Acta Tropica, 58(1994)127–140

ACTROP 00421

Control of *Schistosoma mansoni* and intestinal helminths: 8-year follow-up of an urban school programme in Bujumbura, Burundi

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Received 5 April 1994; revision rceived and accepted 17 June 1994

Annual selective chemotherapy with praziquantel was implemented in primary schools in the endemic suburbs of Bujumbura from 1984 to 1992. During the first 6-year period, the overall prevalence among pupils decreased from 23.3% to 9.1%, a reduction of 61%. During the following 2-year period, in which only children from the 1st, 4th and 6th grade were examined in two of the four endemic suburbs (maintenance strategy), the prevalence decreased further to 6.4% or a 73% reduction from the beginning of the programme. The impact of annually repeated selective chemotherapy was more important on the intensity than on the prevalence of infection. It was also more pronounced in the senior grades of primary school. Its cumulative effect tended to decline over the years. The prevalence of infection in new entrants to the programme also decreased over the years, indicating a reduction of transmission. This change in transmission was different in each suburb and related to changes in the sanitary situation, the degree of urbanization and the accessibility to rural transmission sites. The results of helminth control, a secondary aspect of the school programme, were proportionately less pronounced than those obtained for schistosomiasis. The improvement in hygienic conditions has also contributed much to the outcome of this latter type of control. The cost, per person protected, of the programme was comparable with what has been reported by other, similar programmes. Application of a maintenance strategy to 57% of the target population has reduced the cost by 40%.

Key words: *Schistosoma mansoni*; Schistosomiasis control; Urban control; Intestinal helminthiasis; School programme; Burundi

Introduction

In Burundi, a national programme for the control of schistosomiasis mansoni has been implemented since 1985. The epidemiology of the disease, its consequences for control and the evolution of the control programme in recent years have been reviewed by Gryseels (1991) and Engels et al. (1993).

In the capital Bujumbura, a school treatment programme, based on the yearly examination of schoolchildren with direct slides and ambulant treatment of positive cases with niridazole 25 mg/kg for 7 days (!), had already been going on between 1973 and 1981. Prevalences of infection, as detected by direct examination of stools,

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SSDI 0001-706X(94)00056-5

had decreased from 16% in 1974–75 to 10% in 1980–81. In 1982, new surveys (based on examination of duplicate 25 mg Kato-Katz slides) among primary school children showed prevalences which ranged from 20 to 45% in the suburbs Kinama, Cibitoke, Kamenge and Buyenzi (Fig. 1). In the other residential areas, these figures were below 10% (Gryseels, 1991). More detailed surveys on random 5% samples of the whole population in Buyenzi and Kinama revealed that more than 1/3th of all infections and almost half of all heavy infections (>400 eggs per gram) were encountered in the agegroup 6–15 years old, which constituted 1/4 of the total population (Gryseels, 1991 and unpublished data).

As selective chemotherapy of the entire population was unfeasible in this suburban environment, the continuation of a school-based strategy seemed entirely justified. In 1984, the programme was redesigned and implemented in the suburbs Kinama, Cibitoke, Kamenge and Buyenzi. Praziquantel was introduced as schistosomicidal drug and annual selective chemotherapy from then onwards based on screening with 25 mg Kato-Katz slides. Health education was added as a routine activity in 1989. The present paper describes the results of this programme after 8 years of implementation.

Area and population

Situated at the tip of Lake Tanganyika at an altitude of 770 m, Bujumbura (Fig. 1) had a total population of 190 000 in 1984, which had grown to 235 000 in 1990. The town consists of an administrative and commercial centre, surrounded by residential areas.

The suburbs Kinama, Cibitoke, Kamenge and Buyenzi are of low socio-economic level. Their population has grown from 80 000 in 1984 to 130 000 in 1990. The mean annual growth rate, for the period 1979–1990 (in-between 2 national censuses), of the resident population in these suburbs was −1% in Buyenzi, 4.7% in Kinama, 7.1% in Cibitoke and 7.8% in Kamenge. The number of primary schools in these suburbs increased from 15 in 1984–85 to 23 in 1989–90; the number of classes increased from 218 to 336 during the same period.

In Burundi, primary school education takes 6 years. A school-year starts in September and ends in June of the following year. Gross and net school enrollment rates in suburban Bujumbura were, respectively, 72% and 50% in 1984–85 and 97% and 66% in 1989–90. As adult literacy classes were excluded from the analysis, the age of the primary school population ranged from 5 to 19 years old. More than 95% of the pupils were between 6 and 15 years old. Grade 1 pupils constituted roughly 24% of the children in primary schools. The proportion of children in the following grades gradually decreased to about 13% in grade 6.

Materials and methods

Chemotherapy

During the initial phase of the programme (1984–1990), selective chemotherapy was applied annually to all pupils in primary schools. Screening was based on the examination of a single 25 mg Kato-Katz smear (Katz et al., 1972), prepared from

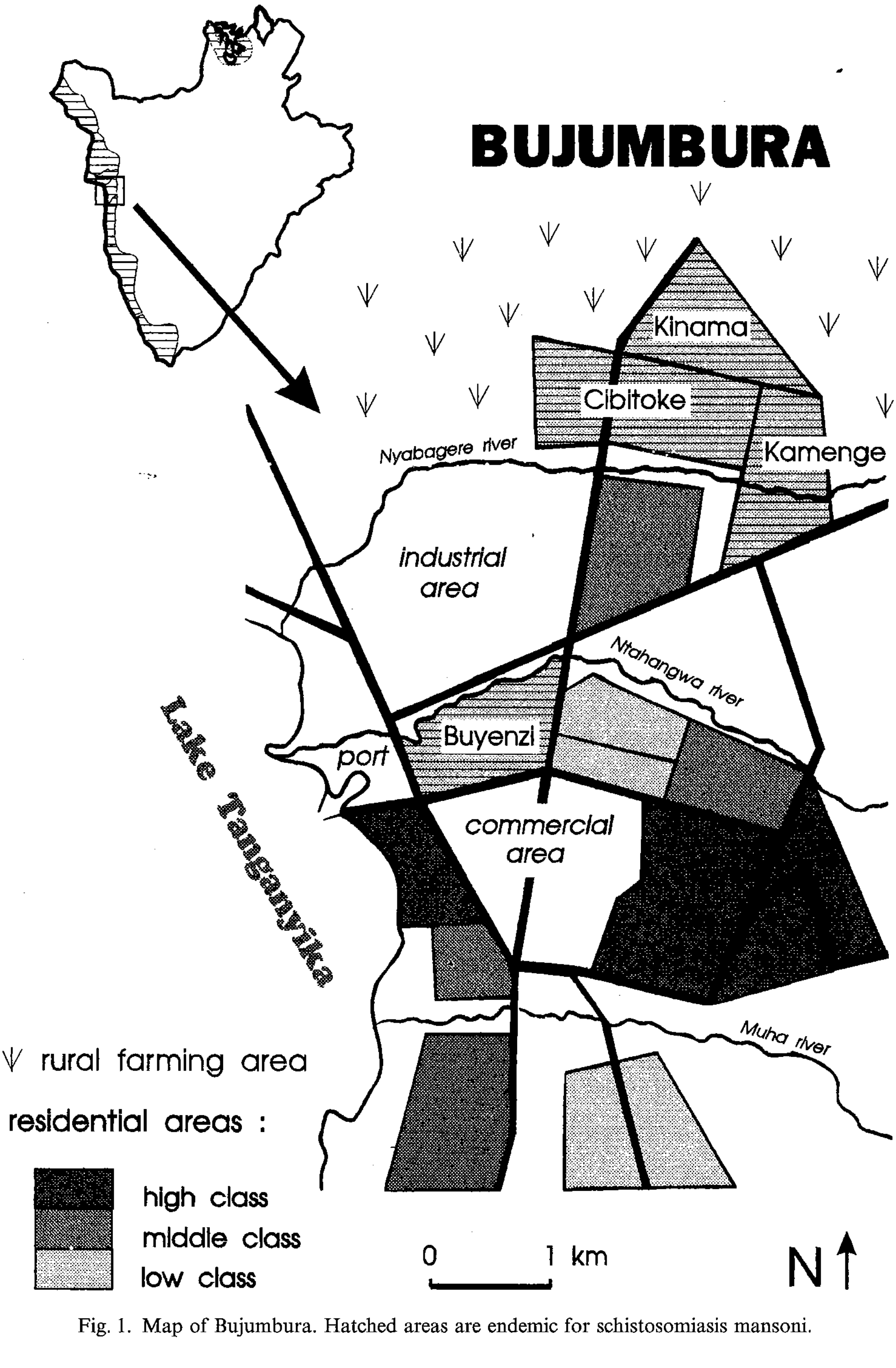

Fig. 1. Map of Bujumbura. Hatched areas are endemic for schistosomiasis mansoni.

a fresh stool sample and left to clear for a minimum of 45 min (Peters et al., 1980) and a maximum of 2 h. Gryseels et al. (1991) demonstrated this to be an adequate technique for large scale operational screening programmes aiming at the control of morbidity. Up to 1987, stool samples were collected in the schools and brought to the central laboratory where the Kato-Katz slides were prepared and examined. From 1987–88 onwards, the slides were prepared in the schools and brought to the central lab for examination. This latter method allowed a better observation of the fixed clearing time.

All schistosome eggs were counted; the presence of eggs of other common intestinal helminths (hookworm, ascaris, trichuris and taenia) was recorded in a semi-quantitative manner. Schistosomiasis was treated with a single dose of praziquantel (Biltricide^{R}), 40 mg/kg body weight; roundworm infections, up to 1990–91 with a single dose of 50–150 mg levamisole and thereafter with a single dose of 500 mg mebendazole; hookworm, whipworm and combined infections with a single dose of 500 mg mebendazole. Tapeworm was treated with a single dose of praziquantel, 20 mg/kg. Allergic reactions, the only serious side effects (rarely) encountered after intake of praziquantel, were treated with promethazine (Phenergan^{R}). Minor transient side effects as abdominal pain, nausea and headache – encountered only after intake of praziquantel – were not treated.

A maintenance strategy, consisting of annual selective chemotherapy of the pupils of only the 1st, 4th and 6th grades of primary schools, was introduced where the prevalence had decreased to less than 6%. This was the case in Kamenge and Buyenzi from 1990–91 onwards.

The programme was carried out by a specialized team composed of one team leader (S.N.), 4 microscopists and 2 general hands. Quality control was performed by systematic random re-examination, by the team, of about 1/8th of the daily examined Kato-Katz slides.

Health education

A 25′ educational video-film was produced and is shown yearly to the senior grades of all primary schools since 1989–90. Projection of this film is followed by plays and exercices intended to enhance comprehension of the educational message. From 1991–92 onwards a drawing contest is organized yearly in each 6th grade class and educational T-shirts given to the prize-winners.

Data collection and analysis

Data were collected on standard record forms. Simple indices were calculated by hand by the teamleader in order to allow day-to-day monitoring. Data were further processed and analysed on computer using common software as DBase III+ and SPSS PC+. 'Mean egg loads' (MEL) were calculated as geometric means of positive individual egg loads per gram (epg) of faeces. Egg count categories were defined as: 1–100 epg (1–2 eggs/Kato-Katz slide); 101–400 epg (3–10 eggs/Kato-Katz slide); more than 400 epg (> 10 eggs/Kato-Katz slide). The Chi-square test (with Yates' correction as appropriate) was used for the comparison of proportions, the *t*-test for the comparison of logarithmic mean egg counts. *P* values are two-tailed.

Results

The number of children examined yearly is shown in Fig. 2. It increased from 7462 in 1984–85 to 15886 in 1989–90. This was, respectively, 80% and 99% of the enrolled pupils. The application of the maintenance strategy in 2 of the 4 endemic suburbs in 1990–91 resulted in a decrease in the number of children examined (n = *9991*, 87% of the enrolled pupils). In 1991–92, this figure increased again to 12145 (94% of the enrolled pupils).

The evolution of prevalences and intensities of infection, for all four suburbs as a whole, is also shown in Fig. 2. The prevalence of infection decreased from 23.3% to 14.3% (a 39% reduction) in 1 year, further to 9.1% (a total reduction of 61%) during the next 4 years and to 6.4% (or a total reduction of 73%) in the examined grades during the 2 following years. The prevalence of moderate-to-heavy infections (> 100 epg) was reduced by 73% after 6 years and by 81% after 8 years of implementation; the prevalence of heavy infections (>400 epg) by 83% and 87%, respectively.

After an initial decrease up to 1986–87, the prevalences of infection increased again in 1987–88. This was a general phenomenon, recorded in all suburbs (Table 1) and agegroups. From 1987–88 onwards, the figures further decreased up to 1991–92. Year-to-year differences from 1984 to 1990 were statistically significant ($p<0.01$)

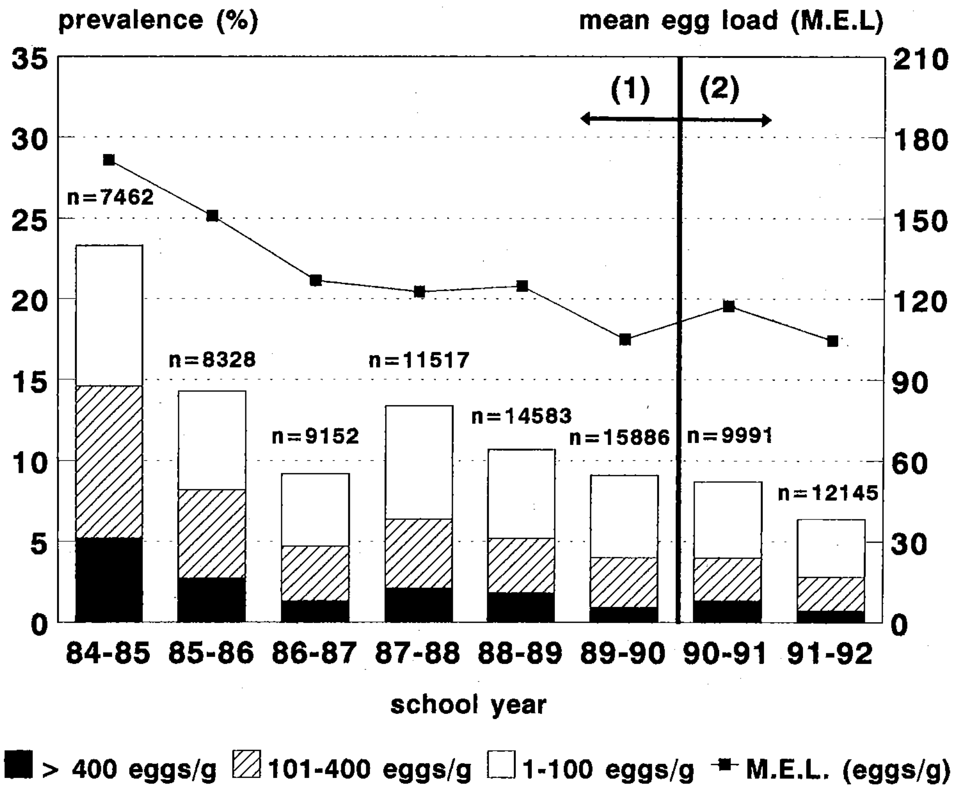

Fig. 2. Year-to-year evolution of prevalences and intensities of schistosomal infection for all four covered suburbs as a whole. (1) all primary school grades examined in all suburbs; (2) all grades examined in Kinama and Cibitoke, grades 1–4–6 examined in Kamenge and Buyenzi.

TABLE 1

Evolution of prevalences and intensities of schistosomal infection, per school-year, in suburban Bujumbura

Suburb	Parameter	School year							
		84–85	85–86	86–87	87–88	88–89	89–90	90–91	91–92
Kinama	prevalence of infection (%)	35.0	23.1	13.8	23.6	19.9	17.5	15.2	8.7
	prevalence of infections >100 epg (%)	22.7	13.5	7.5	12.6	11.0	8.5	7.9	4.1
	prevalence of infections >400 epg (%)	8.9	4.6	2.4	4.7	4.0	4.0	2.3	2.9
	mean egg load (epg)	192.7	152.8	140.2	146.1	145.6	116.0	135.9	110.2
Cibitoke	prevalence of infection (%)	21.5	11.1	11.6	14.6	11.4	9.3	8.0	5.9
	prevalence of infections >100 epg (%)	11.7	5.9	5.9	6.5	6.3	4.1	3.8	2.6
	prevalence of infections >400 epg (%)	4.7	1.7	1.8	2.1	2.7	0.8	1.2	0.8
	mean egg load (epg)	146.0	132.4	137.2	114.9	152.4	104.9	121.4	103.7
Kamenge	prevalence of infection (%)	21.5	12.2	8.2	11.1	6.6	6.1	4.8[a]	7.1[a]
	prevalence of infections >100 epg (%)	12.2	6.9	3.4	4.9	2.4	2.5	1.8[a]	3.5[a]
	prevalence of infections >400 epg (%)	3.7	1.5	0.6	1.2	0.7	0.4	0.3[a]	0.9[a]
	mean egg load (epg)	144.7	127.3	101.2	105.3	96.7	92.6	88.0[a]	114.9[a]
Buyenzi	prevalence of infection (%)	15.4	10.5	6.6	7.6	6.6	5.5	3.9[a]	3.2[a]
	prevalence of infections >100 epg (%)	10.1	6.2	3.4	3.2	2.5	2.1	0.9[a]	0.9[a]
	prevalence of infections >400 epg (%)	3.2	2.3	0.8	0.8	0.5	0.5	0.1[a]	0.3[a]
	mean egg load (epg)	165.3	167.9	121.7	102.8	89.6	92.9	63.9[a]	76.0[a]
All 4 suburbs	prevalence of infection (%)	23.3	14.3	9.2	13.5	10.6	9.1	8.8[a]	6.4[a]
	prevalence of infections >100 epg (%)	14.6	8.2	4.7	6.4	5.2	4.0	4.0[a]	2.8[a]
	prevalence of infections >400 epg (%)	5.2	2.7	1.3	2.1	1.8	0.9	1.3[a]	0.7[a]
	mean egg load (epg)	171.4	150.8	126.9	122.7	124.8	105.0	117.3[a]	104.6[a]

[a] Figures influenced by the application of the maintenance strategy.

for all parameters, apart from the MEL between 1986–87 and 1988–89. The overall prevalence of infection of 8.8% in 1990–91, the year in which the maintenance strategy was introduced in Kamenge and Buyenzi, was not statistically different from the one detected in 1989–90. However, the difference became significant ($p < 0.01$) when only those grades examined in 1990–91 (grades 1–4–6) were considered for analysis in the 1989–90 data, resulting in a prevalence of 10.3% that year (Table 2). An inverse phenomenon was observed when the mean egg loads were considered. Prevalence and intensity of infection continued to decrease significantly in 1991–92.

The evolution, in each suburb separately, of prevalences and intensities of infection is shown in Table 1. Apart from a slight increase in Cibitoke in 1986–87 and a generalised increase in 1987–88, all figures are decreasing up to 1989–90. Since the application of the maintenance strategy, the prevalence in Kamenge has increased again from 4.8% in 1990–91 to 7.1% in 1991–92 ($p < 0.01$).

Table 3 shows the evolution, over 6 and 8 years, of the total prevalence, the proportions of moderate-to-heavy (> 100 epg) and heavy (> 400 epg) infections and the mean egg loads for, respectively, the 1st, 4th and 6th grades. The proportional reduction in prevalence of infection is similar in the 3 analyzed grades (approximately 70%). The proportional reduction of moderate-to-heavy and heavy infections and mean egg loads is much more marked in the 4th and 6th grades, which have been subject to annual selective chemotherapy. This phenomenon was also consistently observed in each suburb separately.

The evolution, per suburb, of prevalences and intensities of infection for new entrants in the 1st grade, is analyzed in Fig. 3. In Kinama, the prevalence of infection was substantially reduced (a proportional decrease of 74% between 84–85 and 91–92) but the proportion of heavier infections as well as the MEL stay high. In Cibitoke, after a 63% reduction in prevalence between 84–85 and 89–90, the proportion of heavier infections and the MEL are increasing again. In Kamenge, prevalences of the three egg output categories have increased again in 1991–92, after an important reduction in 1989–90. The MEL, however, has further decreased in 1991–92. In Buyenzi, a marked reduction in all parameters is observed up to 1991–92.

Several 'faithful' cohorts of pupils have been constituted retrospectively for the

TABLE 2

Influence of the application of different strategies on global prevalences and intensities of schistosomal infection

Strategy (grades taken into analysis)	Parameter	School year 89–90	90–91	91–92
Initial strategy (all grades in all suburbs)	prevalence of infection (%)	9.1		
	prevalence of infection > 100 epg (%)	4.0		
	prevalence of infection > 400 epg (%)	0.9		
	mean egg load (epg)	105.0		
Maintenance strategy (all grades in Kinama/Cibitoke, classes 1-4-6 in Kamenge/Buyenzi)	prevalence of infection (%)	10.3	8.8	6.4
	prevalence of infection > 100 epg (%)	4.7	4.0	2.8
	prevalence of infection > 400 epg (%)	1.1	1.3	0.7
	mean egg load (epg)	110.1	117.3	104.6

TABLE 3

Evolution of prevalences and intensities of infection, over 6 and 8 years, in the 1st, 4th and 6th grades

Grade	Age (years)	Parameter	School year		
			84–85	89–90	91–92
1st	6–9[a]	prevalence of infection (%)	17.4	7.5	4.7
		proportion of infections >100 epg	59.2%	53.3%	51.1%
		proportion of infections >400 epg	23.0%	16.0%	17.0%
		mean egg load (epg)	171.4	130.4	132.3
4th	10–14[a]	prevalence of infection (%)	25.4	10.2	6.6
		proportion of infections >100 epg	66.1%	40.2%	30.3%
		proportion of infections >400 epg	26.4%	6.9%	7.6%
		mean egg load (epg)	195.0	94.2	84.5
6th	12–16[a]	prevalence of infection (%)	18.1	8.5	5.9
		proportion of infections >100 epg	58.6%	38.8%	44.1%
		proportion of infections >400 epg	13.8%	5.9%	5.1%
		mean egg load (epg)	134.2	93.9	94.2

[a]Age interval including 90% of the pupils in the specified grade.

period 1984–1990. Indeed, parasitological results of 6 consecutive years were available for 1119 pupils; of 5 consecutive years for 1237 pupils and of 4 consecutive years for 2238 pupils. All these cohorts showed results which were similar to the general ones, including a marked increase in total prevalence and in prevalences of the different egg output categories in 1987–88. Among the 1119 pupils constituting the cohort which was followed during 6 years, the prevalence of infection decreased from 19.7% in 1984–85 to 8.7% in 1989–90; 52.0% of these pupils stayed negative and only 0.2% were consistently positive throughout these 6 years. Other details of cohort analysis will be published elsewhere.

The evolution, for each suburb separately and for all four suburbs as a whole, of the prevalences of the three most common intestinal helminthiases (hookworm, ascariasis and trichuriasis) and of unspecified helminthiasis (one, or a combination of these three helminthiases) is shown in Table 4. As for schistosomiasis, some figures in 1990–91 have been influenced by the application of the maintenance strategy. Comparison with the data of the previous year, analyzed according to this strategy, showed significant differences in global prevalence for ancylostomiasis ($p<0.05$), ascariasis ($p<0.01$) and trichuriasis ($p<0.01$), but not for unspecified helminthiasis ($p>0.05$). Proportional reductions in prevalence of infection, over the 8-year period, were, respectively, 40% for unspecified intestinal helminthiasis (varying from 32% to 48% in the different suburbs), 41% for ancylostomiasis (range per suburb: 32–54%), 25% for ascariasis (range per suburb: 16–30%) and 64% for trichuriasis (range per suburb: 55–66%). These reductions, although all statistically significant ($p<0.01$), are less marked than those obtained in schistosomiasis control.

As for schistosomiasis, the 1984–92 decrease in prevalences of infection, for all four types of helminthiasis in the 1st grades, was comparable to the one observed in the other grades. Analysis of the semi-quantitative data for ancylostomiasis, ascariasis and trichuriasis did not reveal more marked reductions in intensities of

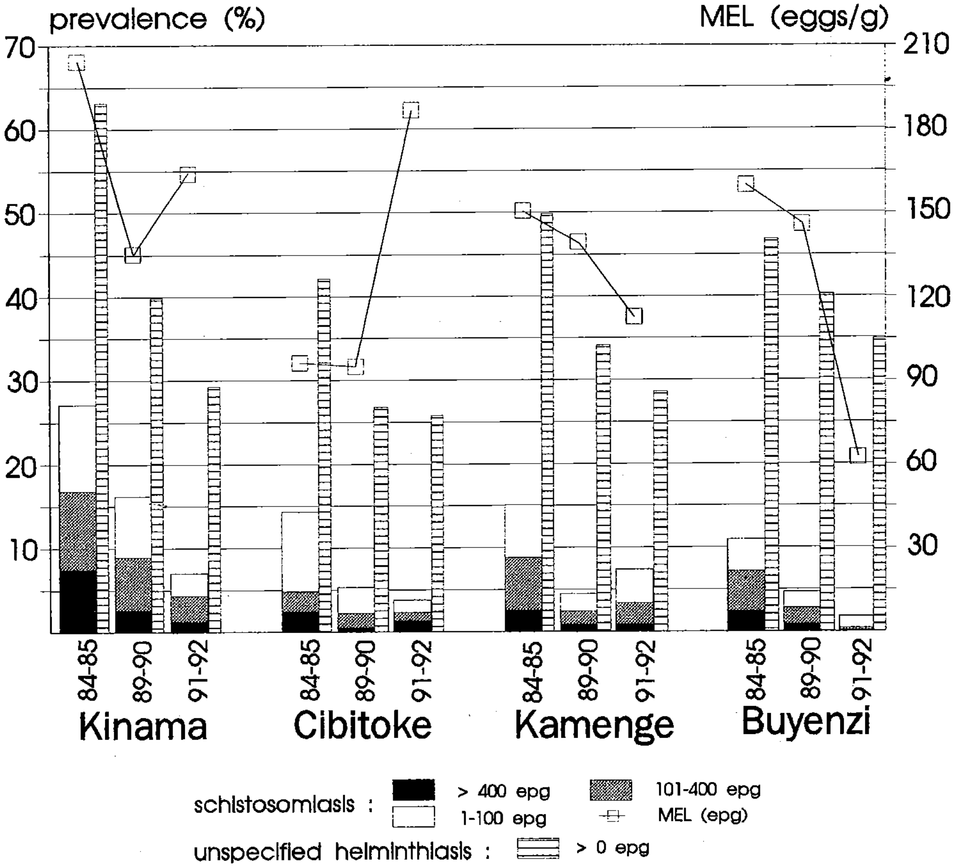

Fig. 3. Evolution, over 6 and 8 years, of prevalences and intensities of schistosomal infection and of prevalences of unspecified helminthiasis among grade 1 pupils (new entrants to the programme) in the different suburbs.

infection in grades 2 to 6 either. The evolution, per suburb, of prevalences of unspecified helminthiasis among grade 1 pupils is shown in Fig. 3.

The evolution of the cost of the school programme and its breakdown are summarized in Table 5.

The effective coverage of the population aged 6–15 years by this school programme in the four covered suburbs, has increased from 35% in 1984–85 to 61% in 1989–90. Equivalent figures for the agegroup 7–14 years old were, respectively, 40% and 70%.

Discussion

From an operational point of view, the schistosomiasis control programme in suburban Bujumbura, based essentially on selective chemotherapy of primary school children, has become a yearly routine since 1973. The growth of the suburban population and the increase in school enrollment rates have almost doubled the workload between 1984–85 and 1989–90. The percentage of children of school-

TABLE 4

Evolution, per school-year, of the prevalences of the three most common intestinal helminthiases in suburban Bujumbura

Suburb	Type of helminthiasis	School year							
		84–85	85–86	86–87	87–88	88–89	89–90	90–91	91–92
Kinama	ancylostomiasis	49.8%	37.6%	29.4%	19.7%	32.5%	31.5%	26.5%	23.0%
	ascariasis	11.6%	9.6%	8.4%	8.1%	6.5%	7.1%	9.7%	8.1%
	trichuriasis	19.3%	16.7%	9.8%	12.9%	11.6%	10.4%	10.1%	6.5%
	unspecified helminthiasis[a]	62.1%	50.2%	40.1%	35.1%	42.2%	39.1%	37.7%	32.1%
Cibitoke	ancylostomiasis	27.9%	23.9%	19.8%	10.0%	16.7%	19.1%	16.2%	17.1%
	ascariasis	9.1%	9.5%	11.7%	8.0%	5.4%	6.8%	8.4%	7.6%
	trichuriasis	16.3%	13.1%	12.5%	12.2%	9.8%	9.4%	8.9%	6.1%
	unspecified helminthiasis[a]	42.7%	37.9%	36.4%	26.2%	27.3%	29.6%	28.0%	25.6%
Kamenge	ancylostomiasis	32.3%	28.9%	29.9%	8.5%	25.4%	22.5%	27.1%[b]	21.9%[b]
	ascariasis	11.8%	12.9%	10.7%	11.2%	8.2%	8.9%	13.4%[b]	11.0%[b]
	trichuriasis	17.9%	14.6%	11.7%	14.8%	10.6%	11.6%	13.1%[b]	7.8%[b]
	unspecified helminthiasis[a]	47.8%	43.4%	41.5%	28.1%	34.2%	32.8%	40.4%[b]	32.1%[b]
Buyenzi	ancylostomiasis	12.5%	10.9%	12.3%	2.7%	8.5%	11.9%	8.9%[b]	6.6%[b]
	ascariasis	17.6%	18.9%	18.3%	20.3%	20.2%	21.1%	16.2%[b]	16.7%[b]
	trichuriasis	27.0%	24.8%	19.9%	24.2%	19.7%	20.5%	19.1%[b]	12.2%[b]
	unspecified helminthiasis[a]	41.6%	39.7%	37.8%	36.5%	35.6%	38.1%	33.3%[b]	28.4%[b]
All 4 suburbs	ancylostomiasis	29.6%	23.0%	20.0%	9.3%	19.4%	20.3%	19.3%[b]	17.4%[b]
	ascariasis	13.8%	14.1%	13.9%	13.4%	11.6%	12.3%	11.5%[b]	10.4%[b]
	trichuriasis	21.8%	19.3%	15.2%	17.5%	14.0%	14.9%	12.4%[b]	7.9%[b]
	unspecified helminthiasis[a]	49.3%	43.0%	38.7%	32.7%	35.3%	35.4%	34.2%[b]	29.4%[b]

[a] One, or a combination of the three mentioned helminthiases.
[b] Figures influenced by the application of the maintenance strategy.

TABLE 5

Evolution of the cost of the school programme between 1984–85 and 1991–92

	School year		
	84–85	89–90	91–92
Number of children examined	7462	15886	12145
Number of cases detected (schistosomiasis)	1739	1446	0777
Number of children protected	7462	15886	17768
Costs (US dollars)[a]:			
Transport (investment & running costs)	5639 (28%)	5482 (29%)	3851 (31%)
Salaries	10587 (53%)	10378 (54%)	7539 (60%)
Drugs — schistosomicidal	3261 (16%)	2387 (13%)	671[b] (5%)
Drugs — anthelminthic	386 (2%)	726 (4%)	467 (4%)
Total cost	19873 (100%)	18973 (100%)	12528 (100%)
Cost per stool sample examined[c]	2.2	1.0	0.9
Cost per case detected (schistosomiasis)[d]	9.6	11.5	15.3
Cost per person treated (schistosomiasis)	11.4	13.1	16.1
Cost per person protected	2.7	1.2	0.7

[a]Based on expenses in local currency, converted into US$ at the prevailing exchange rate.
[b]Taken into account the reduced needs as well as the reduced price of praziquantel.
[c]Not counting the cost of any drugs.
[d]Not counting the cost of schistosomicidal drugs.

going age effectively covered by the programme will further increase with these latter rates. More close supervision has made the percentage of enrolled pupils covered by the programme increase from 80% in 1984–85 to almost 100% in 1989–90. Application of a maintenance strategy has, from 1990–91 onwards, reduced the workload in Bujumbura and allowed the school programme to be extended to the Imbo-Sud region, where another 5000 pupils are now examined every year (Engels et al., 1993).

Although some progress had already been made in schistosomiasis control since the early 1970s (a 38% reduction in prevalence between 1974 and 1981 – as measured by direct stool examination), the introduction of the Kato-Katz diagnostic method and praziquantel have greatly improved the outcome of the programme since 1984.

The general increase in parameters of infection, observed in 1987–88, is probably due to an increase in sensitivity of the diagnostic test, due to a better observation of the minimal clearing time. There was, indeed, no evidence for any increased transmission due to climatological factors that year. A sudden increased influx of more heavily infected new entrants in the programme was also excluded, as cohort analysis revealed a similar increase in parameters. The probability of the former hypothesis was confirmed by dual examination of Kato-Katz slides (clearing time of 30′ vs. 90′) on a smaller series of children (Engels, unpublished data). It is to be noticed that this change in the routine procedure has also brought about a (temporary) loss of accuracy of hookworm detection (Table 4).

Although figures have continued to decline since 1987–88, the proportional improvement tends to stagnate. This is a phenomenon which has also been recorded in other control programmes based on repeated selective chemotherapy (Anonymous, 1987; Gryseels et al., 1991; King et al., 1991; Sleigh et al., 1986;

Webbe and El Hak, 1990)). Possible explanations have been brought forward by several authors. Kloetzel and Schuster (1987) revealed the importance of clustering of reinfection in space. Our cohort analysis, however, could not confirm this. Most treated children, indeed, stayed negative for several years. There was no evidence either for reduced drug efficacy as suggested by King et al. (1991). The progressive loss of sensitivity of the diagnostic test as the proportion of light infections increases (Gryseels et al., 1991), is surely a factor contributing to residual infection in our repeatedly examined school population. The major factor though is probably a recent stagnation or even increase in transmission in certain suburbs, as will be discussed further.

Comparison of the results obtained in the 1st grades, which have never been subject to any specific control action, with those obtained in the other grades (Table 3), gives an idea of the contribution of the different control efforts to global improvement. In this respect, the effect of annual selective chemotherapy is clear. Indeed, the best results were obtained in the higher grades, who are traditionnally more, and more intensely, infected because of age-related risk behaviour and a relative lack of immunity (Bensted-Smith et al., 1987; Butterworth et al., 1985; Tingley et al., 1988). The effect on intensity of infection is also more pronounced than on total prevalence. This phenomenon has also been observed in other programmes and studies (Sturrock et al., 1987; Wilkins, 1989).

The decrease in prevalences and intensities of infection observed in the first grades indicates a reduction of transmission. It is tempting to attribute this to the impact of chemotherapy on transmission, suggested by several authors (King et al., 1991; Sturrock et al., 1990). However, Gryseels (1991), has never been able to detect any convenient intra-urban transmission sites in Bujumbura and concluded that schistosomal infection is probably contracted in the surrounding rural areas. These have been subject to only one round of selective population chemotherapy in 1988 (Engels et al., 1993), which could not have brought about such a longlasting reduction in transmission. On the other hand ongoing urbanization has considerably improved living conditions in the capital's suburbs, keeping their population more and more away from the surrounding rural areas. Progress has particularly been important in fields as communal and individual water supply, road infrastructure, drainage of sewage and rainwater and refuse disposal. Parallel with the health education component of the school programme, a large-scale Information-Education-Communication programme, aiming to improve general hygienic behaviour, has been operational since several years. A reduction in transmission has thus more likely to be attributed to the improvement in hygienic conditions than to an indirect effect of chemotherapy.

Further analysis of the evolution of the parasitological results in first grade pupils gives an idea of the evolution of the transmission in the different suburbs since the start of the programme. In Kinama, the suburb where the relative improvement of hygienic conditions has been most important, the decrease in transmission has been continuous up to 1991–92. In Cibitoke and Kamenge, two suburbs which, in recent years, have rapidly grown and extended into the surrounding endemic rural areas, transmission tends to be on the increase again. In Buyenzi, a stable suburb which is more and more isolated from the rural surroundings by a developing industrial area, transmission seems to be definitely under control. As a consequence, the application of the maintenance strategy, since 1990–91, has proved to be entirely justified here, unlike in Kamenge, where this same decision seems to have been premature. The initial strategy has thus been reintroduced in this latter suburb from 1992–93 onwards.

The results of helminth control, although not the first objective of the control programme, were proportionately less impressive than those obtained for schistosomiasis. It is to be noticed that the results of trichuriasis control were markedly better than those obtained for the other common helminthiases. As for schistosomiasis, the evolution of the prevalence of unspecified helminthiasis among grade 1 pupils shows the importance of the part played by hygienic measures in global control (Fig. 3). Prevalence of helminthiasis among new entrants to the programme has most decreased in Kinama, where, as already stated, the relative improvement in hygienic conditions during the last 8 years has been most important. Results of helminth control were poorest in Buyenzi, where the initial hygienic situation was surely better, but the relative improvement less pronounced. It is also worth noticing that, although the proportional decrease in prevalence of unspecified helminthiasis has generally been less than for schistosomiasis, the absolute number of children cured of the former disease considerably exceeds the number cured of the latter one.

The cost of our programme, per person protected, is comparable with what has been observed in other, similar programmes (Savioli et al., 1989). The application of a maintenance strategy in 2 of the 4 covered suburbs (or to 57% of the target population) has allowed to reduce this cost by 40%.

As a general conclusion, it can be stated that annual selective chemotherapy in primary schools has greatly reduced infection rates of schistosomiasis mansoni and, to a lesser extent, of intestinal helminthiasis among pupils in suburban Bujumbura. The use of the Kato-Katz diagnostic method and praziquantel, during the last 8 years, has much improved the outcome of this control strategy. Although it was not checked during this strictly operational programme, a positive impact on morbidity of schistosomiasis can be assumed (Gryseels and Nkulikiyinka, 1989; Gryseels et al., 1994). Improvement of the sanitary situation, directly related to urbanization, has enhanced and sustained the effect of repeated selective chemotherapy. If the actual trend is confirmed, the schistosomiasis control programme might even be stopped in Buyenzi in a foreseeable future. In the other suburbs, where the evolution is less predictable, it will have to be continued until transmission is definitely under control or primary health care improved to an extent that it can satisfactorily take over early diagnosis and treatment in school-aged children.

Acknowledgments

Our sincere thanks go to the microscopists of the executing team, E. Nkurunziza, S. Nahayo, P. Nyabenda and J. Bigendiwabo, for their sustained and dedicated efforts during the execution of this programme. We also thank Miss A. Niyonzima for her patient entering of data and Mr. B. Sindayigaya for his technical assistance. We also thank all primary school headmasters, teachers and pupils for their cooperation.

The schistosomiasis control programme in Burundi was initiated by the Prince Leopold Institute for Tropical Medicine, Antwerp, Belgium and receives financial support from the national Ministry of Health, the Belgian Technical Cooperation, the European Development Fund and the UNDP/World Bank/WHO Special

Programme for Research and Training in Tropical Diseases (TDR). Improvement of safe water supply and sanitary infrastructure in suburban Bujumbura has been possible thanks to funds from the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), the Kreditanstalt für Wiederaufbau (KFW) and the African Development Bank.

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