the number of absent residents in the selected households, the survey teams revisited the selected households before leaving the village on the day of the survey.

A total of 2658 school-age children were included in the study surveys conducted at the community level, and participants were enrolled at home. Based on 207 Main Sampling Units (MSUs) visited, i.e. 73, 58, and 76 MSUs respectively in the three districts of Bafoulabe, Oussoubidiagnan, and Diema (corresponding to 40% of all MSUs).

Taking into account a non-response rate of 10%, the number of people to be surveyed per cluster is equal to the sample divided by the number of MSUs designated per district. The sample size was 12, 15, and 12 school-age children per MSU in Bafoulabe, Oussoubidiagnan, and Diema respectively.

Inclusion criteria: Included in the study were children ranging from 5 to 14 years; Resident in the study site village in the last six months; Willing to give assent or parental consent; All settlements and hamlets with a

population of at least forty are considered eligible for inclusion as MSUs in this study.

Non-inclusion criteria: Children under 5 and over 14 years. Individuals who had

received deworming medication in the previous two weeks were not included, nor were those who were unwilling or unable to give consent/assent or who were unwell on the day of the survey. Urban areas, defined as those with a population of over 100,000, were excluded from the study.

Urine sampling and laboratory analysis

For each selected school-age child, a urine sample was collected, followed by an interview. Each child in the study was given a container labeled with an identification number for the collection of fresh urine samples. Samples were collected between 10:00 a.m. and 2:00 p.m., the optimum time for egg excretion. Collected urine samples were immediately examined macroscopically by color, whether or not there was visible hematuria. The filtration technique was used to examine each urine sample by microscopy (Plouvier et al., 1975).

Data analysis

All data collected was recorded on smartphones using Open Data Kit (ODK) software in the field. They were imported into Microsoft Excel for cleaning and analyzed using SPSS software® version 20. Infection intensities were classified into two categories according to the World Health Organization's recommendation (i) mild infection (<50 eggs/10 ml urine) and (ii) severe infection (>=50 eggs/10 ml urine) (World Health Organization, 2002). Pearson's Chi2 test or Fisher's exact test was used to compare proportions. All tests were performed at a significance level of 5% ($p<0.05$).

Ethical considerations

The protocol was approved by the ethics committee of the Faculty of Medicine and Dentistry (FMOS) under (Number-2022/91/CE/USTTB). Permission was obtained in advance from the village chiefs and their advisors after a session explaining the protocol before the start of the survey.

Each study volunteer signed an assent (volunteer aged 12-14) and a consent by his/her guardian/parent. Assent and consent were documented on a written form. The aims, procedures, and risks of the study were explained to all participants or their guardians/parents in the local language. Participants signed or, failing that, left their fingerprints on the consent form for the guardian/parent and the assent form for the child.

RESULTS

Socio-demographic characteristics of school-age children in three health districts

Children aged 5-9 years were the most represented in the three districts (Bafoulabe, Diema, Oussoubidiagna) at 80.6%, 80.8%, and 83.6%, respectively (Table 1). The sex ratio was 0.95 and 0.78 in Bafoulabe and Diema respectively, and 1.09 in Oussoubidiagnan (Table 1).

Prevalence of *Schistosoma haematobium* infection among schoolchildren in three health districts

Of 2658 children examined, *Schistosoma haematobium* prevalence was 37.67%, 40.79%, and 34.37% respectively in Bafoulabe, Diema, and Oussoubidiagnan ($p=0.02$) (Figure 2).

There was a significant difference between the prevalence among boys compared to girls in the districts of Bafoulabe (42.6% vs. 33%, $p=0.003$) and Oussoubidiagnan (38.9% vs. 29.4%, $p=0.003$). However, in Diema, there was no significant difference between the prevalence among boys compared with girls (39.9% vs 41.5%, $p= 0.632$) (Table 2). And there was a significant difference between the prevalence of 5-9 year-olds compared to 10-14 year-olds in the districts of Bafoulabe (33.6% vs. 54.7%, $p<0.001$), Diema (39.1% versus 48%, $p=0.031$) and Oussoubidiagnan (33% vs. 41.3%, $p=0.058$) (Table 2).

Intensity of *Schistosoma haematobium* Infection in school-age children in three health districts

Of 2658 children examined, the heavy egg excretions rate was 28.95%, 17.81%, and 13.10% in Diema, Bafoulabe, and Oussoubidiagnan, respectively (*p<0.001)* (Figure 3). According to sex, the heavy egg excretions rate was 30.81%; 21.55%; and 16.70% in favor of boys in Diema, Bafoulabe, and Oussoubidiagnan, respectively. The lowest egg rate of high excretion was observed in Oussoubidiagnan (9.16%) among girls. However, the low egg excretions rate in urine was 22.20% in Oussoubidiagnan, followed by Bafoulabe (21.08%) and Diema (9.09%) for boys. Sex-specific egg excretions rates in the three districts were statistically significant (*p<0.001)* (Figure 4). By age group, the heavy excretion rate was 33.7% in Diema, followed by Bafoulabe (30.59%) and Oussoubidiagnan (20.28%) in the 10-14 age group. Similarly, the low rate for heavy egg excretions in urine was 11.69% in Oussoubidiagnan among 5-9 year-olds. However, the low egg excretions rate in urine was 24.12% in Bafoulabe, followed by Oussoubidiagnan (20.98%) and Diema (14.28%) in the 10- 14 age group. Urinary excretions rates by age group in the three districts were statistically significantly different (*p<0.001)* (Figure 5).

Table 1: Sociodemographic characteristics of school-age children in three endemic health districts of the Kayes region in 2022.

Variables	Bafoulabe (N= 876)	Diéma (N= 912)	Oussoubidiagnan (N = 870)	Total (N = 2658)
Gender				
Female (%)	449 (51.3%)	515 (56.6%)	415 (47.7%)	1380 (51.9%)
Male (%)	427 (48.7%)	396 (43.4%)	455 (52.3%)	1278 (48.1%)
Age ranges				
5-9 (%)	706 (80.6%)	737 (80.8%)	727 (83.6%)	2170 (81.6%)
10-14 (%)	170 (19.4%)	175 (19.2%)	143 (16.4%)	488 (18.4%)

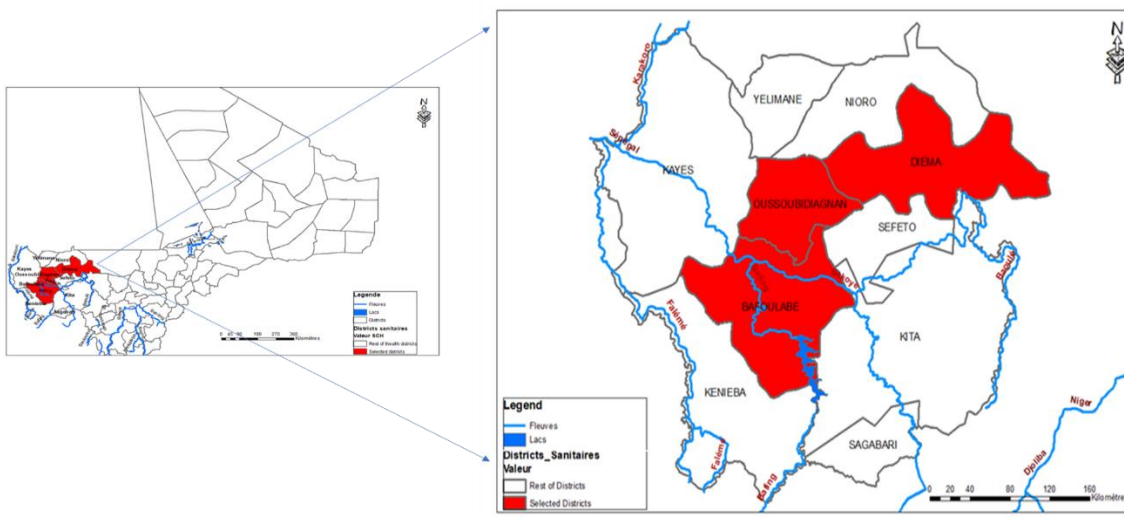

Figure 1: Map of Mali with selected districts in the Kayes region (Source: DGSHP 2021).

Table 2: Prevalence of schistosomiasis among schoolchildren by age group and sex in the three endemic health districts of Kayes region in 2022.

	Négatif		Positif		Total		*p value*
Bafoulabe	**N=546**	**%**	**N=330**	**%**	**N=876**	**%**	
Gender							
Male	245	57.4%	182	42.6%	427	100%	***0,003***
Female	301	67%	148	33%	449	100%	
Age ranges							
5-9 ans	469	66.4%	237	33.6%	706	100%	***<0,001***
10-14 ans	77	45.3%	93	54.7%	170	100%	
Diéma	**N=540**	**%**	**N=372**	**%**	**N=912**	**%**	
Gender							
Male	238	60,1%	158	39,9%	396	100%	***0,632***
Female	302	58.5%	214	41.5%	516	100%	
Age ranges							
5-9 ans	449	60.9%	288	39.1%	737	100%	***0,031***
10-14 ans	91	52%	84	48%	175	100%	
Oussoubidiagnan	**N=591**	**%**	**N=299**	**%**	**N=870**	**%**	
Gender							
Male	278	61.1%	177	38.9%	455	100%	***0,003***
Female	293	70.6%	122	29.4%	415	100%	
Age ranges							
5-9 ans	487	67%	240	33%	727	100%	***0,058***
10-14 ans	84	58,7%	59	41,3%	143	100%	

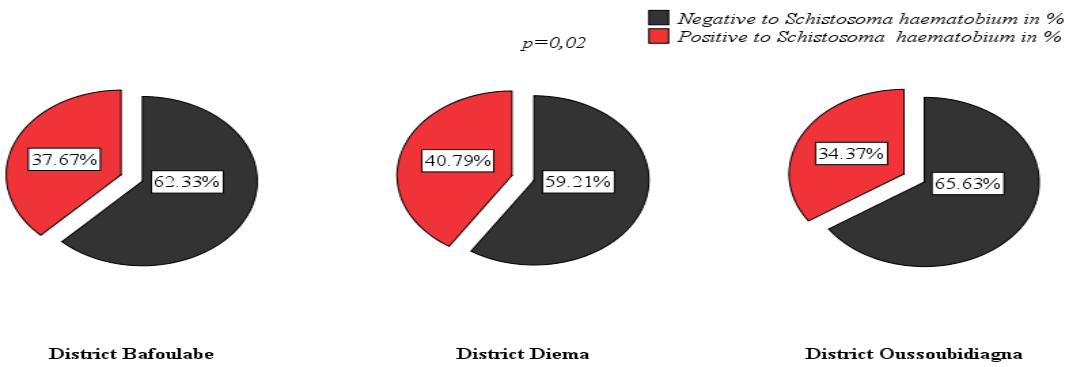

Figure 2: Variation in the prevalence of schistosomiasis among school-age children in the three endemic health districts of the Kayes region in 2022.

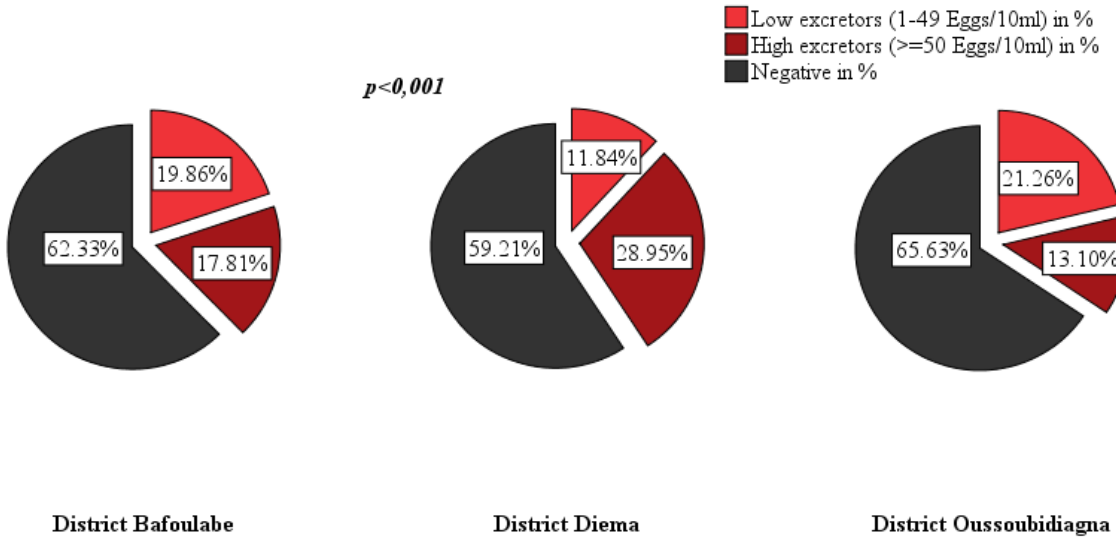

Figure 3: Variation in schistosomiasis intensity among school-age children in the three endemic health districts of the Kayes region in 2022.

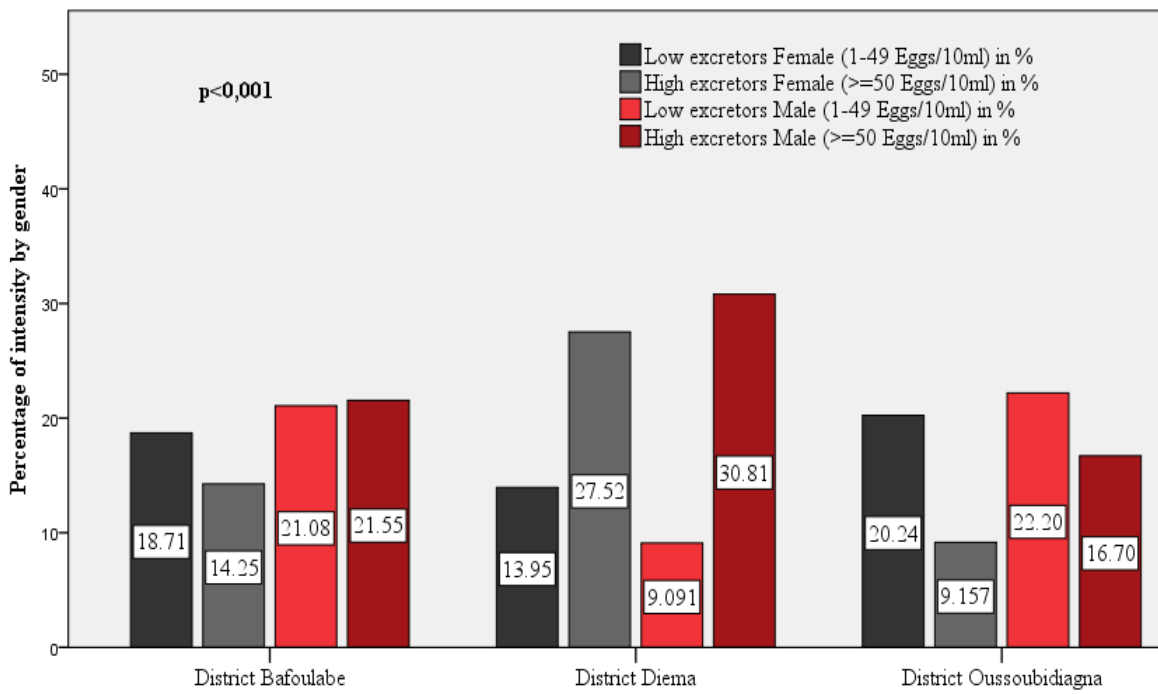

Figure 4: Variation in schistosomiasis intensity among school-age children by gender in the three endemic health districts of the Kayes region in 2022.

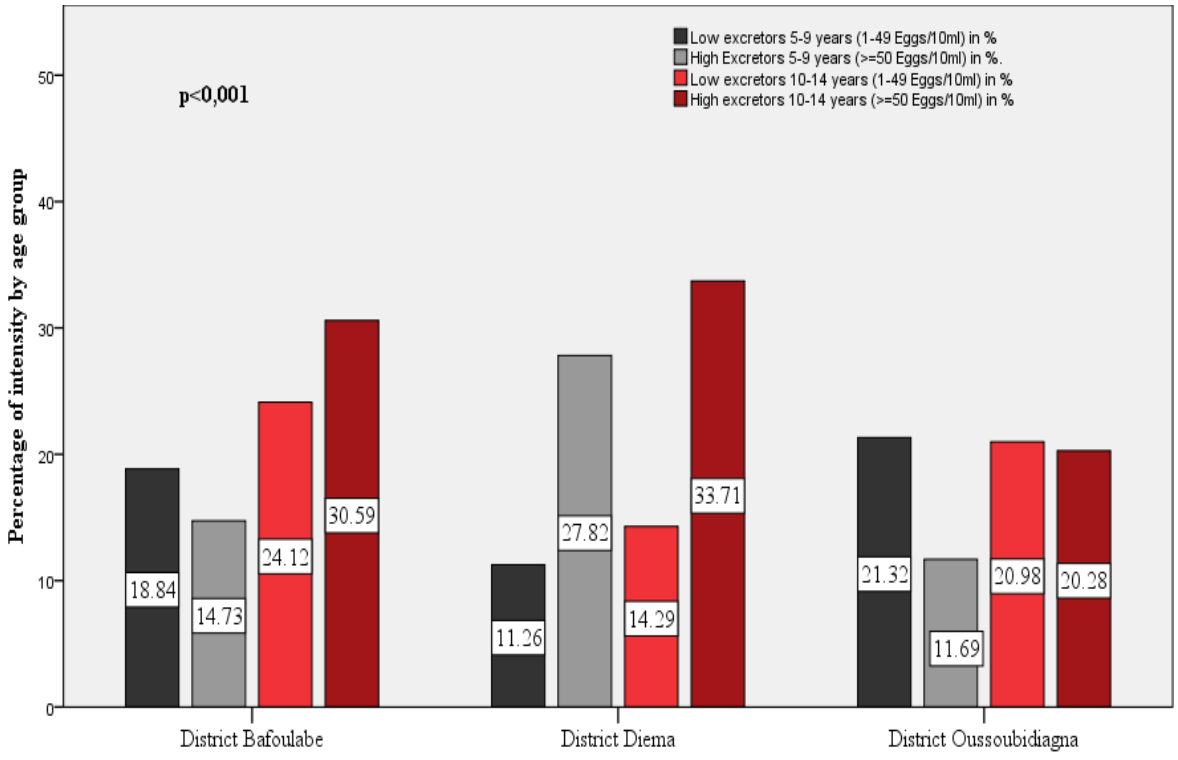

Figure 5: Variation in schistosomiasis intensity among schoolchildren by age group in the three endemic health districts of the Kayes region in 2022.

DISCUSSION

The present study was carried out among school-age children, with the 5-9 age group being the most represented in the three districts of Bafoulabe, Diema, and Oussoubidiagnan. This high proportion of children in the 5-9 age group could be explained by the fact that these children are more stable at home at this age. The sex ratio was in favor of females in Bafoulabe and Diema, and in favor of males in Oussoubidiagnan**.** This could be explained by the fact that girls, due to their domestic responsibilities and frequent participation in family activities, are less likely to be exposed to cercarial-infested rivers and ponds. It could also be due to demographic variation in favor of girls. Other studies have also shown the high participation of females in Mali and Cameroon (Ly et al., 2019; Tchouanguem et al., 2016). However, the present result was contrary to the study carried out by Traoré, (2019), in Mali, which showed that males were the most represented with 52.7%.

The prevalence of *Schistosoma haematobium* infection in the Diema district (40.79%) was significantly higher than in the Bafoulabe (37.67%) and Oussoubidiagnan (34.37%) districts. The prevalence of *Schistosoma haematobium* infection between males and females was not significantly different in Diema but was significant in Bafoulabe and Oussoubidiagnan. Furthermore, the prevalence of infection among males was higher in both the Bafoulabe and Oussoubidiagnan districts. Dabo et al. (2021) obtained a similar prevalence of 33.95% at Babaroto in the Bafoulabe district. In contrast, Ly et al. (2019) obtained a high prevalence at two sites in M'Pèba (72.36%) and Guénidanga

(52.61%) in the Ségou region. Similar studies in other parts of sub-Saharan Africa have been reported, including a prevalence of 47.6% in Dar-es-Salam, Tanzania (Ndyomugyenyi, 2001) and 32.1% in Kumba, Cameroon (Sama et al., 2007). However, the prevalence of Diema corroborates that of Ly et al. (2019) in Mali's Ségou region, who found a comparable prevalence of infection in both the female and male groups (57.84% vs. 55.73%). Similarly, a study carried out by Sangho et al. (2005) in Molodo, a rice-growing area, found that the prevalence rates were comparable according to sex ($p>0.05$) Other studies from Cameroon and Nigeria reported similar S. haematobium prevalence rates by sex. (Dawet et al., 2012; Garcia et al., 2013). High prevalence rates among boys were found in several studies in Mali and Senegal (Niaré et al., 2018; Senghor et al., 2014). These rates can be explained in part by sociocultural and behavioral factors (animal watering, bathing, market gardening) that expose boys more than girls to contact with cercarial-infested water (Hotez, 2009). This could also be linked to customs, that is girls are busier with domestic activities than boys, who have more free time for bathing and other extracurricular activities that lead them to frequent ponds and marshes (Njiokou et al., 2004). In addition to this, feminine intimacy is said to discourage girls from bathing in the presence of boys (Njiokou et al., 2004). In the Diema district, on the other hand, the prevalence rate in the female group was comparable to that of the male group. It can therefore be said that in the Diema district, both sexes are equally exposed to infection through contact with cercarial-infested water.

The present study showed a variation in the rate of urogenital schistosomiasis infection with the age of the children. The 10-14 age group was the most prevalent. This prevalence decreased with age in all three health districts. Similar studies have been reported in Africa that the prevalence of urogenital schistosomiasis was higher in children aged over 10 compared with those aged under 10 (Sady et al., 2013). In Sudan, the highest number of positive cases was reported in children aged 12 to 15 years (Elsiddig et al., 2019). Senghor et al. (2014) recorded the highest prevalence values for urogenital schistosomiasis in children in the 10-15 age group (Senghor et al., 2014). An increase in the rate of urogenital schistosomiasis infection in children has also been reported in Darfur (Sudan) among children aged 10 to 14 years (Deribe et al., 2011). Geleta et al. (2015) also reported higher urogenital schistosomiasis infection rates in the 13 to 14 age group than in the 7 to 9 age group in Abobo (Ethiopia).

The heavy egg excretion rate in the three health districts was 28.95% in Diema, followed by Bafoulabe (17.81%) and Oussoubidiagnan (13.10%). However, the low egg excretion rate was 21.26% in Oussoubidiagnan, followed by Bafoulabe (19.86%) and Diema (11.84%). This difference could be explained by certain genetic factors that play an important role in susceptibility to the disease (Kouriba et al., 2005). Also, this disparity may simply due to differences in contact activity with cercarial-infested water in children (Amuta, 2014). Amuta and Houmsou, (2014) have shown that a high intensity rate may also reflect a high transmission rate in the region. This rate should be considered a serious public health issue, as it could reflect the parasite load and, if not contained in time, will have an increasing effect on egg excretion that will directly affect children's physical conditions and cognitive ability (Amuta, 2014). With boys having a higher parasite load than girls, this could be due to the intense water-contact activities of boys, as they can engage in all water-contact activities such as washing, swimming, watering, farming, and fishing, among others. These results are contrary to those of Nnoruka, (2000) who found that girls were the most exposed to water in south-eastern Nigeria. On the other hand, the highest rate of egg excretion in the districts among infected children was in the 10-14 age group. Previous studies reported that children over 6 years of age were at greater risk of urogenital schistosomiasis than age groups up

to 6 years (Angelo et al., 2018). This may be explained by the increased duration and frequency of contact activities between boys and water among age groups exposed to infection (Angelo et al., 2018). Urogenital disorders due to the complication of schistosomiasis have been observed by many other authors around the world for a long time (Adedojaet al., 2015). hence the importance of more in-depth investigation to prevent or limit the extent (Bosier, 2001). One of the study's limitations is that it was conducted during the rainy season, which can affect schistosomiasis transmission.

Conclusion

After a decade of mass drug administration, *Schistosoma haematobium* prevalence and intensity remain high in the three health districts of Kayes, Mali. The present results point to the need for greater efforts in transmission surveillance and large-scale treatment of school-age children, to reduce the prevalence and intensity of this condition. This could be reinforced by control of the mollusk vectors responsible for urogenital schistosomiasis, health education, and the provision of drinking water. The results obtained in this study show that, despite the existence of praziquantel-based mass treatment campaigns for school-age children in the three health districts, schistosomiasis remains a public health problem.

COMPETING OF INTERESTS

The authors declare that they have no competing of interests.

AUTHORS' CONTRIBUTIONS

MD collected, processed, and analyzed the data and then wrote the first draft of the paper. HM, AKK, and MT participated in the supervision of this field study and contributed to the critical reading and correction of the paper. AMD, AO, RS, KM, OC, OM, and FKM contributed to the proofreading of the paper.

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