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Recent urban growth and urinary schistosomiasis in Niamey, Niger

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Summary A cluster sample survey was conducted in 1998 in 30 schools to assess the effect of the growth of Niamey during the last decade on a urinary schistosomiasis urban focus described in 1989. Two thousand and forty-two children (11.0 ± 0.1 years old) had a urine filtration test and answered a behavioural questionnaire. Snail populations of the sites used by schoolchildren were followed up in 1999. The global prevalence was 15.7% in 1998, as opposed to 23.7% in 1989. The prevalence was very low in schools far from the river and higher in those along the Niger banks, particularly in villages on the periphery of the urban area. Geographical factors were more important than socio-economic ones in explaining the distribution of the disease. Only 46% of the children in Niamey reported water contact, mainly in the river, rarely in pools and the canal. The infection risk was low in pools (RR = 1.6), high in the river (RR = 3.5) and very high in the canal (RR = 12.5). Malacological studies confirmed the location of transmission sites obtained through parasitological studies and the questionnaire. Sixty-one per cent of the children travelled outside Niamey to the hyperendemic surrounding areas. However, these movements did not increase their infection level. The results are discussed in relation to water contact behaviour and *Schistosoma haematobium* transmission features.

keywords *Schistosoma haematobium*, epidemiology, transmission, urban focus, Niger

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Introduction

With urbanization being an important feature of rural regions worldwide (Rossi-Espagnet *et al.* 1991), urban foci of parasites in tropical areas can no longer be ignored. Control programmes must now be adapted to the epidemiological patterns of cities. Three features have to be taken into account when considering parasites, particularly schistosomes: Firstly, the high mobility of people between urban and rural areas favours individual external infection and importation of new parasites to urban areas (Mott *et al.* 1990). Secondly, although the general development of cities results in less intense transmission than in surrounding rural areas, the transmission level is usually higher in less developed urban quarters (Gryseels 1991). Thirdly, health care facilities are more numerous in urban than in rural areas, underlining the role of social heterogeneity in parasite distribution in urban areas (Cadot *et al.* 1998).

Niamey is located along the Niger river in an area endemic for *Schistosoma haematobium*, which allows the development of urban foci. A school survey from 1989 (Aboubacarim 1989) showed that 23.7% of the children in Niamey were infected. Prevalence distribution was irregular and higher near the river. However, pools could also have played a role in local transmission. During the past decade, the city's population has increased from 392 169 (Recensement Général de la Population 1988) to 591 699 (Demographic & Health Surveys 1999), creating new quarters and integrating old villages. Our aim was to assess the impact of these changes on the urinary schistosomiasis focus described in 1989.

Our objectives were to measure the present distribution of urinary schistosomiasis in schools, to compare the role of the river and the pools in local transmission, and to assess the influence of seasonal travel on the level of endemicity.

Materials and methods

Baseline

Niamey is a town of 100 km² along the Niger river in a

sahelian climate zone. The average annual rain fall is 600 mm (July–October), the average temperature 29 °C (22 °C in January and 31 °C in May). The river is regulated by a low-volume dam and is an important source of water for people living on its banks and piped for the city centre. Bore holes and wells supply water to other parts of town. Variable pools occur, mainly on the city's periphery. Drainage systems exist only in modern neighbourhoods.

Study population

We conducted a one-stage cluster sampling survey from May to June 1998 in the schools of urban Niamey. The sampling list included all 157 schools (public, private or koranic) declared operational in 1997 (87 596 pupils). Each school was roughly located on a map and the sampling list ordered by quarters from West to East. A random sample of 30 registered schools was selected with probability proportional to size (Bennett *et al.* 1991). Third grade primary school pupils aged 10–12 years were included in the study. Depending on the school size, one or two groups were recruited to get a sample of a maximum of 100 children. Lists of pupils were obtained from the teachers and included name, sex, age and birthplace. Of 2336 registered children 2024 had a full examination.

Methods

Urine samples were collected between 1100 am and 1200 noon and filtered through Nytrel 20 with lugol staining (Mott *et al.* 1982). Individual questionnaires elicited socio-economic and behavioural patterns: residence quarter, parents' occupation, use of transmission sites in Niamey (location, frequency and duration of contacts) and movements outside of Niamey (place, length and period of stays). All water contact sites used by the children were identified and located with GPS. Of 22 registered sites, 11 were on the riverside, 10 in pools and one in an irrigation canal. These sites were investigated every 15 days from January to December 1999. Each snail found to be a potential host for *S. haematobium* was checked for infection with *Schistosoma sp*.

Data analysis

The data were analysed with Statistica 5.0. The prevalence and William's geometric mean of individual egg excretion (WGM) were compared using bilateral χ^2 and Student tests. Because of the probable design effect of the cluster sampling, confidence intervals were calculated according to Bennett *et al.* (1991). We used for multivariate analysis a logistic regression with a stepwise ascending procedure including two order interactions. $P < 0.05$ was considered significant.

Ethical considerations

The means and the objectives of the study were explained to the Regional Board of Primary Schools, to parental associations and to headteachers. This information was passed on by teachers to children's relatives. Children's participation in the study was voluntary. Global results were sent to headteachers and all infected children were treated with praziquantel.

Results

In the study population (Table 1), the sex ratio showed an insignificant female predominance (M/F ratio = 0,96). Age ranged between nine and 16 and the mean age was lower in private schools (10.5 years) than in public or koranic schools (11.0 years) ($P < 0.001$). Participation was particularly high in private (95%) and low in koranic schools (68%). More than 80% of the children were born in Niamey, whereas that was true for less than 10% of their parents.

The global prevalence was 15.7 + 5.9%. However, there was an important spatial heterogeneity with prevalences ranging from 0% to 100% (Figure 1 and Table 1). In two schools situated in traditional villages near the river on the periphery of the city, the prevalence exceeded 90%. In seven schools it ranged from 21% to 42%; five of these were near the river. Prevalences from 1% to 13% were found in 20 schools; 17 were located far from the river. In one school, no schistosomes were found. While the global mean egg excretion was 0.6 egg/10 ml urine (CI 0.3–1.1 egg(s)/10 ml), it reached 26 and 412 eggs/10 ml in the two schools where prevalence exceeded 90%. In other schools, individual loads of infected children were very low.

Prevalence was higher in public and koranic schools than in private ones and lower in modern or renovated areas than in traditional neighbourhoods (Table 2). Prevalence was higher in peripheral quarters than in the centre and higher near the river (Table 2). These parameters were included in a logistic regression model with position relative to the river as main variable and other variables as confounding factors (Table 3). Sex was also included in the model because prevalence is usually higher in males than in females (19.0% and 12.6% in our study). The distribution of parasites depended on location rather than socio-economic factors such as type of quarter or school. The socio-economic level was only significant factor for quarters near the river.

Fifty-six per cent of children did not contact water sites in Niamey; 33% used the river, 9% used pools and 2% used an irrigation canal. The prevalence was higher in children with water contact than in those without (26.2% and 7.4%, $P < 0.001$). Infection risk in the studied sites differed according to the habitat. The relative risk was low in pools (1.6),

Table 1 Full list of the examined schools, including parasitic results and general characteristics of quarters

School name	School type*	Sample size	Prevalence	WGM (eggs/10 ml)	CI (α = 5%)	Quarter name	Living quarters†	Distance of quarter from river: Near (< 1 km)	Distance of quarter from river: On city limits
Tondibiah	P	32	90.6%	26.2	[13; 52]	Tondibiah	T	+	+
Yantala IV	P	82	13.4%	0.2	[0.1; 0.4]	Yantala	T	+	
Yantala I	P	77	28.6%	1.0	[0.5; 1.7]	Yantala	T	+	
Yantala recasement	P	91	4.4%	0.1	[0.0; 0.2]	Yantala recasement	T		
Medersa Nogare	Kor	39	30.8%	0.6	[0.2; 1.2]	Nogare	R	+	
Tassi Konou	P	85	42.4%	3.2	[1.8; 5.3]	Banga Bana	T		+
Pont Kennedy	P	80	40.0%	3.0	[1.6; 5.1]	Nouveau Gaweye	T	+	
Hermann Gmeiner	Priv	63	3.2%	0.1	[0.0; 0.2]	Dar Es Salam	R		
Zongo	P	83	8.4%	0.3	[0.1; 0.5]	Zongo	M	+	
Foulani Koira II	P	64	6.3%	0.1	[0.0; 0.1]	Foulani Koira	T		+
Dezeibon	P	71	8.5%	0.2	[0.0; 0.4]	Koira Tegui	R		
Terminus II	P	72	9.7%	0.3	[0.1; 0.7]	Terminus	M	+	
Boukoki I	P	75	6.7%	0.1	[0.0; 0.3]	Boukoki	T		
Diori I	P	65	10.8%	0.3	[0.0; 0.6]	Banizoumbou	R		
Kallay	P	93	6.5%	0.2	[0.0; 0.4]	Kallay Sud	R		
Lazaret I	P	72	4.2%	0.1	[0.0; 0.2]	Lazaret	T		+
Gamkallay I	P	67	34.3%	1.5	[0.7; 2.5]	Gamkallay	T	+	
Boukoki IV	P	80	7.5%	0.2	[0.0; 0.5]	Koira Me	T		
Abidjan II	P	50	8.0%	0.1	[0.0; 0.3]	Madina	R		
Medersa Gamkallay	Kor	28	21.4%	0.6	[0.1; 1.4]	Gamkallay	T	+	
Kallay Est III	P	83	10.8%	0.4	[0.1; 0.8]	Kallay Est	R		
Poudriere II	P	85	1.2%	0.1	[0.0; 0.1]	Poudrière	R		
Madina II	P	81	0%	0	–	Madina	R		
Baby School	Priv	57	7.0%	0.1	[0.0; 0.3]	Poudrière	R		
Koida III	P	83	7.2%	0.3	[0.0; 0.5]	Talladje	T		+
Sikia	Priv	24	8.3%	0.2	[0.0; 0.5]	Route Filingue	T		+
Garbado II	P	78	6.4%	0.2	[0.0; 0.4]	Route Filingue	T		+
Humanité	Priv	61	6.6%	0.3	[0.0; 0.6]	Talladje	T		+
Aéroport III	P	74	33.8%	1.7	[0.8; 3.1]	Aéroport	T		+
Gueri Guindi	P	29	100%	412.3	[183; 926]	Saga	T	+	+

*P, public school; Priv, private school; Kor, koranic school.

†M, modern quarters (modern habitat, piped water supply, low population density, upper classes); R, renovated quarter (traditional or modern habitat, public piped water, middle classes); T, traditional quarter (traditional habitat, no piped water, high population density, lower classes or migrants).

high in the river (3.5) and very high in the canal (12.5) (Table 4). Increase of infection risk was significant in one permanent pool and most river sites. Calculation of attributable fraction related to local exposure suggested transmission focuses in four river sites and in the canal (Table 4).

In 1999, *Bulinus truncatus* and *B. globosus* were found in most river sites and the pool with an increased risk of infection in 1998 (Table 4). Only *B. truncatus* was infected with *Schistosoma* sp. (from January to March in the river and from February to May in the pool). Infected *B. senegalensis* was also found in one temporary pool at the end of the rainy season. Except in the canal, where snails appeared to be absent from the portion used by schoolchildren, there was no major difference between malacological results and mapping of infection risk (Table 4).

Most children (60.8%) left Niamey during the summer holidays: mainly for the surrounding areas (54.3%), other parts of Niger (28.3%) or foreign countries (17.4%). Prevalence, but not egg count, were higher in children who had recently stayed in the Niger valley than in children who had not left Niamey, independently of the use of water contact sites in Niamey (Mantel–Haenszel $\chi^2 = 6.75$).

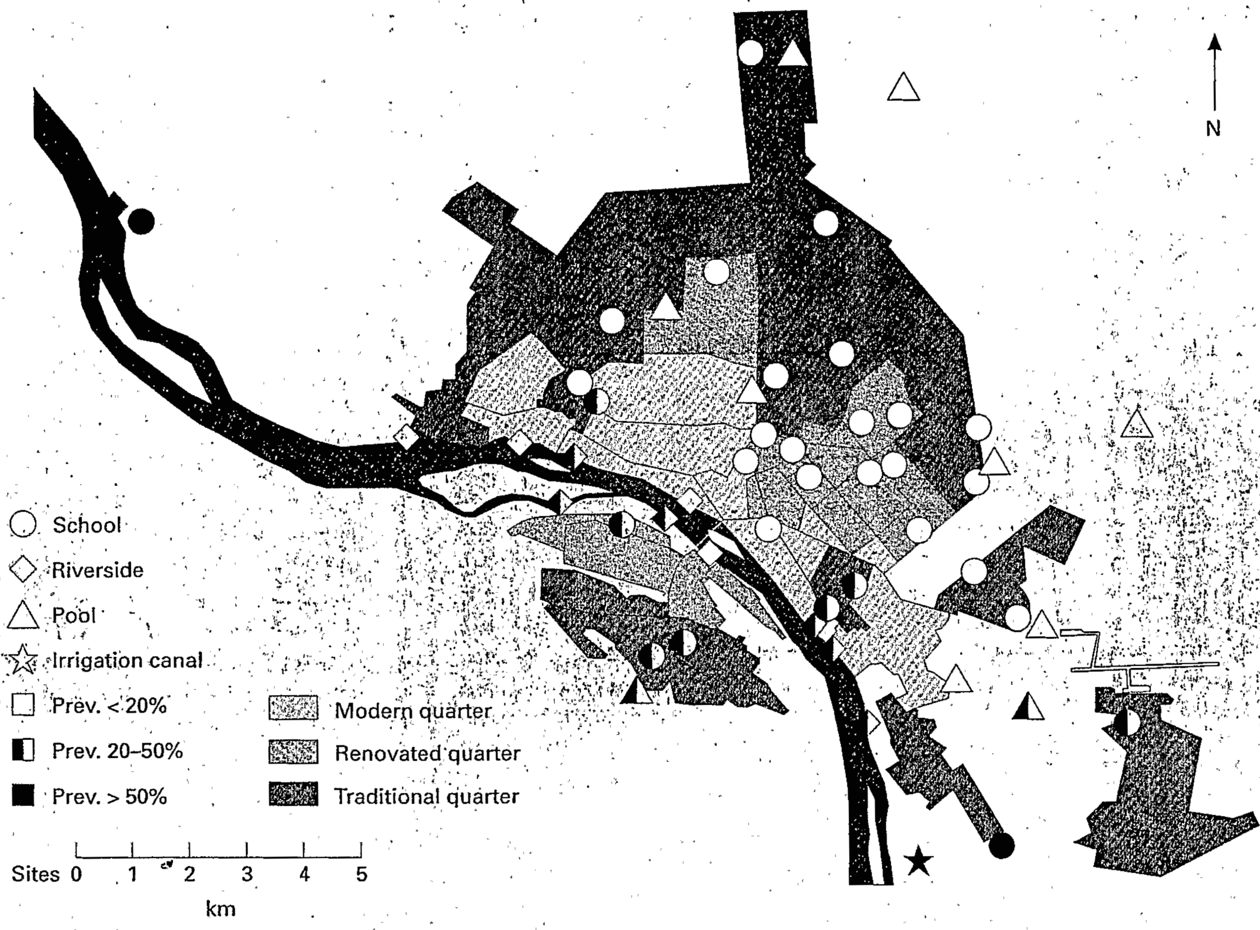

Figure 1 Distribution of *S. haematobium* prevalence in Niamey schoolchildren and in users of Niamey water contact.

Discussion

Mapping of prevalences does not necessarily indicate the origin of infections, particularly in urban areas, where the mobility of the population is high. Associated with malacological surveys, however, prevalence mapping can confirm local transmission, although it cannot distinguish local from

Table 2 Influence of socio-economic and geographical factors on *S. haematobium* distribution in Niamey (univariate analysis)

	(Number)	WGM (eggs/10 ml)	Prevalence	OR [CI OR]
Private schools	(205)	0.2	5.9%	1
Public schools	(1752)	0.7***	16.4%***	3.15 [0.7–5.7]
Koranic schools	(67)	0.6**	26.9%***	5.91 [2.7–13.1]
Renovated quarters	(687)	0.2	7.4%	1
Modern quarters	(155)	0.3	9.0%	1.24 [0.6–2.4]
Traditional quarters	(1182)	1.0***	21.3%***	3.38 [2.4–4.7]
Central quarters	(1422)	0.4	12.2%	1
Peripheral quarters	(602)	1.4***	23.8%***	2.23 [1.7–2.9]
Quarters far from the river	(1435)	0.3	9.7%	1
Quarters near to the river	(589)	1.8***	30.2%***	4.04 [3.1–5.2]

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.001$.

Table 3 Influence of socio-economic and geographical factors on *S. haematobium* distribution in Niamey (logistic regression)

	Adjusted OR	[CI OR]	*P*
Quarters near to the river	2.19	[1.3–3.7]	**
Peripheral quarters	3.15	[1.8–5.6]	***
Peripheral quarters near to the river	16.94	[4.5–63.6]	***
Sex = M	1.87	[1.4–2.5]	***
Traditional quarters	0.98	[0.5–1.7]	
Traditional quarters near to the river	2.82	[1.3–6.2]	**
Public or koranic schools	1.99	[1.1–3.7]	*

$^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

imported infection. In this study, the combination of parasitological examination and individual questionnaires made it possible to assess the risk related to the use of different sites. This approach is a simple way of locating main transmission sites in a study population and was validated by snail follow-up. *B. truncatus*, the local intermediate host of *S. haematobium*, was only observed in sites where a significantly increased infection risk was. However, its absence in the canal shows the difficulty of obtaining the exact locations of water contact sites by means of a questionnaire.

During the last 20 years, many studies described transmission of schistosomiasis in urban centres in tropical Africa: Bamako (Doumbo *et al.* 1992), Bata (Simarro *et al.* 1990), Bujumbura (Gryseels 1991; Engels *et al.* 1994), Dar Es Salaam (Sarda *et al.* 1985), Harare (Ndamba *et al.* 1994), Ibadan (Okoli & Odaibo 1999), Kampala (Kabatereine *et al.* 1996),

Table 4 List of water-contact sites used by schoolchildren with infection risk observed in users in 1998 and snail densities observed in 1999

Site name	Water source*	Users	Relative risk	*P*†	Attributable risk‡	*B. truncatus*§¶	*B. globosus*§	*B. senegalensis*§¶	*B. forskalii*§
Bangabana	PP	17	6.3	***	0.04	+ + + [a]	+ +	+ +	+ +
Boukoki 2	PP	27	2.0			–	+	–	+ + +
Gorou	PP	40	0.0			–	–	–	–
Kalmaharo	PP	10	1.3			–	–	–	+
Dar-Es-Salam	TP	6	0.0			–	–	+ +	–
Koirategui	TP	38	0.7			–	–	–	–
CEG10	TP	15	0.0			–	–	–	–
ASECNA	TP	9	3.0			–	–	+ + +	–
Escadrille	TP	8	0.0			–	–	–	–
Route Filingue	TP	14	1.9			–	–	+ + + [e]	–
Canal	C	39	12.5	***	0.18	–	–	–	–
Tondibiah	R	36	11.6	***	0.16	+ + [b]	+ +	–	+
Goudel	R	9	1.5			?	?	?	?
Yantala Barrage	R	26	2.6	*	0.02	+ +	+	–	–
Lamorde	R	8	5.1	*	0.02	+	+	–	–
Yantala Bas	R	110	2.9	***	0.10	+ + [c]	+ +	–	–
Nogare	R	36	3.7	***	0.05	+	+	–	–
Kombo	R	73	0.9			+ +	+ +	–	–
Riz du Niger	R	191	2.7	***	0.14	–	+	–	–
Gamkallay	R	101	5.2	***	0.17	?	?	?	?
Tassia	R	52	3.4	***	0.06	+ + [d]	+ + +	–	+
Saga	R	26	3.1	*	0.03	+	+	–	–

*PP, permanent pool; TP, temporary pool (filling period < 4 months); C, irrigation canal; R, Niger river.

† $^*P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$.

‡Attributable risk = e (RR – 1)/(1 + e (RR – 1)) where e is the frequency of site users in the population and RR is the relative risk for users of this site.

§+, 1–9 snails collected in 1999; + +, 10–99 snails collected in 1999; + + +, at least 100 snails collected in 1999.

¶(a) infection rate = 5.9%; (b) infection rate = 9.4%; (c) infection rate = 1.8%; (d) infection rate = 5.9%; (e) infection rate = 1.0%.

Kinshasa (Gryseels & Ngimbi 1983; De Clercq 1987), Lusaka (Mungomba & Michelson 1995) and Port Harcourt (Arene *et al.* 1989). In these cities, prevalences were moderate and usually higher in periurban areas than in the centre. However, transmission patterns can vary over time (Gryseels & Ngimbi 1983; De Clercq 1987), and it is still unclear how increasing urbanization and accompanying population growth might affect schistosomiasis transmission (Okoli & Odaibo 1999).

In 1998, the overall prevalence of urinary schistosomiasis in the school population of Niamey was low (16%). As prevalences usually peak in this age group, the prevalence in the total urban population is probably even lower. A similar study in 1989 in 30 schools of Niamey (1770 children aged 9–16 years) revealed a prevalence of 24% (Aboubacarim 1989). Although there are some differences between the two study populations (exclusion of peripheral villages and sampling without probability proportional to size), we conclude that the endemic level has not increased during the last decade. The recent rapid growth of the city has not been beneficial to the parasite, perhaps even on the contrary.

Our results show that prevalence is higher in traditional parts of town than in modern ones as also observed also by Gryseels (1991) and Ndamba *et al.* (1994), probably due to lower exposure and better health care facilities. In Niamey, water contacts were indeed less frequent in modern areas. Generally water contact is less intense in cities, caused by greater distances between habitat and water contact sites and changes of behaviour in an urban context. Peripheral quarters, where recent migrants are concentrated, were more at risk only if situated near the river, indicating the predominance of locally contracted over imported infection.

Ecological features could also explain the low level of *S. haematobium* transmission. Most infections were contracted in the river and canal; the infection risk was lower in urban pools. *B. truncatus*, intermediate host of *S. haematobium* in this area, was observed in the river only during the cold season, a period when water contacts are less frequent. The low densities could be due to the fact that snails develop less well in irregular and polluted water of urban sites (Gryseels & Ngimbi 1983; Sturrock 1993). Moreover, pools at the urban periphery were infrequently used, limiting the possible role of *B. senegalensis* in urban transmission. Irrigation canals in peripheral villages, however, acted as a very intense transmission site and were responsible for high prevalences and intensities.

The intense transmission in the surrounding rural area had only limited importance for this urban focus. More than 80% of children were born in Niamey and the population increase was mainly due to the specific growth of the city. Therefore, the number of children infected before settling in the city probably decreased during the last decade. Short visits to the Niger valley did not lead to a significant increase of parasite loads.

In conclusion, transmission of *S. haematobium* in Niamey is moderate and the prevalences and intensities of infection are too low to consider schistosomiasis as a main public health priority. Local transmission occurs mainly on the river banks and in canals on the periphery. General urban development will probably lead to decreasing contact with these sites. Urban pools do not play an important role in transmission. Globally, urbanization reduces transmission, and its effect spreads progressively from the city centre to the periphery. Peripheral villages remain at high risk of infection and have to be included in rural control programmes. In the city, regular primary and school health programmes should suffice to keep morbidity under control.

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