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Detailed distribution of schistosomiasis and soil-transmitted helminthiasis among schoolchildren in the Bélier and Marahoué regions, central Côte d'Ivoire: a tool for an efficient control

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ABSTRACT

Cross-sectional epidemiological surveys were conducted from December 2012 to January 2013 to better understand the distribution of schistosomiasis and soil-transmitted helminthiasis in the health districts of the Bélier and Marahoué regions in central Côte d'Ivoire. Urine and stool samples were provided by 4900 schoolchildren of 7-14 years old from six health districts. Urine was consecutively analysed by reagent strips and filtration method whilst stool was examined using Kato-Katz method. Eggs of helminth species were identified under a microscope. The investigated schools were georeferenced. The predominant diseases were hookworm infection (12.7%) and urinary schistosomiasis (11.2%). At the health district level, they are a public health problem with moderate prevalence in Tiébissou, Toumodi, Yamoussoukro (Bélier region) and Sinfra (Marahoué region) for urinary schistosomiasis and in Toumodi for hookworm infection. At the school level (i.e. village), the focal and water-related characteristics of schistosomiasis were highlighted mainly alongside Marahoué, Bandama and Kan rivers, and around Lake Kossou where was observed highest prevalence. Hookworm infection and urinary schistosomiasis were sex and age-related. Findings call the need for treatment implementation. In the case of schistosomiasis, however, treatment should be based on the school level instead of the entire health district for an efficient control.

Keywords: Hookworm infection, urinary schistosomiasis, predominant, health district level, school level, central Côte d'Ivoire.

INTRODUCTION

Schistosomiasis and soil-transmitted helminthiasis (STHs) are common parasitic infections in tropical and subtropical areas particularly in developing countries, where they cause important public health problems. These helminthiases affect more than 250 million and 2 billion people worldwide, respectively (WHO, 2012; Molyneux et al., 2017). They are chronic diseases and

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recognized for their considerable socio-economic impact in endemic areas (Kpoda et al., 2013). They also have negative effects on nutritional status, physical growth, cognitive performance, wellbeing and school attendance rate (Lobato et al., 2012; Nwaneri and Omuemu, 2013; Colley et al., 2014). The current strategy against schistosomiasis and STHs is the morbidity control through preventive chemotherapy (PC) with praziquantel (40 mg/kg) and albendazole (400 mg) (WHO, 2006). In addition, the endemic countries where elimination of schistosomiasis seems feasible are encouraged to pass of morbidity control to an elimination strategy. This consists in providing praziquantel in intervals shorter than 12 months, snail control and behavior change interventions in order to interrupt significantly the infection transmission (WHO, 2012a).

In Côte d'Ivoire, previous studies showed that schistosomiasis is a public health problem and occurs in urinary and intestinal forms, due to *Schistosoma haematobium* and *Schistosoma mansoni*, respectively (N'Goran et al., 1997; Yapi et al., 2014; Assaré et al., 2015; N'Guessan et al., 2015). The prevalence of schistosomiasis at the country level was estimated at 8.9% in school-aged children with 5.3% for *S. haematobium* and 3.8% for *S. mansoni* infections (Chammartin et al., 2014). With regard to STHs, their distribution show a high variability from the wetter southern forest zone to the more arid northern savannah zone (Yapi et al., 2007). According to a recent survey, hookworm infection is widespread with a prevalence of 17.2% compared with roundworm (1.9%) and whipworm (1.3%) infections across the country (Yapi et al., 2014). To better control such helminthiases, a national control programme (Programme national de Lutte contre la Schistosomiase, les géohelminthiases et la Filariose lymphatique (PNLSGF) created in 2007 has been changed into (Programme National de Lutte contre les Maladies Tropicales Négligées à Chimiothérapie Préventive (PNLMTN-CP)) in December 2016. It aims to reducing the transmission in 2020 through the PC based on the prevalence among schoolchildren at the level of the health districts. With the prospect of the mass drug administration (MDA), a national basic screening was carried out within the framework of the Integrated Control of Schistosomiasis in sub-Saharan Africa (ICOSA) project to appraise the geographical distribution of these parasitic infections. This study aimed at identifying the real extent of schistosomiasis and STHs in the Bélier and Marahoué regions for a further efficient control programme. To achieve this goal, the baseline prevalence and the geographical distribution of these parasitic infections have been determined.

MATERIALS AND METHODS

Ethical consideration, study area and population

This study received clearance from the ethic committee of Côte d'Ivoire (Comité National de l'Ethique et de la Recherche), reference no. 126 MSHP/CNER-dk. Written consents and oral assent were obtained from parents or guardians and from participants, respectively. Identity codes ensured the confidentiality of data concerning each participant. At the end of the study, all participants found infected received free oral dose of praziquantel (40 mg/kg) and/or albendazole (400 mg) from the PNLMTN-CP's medical staff.

Cross-sectional epidemiological surveys were carried out from December 2012 to January 2013 in primary schools of Bélier and Marahoué health districts (6°30'and 7°80' N, 4°80' and 6°50'W) located in the Central area of Côte d'Ivoire in West Africa. In the Bélier region, three health districts (namely Tiébissou, Toumodi and Yamoussoukro) have been considered in this study. Marahoué region includes three health districts (Bouaflé, Sinfra and Zuénoula). Both regions are irrigated by two main rivers namely Bandama (or Bandama blanc) and Marahoué (or Bandama rouge), the Lake Kossou and many other water bodies which could maintain the transmission of schistosomiasis as described elsewhere (Cecchi et al., 2007a; N'Guessan et al., 2015).

Fifty-five primary schools per region were randomly selected among all of the schools using the software SAS. Each school generally represents geographically the village in which it is. Therefore, 15 schools (i.e.

village) in the health districts of Toumodi and Sinfra and 20 schools in those of Bouaflé, Tiébissou, Yamoussoukro and Zuénoula were investigated. In each primary school, 30 to 50 children of 7 to 14 years old were randomly selected from the first grade (CP1) to the last grade (CM2).

Data collection

Each assenting children received two different 50 ml plastic containers labelled with a code and was asked to provide a single sample of stool and urine. Urine collection was carried out between 10 am and 2 pm (Cecchi et al., 2007b). The samples were transported the same day of collection to the laboratory of the nearby hospital. Concomitantly, the geographical coordinates of each investigated school were recorded using hand-held units of global positioning system (GPS, Magellan 315, Thales Navigation, Santa Clara, USA).

Laboratory procedures

In the laboratory, the urine samples were pre-tested for the microhematuria using reagent strips (Hemastix, Siemens Healthcare; Zurich, Switzerland). In addition, positive reagent strip urine samples were subjected to filtration method (Plouvier et al., 1975). Stool samples were analysed by the Kato-Katz's method (Katz et al., 1972). Duplicate 41.7 mg Kato-Katz thick smears were prepared from each stool sample. The eggs of each helminth species were identified and recorded separately. To check the consistency of the results, a quality control was done by randomly selecting 10% of the Kato-katz thick smears for a new reading by another technician. In case of discrepancy results between the first two readers, a third technician who was blinded to previous results was asked to re-examine the respective slide (Speich et al., 2015). The results of the three reading were discussed objectively on microscopes and the good result was held collectively.

Data analysis

Data was double entered and cross-checked using Microsoft Access 2007 software and prevalence was estimated for each helminthiasis. The schoolchildren were stratified by sex and age groups while confidence intervals of 95% (95% CIs) were estimated for prevalence. The prevalence of regions and health district were compared using Chi-square and Fisher exact test with the statistical significant set at p-value less than 0.05. In order to avoid the risk of discovery related to multiple tests, the p-values were adjusted using the FDR procedure (Benjamini and Hochberg, 1995). In addition prevalence were categorized according to WHO classification (WHO, 2006, 2012b). Statistical analyses were carried out using STATA version 12 (Stata Corporation; College Station, TX, USA). A Geographical Information System (GIS) software (Arc View version 3.2, Redlands, USA) was used to plot the coordinates of the investigated schools in association with the prevalence of the parasitic infection.

RESULTS

A total of 4900 schoolchildren of 7-14 years old (2625 boys and 2275 girls) were examined in the health districts of both Bélier and Marahoué regions in central Côte d'Ivoire (Table 1). Results indicate that 3102 (63.31%) of the enrolled schoolchildren were of 7-10 years old whilst those of 11-14 years old were 1798 (36.69%).

Geographic distribution of schistosomiasis

In the study regions where occurred the both form of schistosomiases, the overall prevalence rate was 14.0% (95% IC: 13.0-15.0) with specific prevalence rate of 11.2% (95% IC: 10.3-12.1) and 3.2% (95% CI: 2.2-3.7) for urinary and intestinal schistosomiases, respectively (Table 1). Urinary schistosomiasis was significantly more prevalent than the intestinal form (χ^2 =232.4; p <0.001). The regional prevalence rate showed the same picture. With regards to the intestinal schistosomiasis, the prevalence rate was low (≤ 10%) in Bélier (3.6%, 95% IC: 2.8-4.4) and in Marahoué (2.9%, 95% IC: 2.2-3.6) and statistically similar (χ^2 = 1.88, p = 0.17) (Table 1).

Concerning the infection at the level of the health district, the prevalence rates of urinary schistosomiasis were moderate (10% < rate < 50%), and varied from 15.8% (95% IC: 13.5-18.2) in Yamoussoukro to 17.0% (95% IC: 14.7-19.4) in Tiébissou in Bélier region, though statistically similar (χ^2 = 0.57, p = 0.752). In the Marahoué region, the highest prevalence rate of urinary schistosomiasis was recorded in the health district of Sinfra [10.9% (95% IC: 8.1-14.1)]. Concerning the intestinal schistosomiasis, the prevalence varied significantly as well as in the districts of Bélier (χ^2 = 13.04; p<0.001) and in those of Marahoué (χ^2 = 21.76; p<0.0001). The highest prevalence were of 4.9% (95% IC: 4.4-6.4) and (4.7%, 95% IC: 3.4-6.2) in Tiébissou and Bouaflé, respectively. However, the prevalence rate of this form of schistosomiasis was low in all of the health districts (Table 1).

Concerning the distribution of urinary schistosomiasis at the school level (i.e. village), 85 foci were identified among the 110 investigated schools (Figure 1B). Therefore, schoolchildren bearing this schistosomiasis were found in 82.14% and 70.9% of the schools in the Bélier and Marahoué regions, respectively. Generally, the recorded prevalence rates were moderate or low (Figure 1B). However in the Bélier region, the prevalence varied significantly from one school to another one respectively in Tiébissou (0.0%-68.0%, Fisher exact test, p=0.032), Yamoussoukro (0.0% 74.0%, Fisher exact test, p=0.034) and Toumodi (0.0%-93.3%; Fisher exact test, p=0.038). In contrast to the Marahoué region, a lower variation of the prevalence rate of urinary schistosomiasis was observed in Bouaflé (0.0%-14.0%, Fisher exact test, p=0.062), Zuénoula (0.0%-36.0% Fisher exact test, p=0.082) and Sinfra (0.0%-36.7% Fisher exact test, p=0.068). For this infection, a total of eight schools at high-risk (prevalence >50%) were recorded and only in the Bélier region where six foci were found in the Northern part, particularly around the Lake Kossou and the river Kan (Figure 1B). With regard to the intestinal schistosomiasis, it is realized that this infection occurred only in 51 out of 110 schools (46.36%). The prevalence rates were mainly low (<10%), however, six foci at moderate-risk were observed. Most of them (5 foci) were located alongside the Marahoué and Bandama rivers (Figure 1C).

Geographic distribution of soil-transmitted helminthiasis

Three soil-transmitted helminthiases were identified with overall prevalence rate of 12.7% (95% IC: 11.7-13.6), 2.2% (95 % IC: 1.8-2.6) and 1.4% (95% IC: 1.1-1.7) for hookworm, whipworm and roundworm, respectively (Table 1). Hookworm infection was the most prevalent soil transmitted helminthiasis (χ^2 = 761.36, p <0.0001). This trend was observed at both the regional health district levels.

In the Bélier region, the prevalence rate was moderate (20%≤ prevalence < 50%) and significantly higher (χ^2 = 18.74, p < 0.0001) in Toumodi only (24.2%, 95% IC: 20.3-28.4). The recorded prevalence in the other health districts was low (<20%) in both regions.

At the school level (i.e. village), roundworm and whipworm infections were almost null, whereas hookworm infection was observed in 82.72% of the visited schools (Figure 2 B-D). The prevalence rate of hookworm ranged from low (<20%) to moderate (>20% but <50%). Only five schools at high-risk (>50%) were observed at Toumodi (three schools), Yamoussoukro (one school) and Sinfra (one school).

Distribution of helminthiases according to gender and age groups

Among the schoolchildren, only urinary schistosomiasis and hookworm infection were found with relationship to gender or age groups (Figure 3). Urinary schistosomiasis was more prevalent among 11-14 years old children than those between 7-10 years old (13.1% *vs.* 10.2%, χ^2 = 9.708, p = 0.002). Concerning hookworm infection, it was more prevalent in boys (14.1% *vs.* 11.1%, χ^2 = 10.018, p < 0.002) and 11-14 years old children (14.8% *vs.* 11.5%, χ^2 = 11.305, p < 0.001).

Table 1: Prevalence of helminthiases (95% CI) in percentage among school children in the health districts of Bélier (a) and Marahoué (b) regions, Côte d'Ivoire 2013.

	No of subjects	Urinary schistosomiasis	Intestinale schistosomiasis	Ankylostomiasis	Ascaridiasis	Whipworm Infection
Overall	4900	11.2 (10.3-12.1)	3.2 (2.7-3.7)	12.7 (11.7-13.6)	1.4 (1.1-1.7)	2.2 (1.8-2.6)
Region						
Bélier	2450	16.3 (14.8-17.8)	3.6 (2.8-4.4)	18.6 (17.1-20.1)	1.8 (1.3-2.3)	1.8 (1.2-2.3)
Marahoué	2450	6.1 (5.2-7.1)	2.9 (2.2-3.6)	6.8 (5.7-7.7)	0.9 (0.5-1.2)	2.6 (1.9-3.2)
		0.0001	*0.170*	***0.0001***	***0.005***	***0.005***
Health districts						
Tiébissou [a]	1000	17 (14.7-19.4)	4.9 (3.6-6.4)	15 (12.8-17.3)	3.6 (2.5-4.9)	2.1 (1.3-3.1)
Toumodi [a]	450	16 (12.7-19.7)	1.1 (0.3-2.5)	24.2 (20.3-28.4)	0	0.7 (0.1-1.9)
Yamoussoukro [a]	1000	15.8 (13.5-18.2)	3.4 (2.3-4.7)	19.7 (17.2-22.3)	0.9 (0.4-1.7)	2 (1.2-3.1)
		0.752	***0.001***	***0.0001***	***0.0001***	*0.113*
Bouaflé [b]	1000	4.6 (3.3-6.1)	4.7 (3.4-6.2)	3.5 (2.4-4.8)	0.8 (0.3-1.5)	2.2 (1.3-3.3)
Sinfra [b]	450	10.9 (8.1-14.1)	0.7 (0.1-1.9)	19.6 (15.9-23.5)	0.7 (0.1-1.9)	2.4 (1.2-4.3)
Zuénoula [b]	1000	5.5 (4.1-7.1)	2.1 (1.3-3.1)	4.3 (3.1-5.7)	1.1 (0.5-1.9)	3.1 (2.1-4.3)
		0.0001	***0.0001***	***0.0001***	*0.837*	*0.419*

Italic numbers correspond to adjusted p-value with the statistical significant ($p<0.05$) in bolt; CI: Confidence Interval.

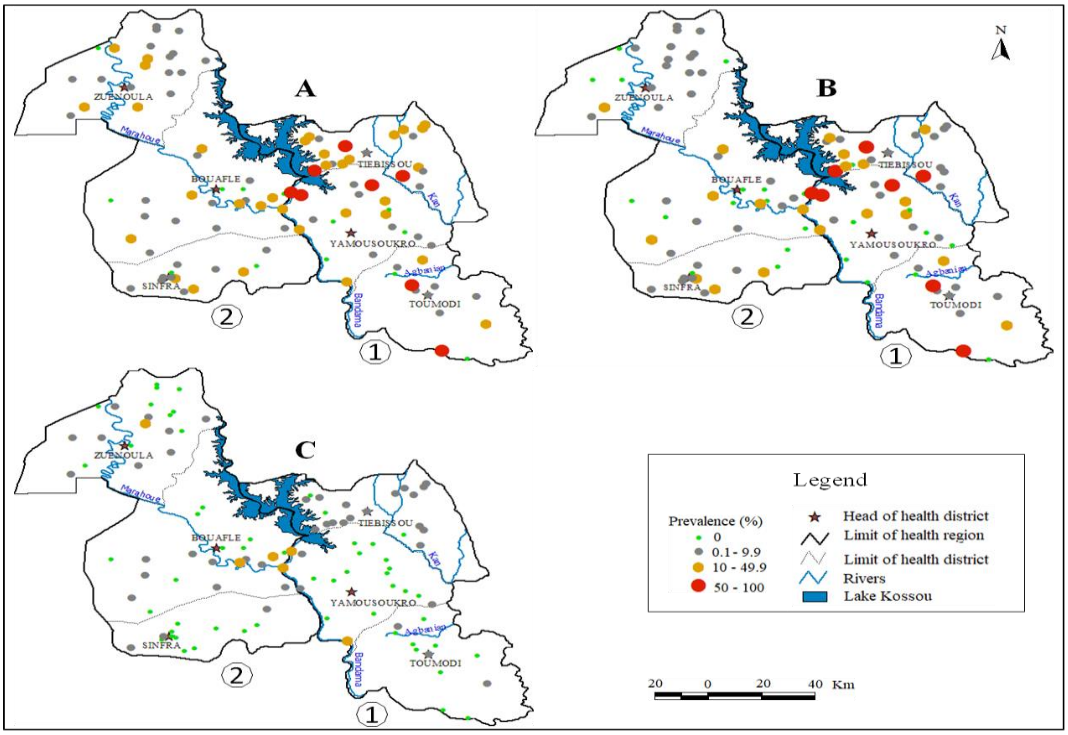

Figure 1: Distribution of schistosomiases prevalence at the level of school in the health districts of the Bélier (1) and Marahoué (2) regions.
A: Overall schistosomiases, B: urinary schistosomiasis, C: Intestinal schistosomiasis.

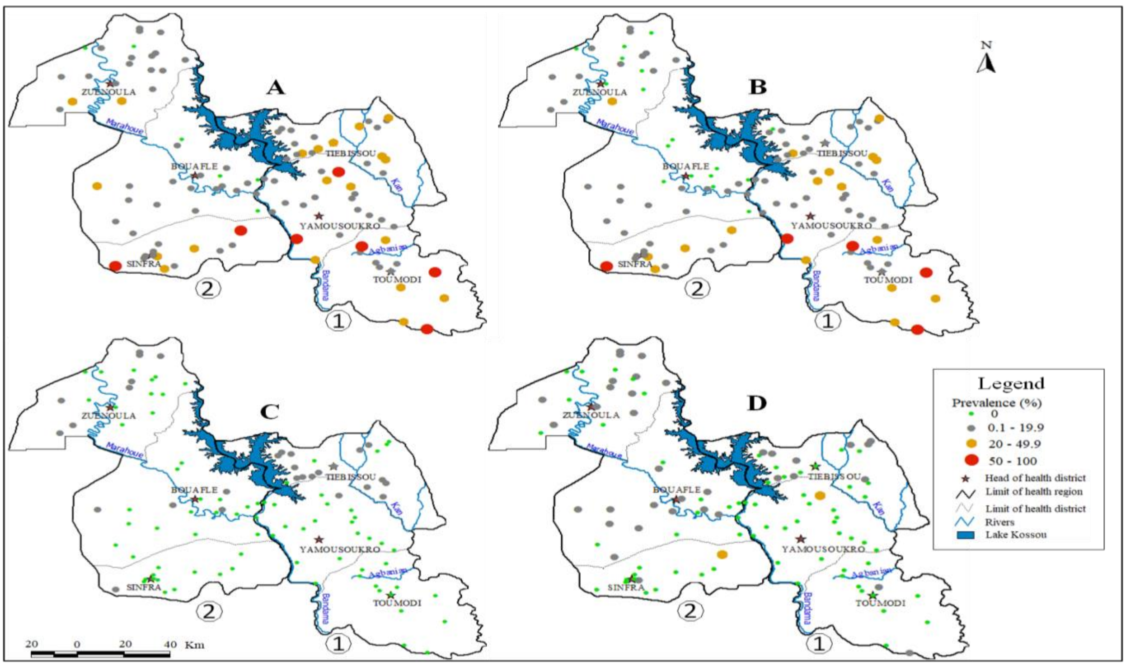

Figure 2: Distribution of soil-transmitted helminthiases prevalence at the level of school in the health districts of the Bélier (1) and Marahoué (2) regions.
A: Overall STHs, B: Hookworm infection, C: Roundworm infection, D: Whipworm infection

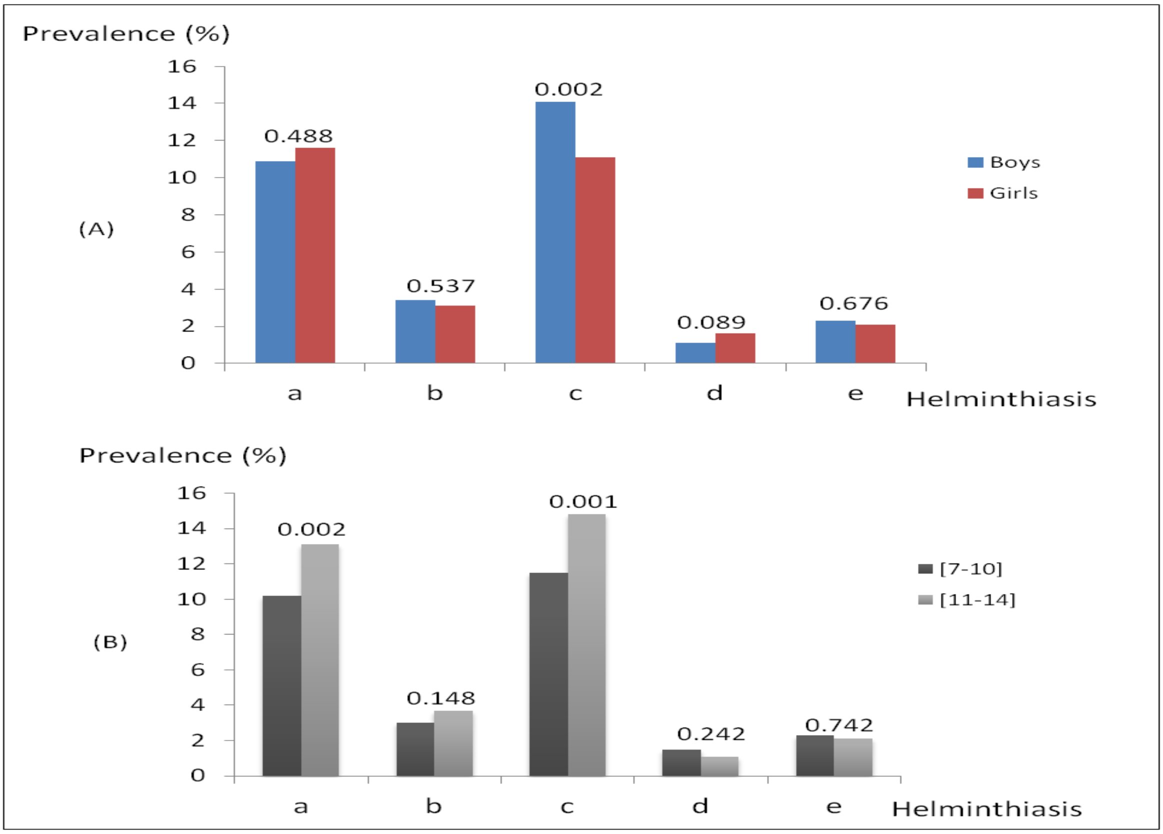

Figure 3: Distribution of helminthiases prevalence according to sex (A) and age (B) among the examined pupils.

a: Urinary schistosomiasis, b: Intestinal schistosomiasis, c: Hookworm infection, d: Roundworm infection, e: Whipworm infection.

Numbers above the bar graphs correspond to adjusted p-value with the statistical significant at $p < 0.05$.

DISCUSSION

Geographic distribution of schistosomiasis

This study showed that urinary schistosomiasis was more prevalent compared to intestinal schistosomiasis in the study regions in central Côte d'Ivoire. This schistosomiasis occurred with moderate prevalence whereas that of the intestinal form was low. The low prevalence rate of the intestinal schistosomiasis could be explained by the fact that it would be introduced into the study area with less local transmission. Indeed, previous studies carried out in some part of the current study area, around Lake Kossou displayed a similar trend of these two forms of schistosomiasis (N'Goran et al., 1997). Since then, the trend has not changed enough with prevalence rate of intestinal schistosomiasis remaining low in the central part of the country. In contrast to West of the country, the intestinal form is more prevalent with a higher prevalence rate than the urinary form (Yapi et al., 2014; Assaré et al., 2015, 2016).

The distribution of the schistosomiasis at the level of the health districts revealed that the urinary form is a public health problem in two thirds of the investigated districts. These districts are Tiébissou, Toumodi, Sinfra and Yamoussoukro where this urinary schistosomiasis occurred with moderate prevalence; whilst it was low in Bouaflé and Zuénoula. These four districts should be primarily targeted for control actions. This result was in contrast in part with previous estimation in the same area where urinary schistosomiasis was observed with a low prevalence rate in all of the health districts of Bélier and Marahoué regions (Chammartin et al., 2014).

The distribution at school units highlighted a strong variation of urinary schistosomiasis prevalence. This prevalence varied significantly from school to school, mainly in the three health districts of the Bélier region where the most foci (6/8) were observed with a high prevalence. This school prevalence variation and the concentration of at high-risk foci of schistosomiasis (urinary and intestinal forms) alongside the rivers (Bandama, Kan and Marahoué) and around the lake Kossou confirm the focal and water-based disease characteristics of the distribution of this parasitic infection as stated by N'Guessan et al. (2007). From these observations, it would be more efficient to implement the MDA in the case of the schistosomiasis based not on the global prevalence of the health districts but rather on schools as suggested by Hodges et al. (2011) and Tchuem Tchuenté et al. (2017). Such approach should be applied particularly in the three health districts with greater heterogeneous school prevalence in Bélier in order to ensure the good dosage and good frequency related to the recorded prevalence. In those of the Marahoué region, treatments should be provided based on the prevalence rate of the health districts. This is because schistosomiasis prevalence rates at the level of the schools was low and showed only few variations.

Geographic distribution of soil-transmitted helminthiasis

With regards to STHs, the overall prevalence was 15.3% (95% IC: 1.3-16.3). Hookworm infection was predominant with a prevalence rate of 12.7%. It was followed by the whipworm (2.2%) and roundworm (1.4%) infections. This finding was different from that reported in the western region of the country by Assaré et al. (2016) with a prevalence rate of 3.2%, 1.4% and 0.9% for whipworm, hookworm, and roundworm infections, respectively. However, it reflects the national trend (Yapi et al., 2014). The predominance of the hookworm infection could mean that hands-washing as preventive hygiene measure against roundworm and the whipworm infection is well known and practiced by the schoolchildren than the wearing of shoes against the hookworm infection (Acka et al., 2010; Schmidlin et al., 2013). Indeed, during the survey, although it was not quantified, during the break, the schoolchildren were often observed removing their shoes before playing in the school ground, in order not to damage them. Besides, this study reveals that concerning STHs, the hookworm infection remains a public health problem only in Toumodi with moderate prevalence. The same trend was observed during a previous survey carried out in this health district (Utzinger et al., 2008). Therefore, the health district of Toumodi should be a priority for MDA and implementation of preventive measures.

Distribution of helminthiases according to gender and age groups

This study reveals a relationship between the most predominant helminthiasis urinary schistosomiasis and hookworm infection only and the gender or the age groups of examined children. Both diseases occurred more significantly in 11-14 years old schoolchildren while only hookworm infection was more prevalent in boys. Our results on urinary schistosomiasis are in contrast to those of Hürlimann et al. (2014) and Yapi et al. (2014) who reported in the health district of Taabo that this schistosomiasis was gender-related, with boys being significantly more infected. But a similar age group of 10-15 years old was observed with the same occurrence in Senegal (Senghor et al., 2014). Concerning the hookworm infection, current observations are similar to those reported previously in Taabo (Hürlimann et al., 2014) and in the regions of littoral of Cameroon (Tchuem Tchuenté et al., 2013). These authors showed that these groups were part of the schoolchildren at high-risk of urinary schistosomiasis and hookworm infections in the study area. Therefore, they must be given priority for health education, self-hygiene and treatment.

Conclusion

This study provided the current status of the schistosomiasis and the STHs among the pupils of the Bélier and Marahoué regions in central Côte d'Ivoire. Urinary schistosomiasis and hookworm infections were the most predominant helminthiases. Urinary schistosomiasis is a public health problem in four health districts among which Tiébissou, Toumodi and Yamoussoukro in Bélier, and Sinfra in Marahoué. The recorded prevalence rates were moderate. Occurring with moderate rate, hookworm infection is a public health problem in Toumodi only. The detailed mapping of these parasitic infections highlighted the focal and water-related characteristics of schistosomiasis, specifically for urinary in the Bélier region, whilst the distribution of hookworm infection was homogeneous. Therefore, it could be advisable to implement control programmes at the school level for schistosomiasis and at the level of the health district for STHs. Our detailed mapping could be used as a tool to refine the planning of the PNLMTN-CP's control actions in the regions investigated and elsewhere in Côte d'Ivoire.

COMPETING INTERESTS

The authors declare that they have no competing interest about the work reported in this paper.

AUTHORS' CONTRIBUTIONS

Conception and design of the study: MNO, AM, NAN and EKN. Maps drawing: MNO and MO. Data collection: MNO, NAN, NND, and NRD. Statistical analysis and interpretation: MNO, JTC and RKA. Draft of the article: MNO. Critical revision of the article for important intellectual content: MNO, AM, NAN, NND, MO, JTC, RKA, NRD, ADM, LMAD and EKN. All authors read and approved the final version of the manuscript.

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