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Epidemiological Profile of Urinary Schistosomiasis in Urban School Children in Bouaké, Ivory Coast

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Abstract: Introduction: Urinary schistosomiasis due to *Schistosoma hæmatobium* is a major public health problem in sub-Saharan Africa. In the Ivory Coast, this disease is endemic in several regions where poor hygiene conditions, the presence of stagnant bodies of water, and children's risk-taking behavior favor its transmission. The objective of this study was to describe the epidemiological features of urinary schistosomiasis in urban areas. **Methods:** This descriptive and analytical cross-sectional study was conducted from March to April 2024 in Bouaké, a city located in central Côte d'Ivoire (≈7°69′ N; 5°03′ W), characterized by a transitional subequatorial climate and the presence of several surface water bodies conducive to human–water contact. The survey included 140 children aged 5 to 14 years attending Barakat School in the Belleville neighborhood, a densely populated urban area crossed by small streams and seasonal water channels. Urine samples were collected and analyzed after centrifugation to detect *Schistosoma haematobium* eggs. **Results:** The prevalence of urinary schistosomiasis was 3.6%. None of the children were aware of the disease. All positive cases regularly swam in freshwater areas, mainly during their break time. There was a statistically significant association between this exposure and the presence of eggs (p = 0.02). However, age, gender, and school level were not related to infection contagion. **Conclusion:** These results, although showing a low prevalence, underline the silent persistence of the disease in urban areas and the need for intensive awareness campaigns and preventative action against schistosomiasis.

Keywords: urinary schistosomiasis; *Schistosoma haematobium*; urban school; children; Bouaké

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1. Introduction

Schistosomiasis is a chronic parasitic disease caused by trematodes of the genus *Schistosoma* [1]. They remain a Neglected Tropical Disease (NTD) responsible for infant morbidity and mortality in sub-Saharan Africa, particularly in tropical and subtropical regions [2,3]. Of the various forms of schistosomiasis, urinary schistosomiasis, caused by *Schistosoma hæmatobium (S. hæmatobium)*, is the most common in sub-Saharan Africa [4,5]. It mainly affects school-age children, who are considered to be the most exposed group because of their risk-taking behaviors, such as bathing or playing in contaminated water [6]. *S. hæmatobium* infestation can lead to urological complications, anemia, and stunted growth in young children [7]. Despite chemoprevention interventions and mass treatment campaigns targeting children, the disease remains a significant public health problem [8]. Although schistosomiasis is predominantly prevalent in disadvantaged rural communities, particularly in areas with high fishing and agricultural activity [9], urban populations should not be overlooked. Indeed, recreational activities such as bathing in untreated water combined with a lack of hygiene also expose children to the risk of schistosomiasis. In the Ivory Coast, urinary schistosomiasis is endemic in many regions, but the majority of epidemiological studies have been done in rural areas, thus leaving cases in urban areas under-documented. However, the rapid urbanization of some cities, such as Bouaké, along with inadequate hygienic conditions, favors the increase in urban foci of transmission. In fact, Bouaké is the country's second-largest city, where precarious neighborhoods coexist with stagnant and undeveloped streams of water. In addition, the COVID-19 pandemic has contributed to a significant reduction in schistosomiasis prevention and treatment activities since 2021 [10]. This situation has led to an upsurge of urinary bilharziasis in Bouaké, as described by cases diagnosed at the Parasitology-Mycology Laboratory of the University Teaching Hospital of Bouaké. Therefore, the objective of the study was to determine the epidemiological knowledge of the prevalence of urinary schistosomiasis in urban areas and its associated risk factors in school-age children in the city of Bouaké.

2. Methods

2.1. Study Site

The study was conducted in Bouaké (Figure 1), a city located in the central region of Côte d'Ivoire (approximately 7°69′ N; 5°03′ W). The city has a transitional sub-equatorial climate and is crossed by several freshwater bodies, including rivers and seasonal streams, promoting frequent contact between humans and water and contributing to the persistent transmission of urinary schistosomiasis. Field investigations were carried out at Barakat Primary School, located in the Belleville neighborhood, a densely populated urban area of the city of Bouaké. The school has approximately 300 students, mainly from the surrounding communities. The immediate environment of the school is marked by the presence of permanent freshwater sources, notably the Kan River, which runs through the city and extends to the Belleville area. The river is located approximately 500 m from the school and is easily accessible. The river and its surroundings are commonly used by students for recreational activities, particularly after school hours and on weekends.

The choice of this school was motivated by the detection of a confirmed case of urinary schistosomiasis in a student attending the school and by the characteristics of its immediate environment, which could facilitate the transmission of the disease.

Parasitological analyses were performed at the Parasitology-Mycology Laboratory of the University Teaching Hospital in a district of the city of Bouaké.

2.2. Period and Population Study

This was a cross-sectional, descriptive, and analytical study conducted from March to April 2024. The study population consisted of schoolchildren aged 5 to 14 years enrolled at Barakat Primary School. All children whose parents or guardians provided written informed consent prior to participation were included in the study. Children who refused to participate were excluded, as were those who were unable to provide a urine sample at the time of data collection.

2.3. Sample Size Determination and Sampling Procedure

The sample size was determined statistically according to the formula $n = (t^2 \times p\,(1 - p))/e^2$, where *t* is the value of the 95% confidence interval (i.e., 1.96), *p* is the prevalence estimated at 0.10 (10%) according to the report of the WHO expert committee on schistosomiasis [11], and *e* is the margin of error, set at 0.05 (5%). This formula resulted in a minimum sample size of 138 students. A random sampling method was adopted, including all eligible students enrolled at Barakat Primary School during the study period. Children were recruited from all grades (CP1 to CM2) after obtaining written informed consent from parents or guardians. The final sample size slightly exceeded the calculated minimum size to account for an anticipated non-response rate, linked in particular to absenteeism or the inability to provide a urine sample at the time of data collection.

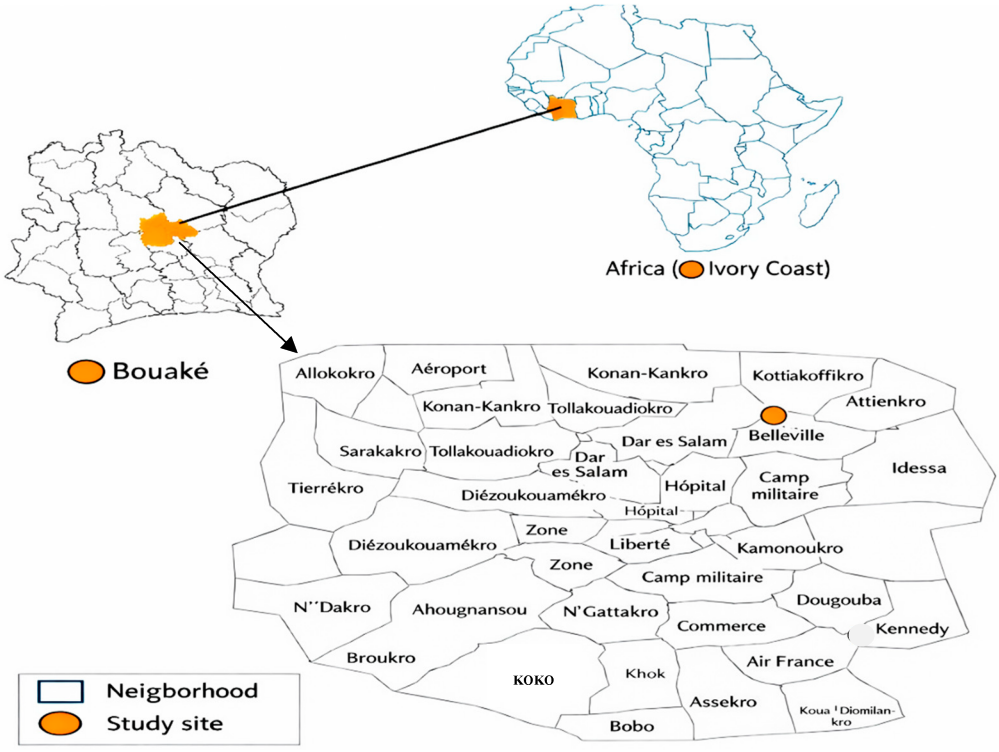

Figure 1: Geographic location of the study area. Bouaké is shown within Côte d'Ivoire and Africa. White grid cells indicate the different neighborhoods of the city, while the orange dot marks the neighborhood where the selected school is located.

2.4. Variables of the Study and Data Collection

The dependent variable was infection status, determined by the presence or absence of *Schistosoma haematobium* eggs in urine samples, as identified by parasitological examination. The independent variables included socio-demographic characteristics (age, gender, level of education), students' knowledge of urinary schistosomiasis (perceptions, causes, and consequences), and students' water-exposure practices. All of these variables were collected using a structured questionnaire.

2.5. Urine Collection and Analysis

Urine samples were collected in the morning in sterile plastic jars, between 8:30 am and 10:00 am. The children were asked to hop before urination to promote the release of eggs from the bladder wall. Each student's jar was identified by an individual barcode (anonymity number). All jars were stored in a cooler and transferred to the Parasitology-Mycology Laboratory at Bouaké University Teaching Hospital for parasitological examination. First, urine samples were subjected to macroscopic examination to describe their appearance (clear, cloudy, hematic). Second, direct microscopic examination was performed after centrifugation at 2000 rpm for 3 minutes. The time between centrifugation and slide preparation was less than 10 min to preserve the integrity of the eggs. Third, a pellet was put on the slide, protected by the coverslip, and observed at x 100 and 400 magnification to look for the characteristics of *Schistosoma hæmatobium* eggs with terminal spurs; the presence of at least one egg was considered positive for schistosomiasis disease. Samples that could not be analyzed or were missing were recorded and excluded from the analysis; no imputation was applied.

2.6. Statistical Analysis

Data were collected using EPI Info version 7.2 (Centers for Disease Control and Prevention, Atlanta, GA, USA). Results were described as frequencies and percentages. The chi-squared test or Fisher's exact test was used to determine the associations, which were considered significant when the p value was less than 0.05.

2.7. Ethical Considerations

All children whose parents or legal guardians had given their informed consent were included in the survey. Anonymity and confidentiality were respected by assigning an anonymity number to each survey form. All participants who provided infected urine were treated with praziquantel. The health district was informed of the results. Praziquantel was supplied to the school infirmary, and all children who tested positive were referred there for treatment in accordance with national guidelines (in a single dose of 40 mg/kg). This procedure ensured that all infected participants received appropriate and safe care.

3. Results

3.1. Socio-Demographic Parameters

A total of 140 schoolchildren were included in the study. The average age was 10.5 ± 1.9 years, with extremes of 5 and 14 years. Children aged between 10 and 14 years were the most important group in the study. Of the study population, 51.4% were female, with a sex ratio of 1.5. Middle-course pupils were the most represented in this survey, comprising 62.86% (Table 1).

Table 1: Socio-demographic parameters of study population.

Variable	Number of Children N = 140 (%)
Age group (years)	
Mean ± SD	10.5 ± 1.9
Extreme	5–14
5–9	46 (32.8)
10–14	94 (67.2)
Gender	
Female	72 (51.4)
Male	68 (48.6)
Primary grades	
Preparatory courses	2 (1.43)
Elementary courses	50 (35.71)
Middle courses	88 (62.86)

SD = standard deviation.

3.2. Knowledge of Urinary Schistosomiasis and Freshwater Exposure Practices

None of the children had any prior knowledge of urinary schistosomiasis. Among them, 45.7% said that they regularly went to a freshwater source close to their school or home. The majority of exposed children played and swam (79.7%) in these fresh waters (Table 2).

Table 2: Children's knowledge of urinary schistosomiasis and practices involving exposure to fresh water.

Variable	Number of Children N = 140 (%)
Knowledge of schistosomiasis	
Yes	0 (0)
No	140 (100)
Frequentation of a freshwater site	
Yes	64 (45.7)
No	76 (54.3)
Activities around and at freshwater site (n = 64)	
Swimming and playing	51 (79.7)
Laundry	6 (7.8)
Fishing	5 (9.4)
Laundry, games, and swimming	2(3.1)

3.3. Parasitological Results

Macroscopically, 21 (15.0%) urine samples were turbid, and 1 (0.7%) was hematic. Microscopic examination detected *Schistosoma hæmatobium* eggs in five children, with an overall prevalence of 3.6%. (Table 3).

Table 3: Urine appearance and results of *S. hæmatobium* egg testing.

Variable	Number of Children N = 140 (%)
Urine appearance	
Clear	118 (84.3%)
Cloudy	21 (15.0)
Hematic	1 (0.7)
S. haematobium eggs	
Positive	5 (3.6)
Negative	135 (96.4)

3.4. Associations Between Variables and S. haematobium Infestation

A statistically significant association was found between frequentation of a freshwater site (p = 0.02), urine appearance (p = 0.00006), and the presence of *S. hæmatobium* eggs in urine. In contrast, gender, age group, primary grades, and knowledge of schistosomiasis were not significantly associated with the status of *S. hæmatobium* (Table 4).

Table 4: Correlation between *S. haematobium* infestation and age group, gender, primary grades, knowledge of schistosomiasis, frequentation of freshwater site, and urine appearance.

Variable	Number of Children Positive for *S. haematobium* Eggs in Urine n (%)	Number of Children Negative for *S. haematobium* Eggs in Urine n (%)	*p* Value
Age group			
5–9	1 (2.17)	45 (97.8)	1.0
10–14	4 (4.26)	90 (95.7)	
Gender			
Female	2 (2.8)	70 (97.2)	0.7
Male	3 (4.4)	65 (95.6)	
Primary grades			
Preparatory courses	0 (0)	2 (100)	
Elementary courses	2 (4)	48 (96)	0.947
Middle courses	3 (3.4)	85 (96.6)	
Knowledge of schistosomiasis			
Yes	0(0)	0(0)	1.0
No	5(3.6)	135 (96.4)	
Frequentation of freshwater site			
Yes	5 (7.8)	59(92.2)	0.02 *
No	0 (0)	76 (100)	
Urine appearance			
Cloudy	5 (23.80)	16 (76.2)	
Hematic	0 (0)	1(100)	0.00006 *
Clear	0 (0)	118 (100)	

* $p < 0.05$: statistically significant difference.

4. Discussion

The present study provides an epidemiological overview of urinary schistosomiasis in school-age children in an urban environment in the Ivory Coast. The study was conducted in the Belleville district of the city of Bouaké and highlighted the persistence of this disease in urban areas despite national strategies of prevention. While chemoprevention programs regularly target children in rural areas [9], our results underline the importance of not neglecting urban areas. In our study, the prevalence of urogenital schistosomiasis was 3.6%, corresponding to an area of low endemicity according to World Health Organization (WHO) criteria [11]. This result was lower than that of rural areas in the Ivory Coast, as described by Angora et al. (16.1%) [12] and Ahoué et al. (24.6%) [13]. Our results suggest that this disease should be carefully reconsidered in urban settings. In addition, the overall difference between our results and those of other local studies could be due to epidemiological factors (rural or urban study areas, climatic zones), children's contact with freshwater, and larger or smaller study numbers, longer or shorter study periods, as well as the analysis techniques used, the age of the studies, and the administration of mass chemotherapy. Our study showed that the prevalence of *S. haematobium* infestation was higher in the 10–14-year-old group (4.26%) than in the 5–9-year-old group (2.17%). This difference could be explained by the fact that younger children more frequently engage in behaviors that increase their exposure, such as bathing, doing laundry, or fishing in stagnant water, due to their greater independence in daily and recreational water-related activities. However, this difference was not significant ($p = 1.0$). Our findings were similar to those reported in Burkina Faso and Nigeria [14,15]. The prevalence of urinary schistosomiasis was higher in boys (4.4%) compared to girls (2.8%), but this difference was not statistically significant ($p = 0.7$). As a result, gender could not be regarded as a risk factor in the occurrence of schistosomiasis in our study population. These results are in accordance with those of Western Africa studies [16,17]. In contrast, our results differ from those of Bleindou in the city of Agboville, Ivory Coast, where a significant female predominance ($p = 0.0067$) was found [18]. Such a difference may be explained by the fact that girls are more often exposed as a result of their household activities involving repeated contact with water in rural areas, while in urban areas in our study, boys are generally more inclined to play around water sources. Moreover, urinary schistosomiasis was more common in elementary school students (4%) than in other grades, but the difference was not significant. Regarding behavior and exposure to water, our study shows that 45.7% of children regularly went to freshwater sources, mainly during break time or recreational activities. All positive cases were identified among children exposed to these bodies of water. A statistically significant association ($p = 0.02$) was found between this frequentation and the presence of *S. hæmatobium* eggs in urine, therefore confirming the classic hypothesis that transmission of *S. hæmatobium* is strongly associated with the aquatic environment [12]. Our results corroborate those of studies conducted in endemic regions [16,19], where repeated contact with stagnant water is the main risk factor. Objectively, all children lacked knowledge about the transmission of schistosomiasis through contaminated water. They did not know how to identify or name this disease, nor were they aware of any preventive strategies. This ignorance was also reported in other African studies. Hereby, ignorance is a major obstacle to effective disease control and results from the absence of educational health programs and of community awareness. This situation reinforces the need for a combined approach of chemoprevention, health education, and environmental management.

Our results must be interpreted with caution due to certain methodological limitations. Firstly, the method used for parasitological analysis was based on urine centrifugation without using more sensitive filtration techniques. Secondly, the small sample size from only one school limited the generalization of our findings to the whole city of Bouaké. Further larger and multicenter studies could be done to validate this trend and identify high-risk areas by using filtration and molecular biology methods. Despite these limitations, our study highlighted the real and silent presence of urinary schistosomiasis in urban areas and recommends a reassessment of national prevention strategies.

5. Conclusions

This study presents the epidemiological profile of urinary schistosomiasis in school-aged children in an urban area of Bouaké, the Ivory Coast. The observed prevalence rate of 3.6% indicates low endemicity according to WHO criteria. There were slightly higher rates among boys and in the 10–14-year-old group, though these differences were not statistically significant. Infection was significantly associated with contact with freshwater sources, but not with sex, school grade, age, or knowledge about the disease. These results underscore the ongoing presence of urban transmission foci despite national mass drug administration programs primarily targeting rural areas. Therefore, schistosomiasis control strategies should also address urban settings by integrating prevention measures, health education, community awareness, environmental management, and chemoprevention to advance toward elimination goals.

Author Contributions: A.S.K. designed the study, wrote the study protocol, supervised the work, performed the statistical analysis, and drafted the first version of the manuscript. K.D.Z. and A.S.J.K. managed the overall analyses of the study and contributed to supervision. O.D.M.N. carried out the survey, data collection, and contributed to data analysis. M.T. contributed to supervision and statistical analysis. G.S.P.D. contributed to data analysis, manuscript writing, revision, and editing. K.D.A. contributed to the study methodology and critically revised and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

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

Ethical Approval: The authors affirm that all procedures contributing to this work comply with ethical standards. The study began after obtaining agreements from the Direction Régionale de la Santé du Gbêkê, the Direction Régionale de l'Education Nationale et de l'Alphabétisation du Gbêkê, the Inspection Primaire et Préscolaire de Belleville II, the Direction Départementale de la Santé de Bouaké Nord-Est, and the principals of the Barakat School group.

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