HIGHLIGHTS ON THE WORLD BANK LOAN SCHISTOSOMIASIS CONTROL PROGRAM IN CHINA (1991-1998): A SPECIAL FOCUS ON HUNAN PROVINCE

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Abstract. A region-wide sampling survey was conducted in 1995 in order to evaluate the current epidemiological status of schistosomiasis japonica in Hunan Province, China. A total of 45,590 humans and 3,726 domestic animals, from 52 villages, were examined parasitologically and/or serologically for current *Schistosoma japonicum* infections. In uncontrolled endemic areas (43 villages) the overall human prevalence of *S. japonicum* was 7.81% across the different geographical subtypes. The geometric mean intensity of infection was 17.71 eggs per gram (epg) among infected individuals and only 1.25 epg in the general population. The bovine prevalence, as determined by the hatching test, was 9.63% in the uncontrolled endemic villages. Only one sero-positive (by indirect hemagglutination assay) child was found among 1,072 children tested aged 10-14 years in the 9 endemic villages under effective control. No infection was confirmed by the Kato-Katz thick smear stool examination. When the results of this survey were compared to those seen at baseline (1989) an overall reduction of 45.65% was seen in the human prevalence but no significant change was apparent in the lake-beach ecotype. Additionally, there was more than a 60% reduction in the prevalence among bovines over the same sampling period. The results demonstrate that the World Bank Loan Schistosomiasis Program was successful in achieving its most basic objectives for this province - to reduce human and bovine infections by 40%.

INTRODUCTION

During the 1980s the Chinese economy underwent a rapid market-oriented economic reform thus funds were severely limited for schistosomiasis control programs at the national level. As a direct result the human prevalence in the remaining five endemic provinces (Jiangsu, Anhui, Hubei, Jiangxi and Hunan) surrounding the Dongting and Poyang lakes increased from 3.00% in 1983 to 6.69% in 1989. Likewise, the occurrence of acute infections (*ie* hepatosplenomegaly, Katayama fever etc) increased from 4,996 cases in 1983 to 13,191 cases in 1989 (MOPH, 1992; Ross *et al*, 1998a). This demonstrated an ever worsening endemic situation in the remaining provinces and a need for immediate intervention and assistance. It is for this reason the World Bank became actively involved in 1991 at the national level with the schistosomiasis control program in China initially for a five year period but later extending for an additional three years (till 1998).

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The World Bank committed a 71 million US dollar loan (with a complementary 82 million US dollars from the PRC government) to China for schistosomiasis control (Ross *et al*, 1997a). Thus, it became an integral part of the national control program with an overall aim of reducing and controlling morbidity and interrupting the transmission of the organism in all known endemic foci. The specific objectives were: to reduce the infection of humans and bovines (cattle and water buffalos) by 40%, to reduce the natural infection rates of snails and to lower the infected snail density by 50-60% (MOPH, 1992). This ambitious task relied primarily on two approaches. The first involves large-scale chemotherapy for both humans and bovines using praziquantel and the other involves selective treatment of humans and snail control with molluscicide and/or environment modification (Gao *et al*, 1994).

From 1956 to 1980 the central schistosomiasis control program in Hunan Province focused on snail hosts with only limited success. By 1989, after a decade of declining community and national support, the disease was resurgent with increasing numbers of chronic cases and outbreaks of acute schistosomiasis even in Yueyang city (Ross *et al*, 1998b). In 1989, a region-wide sampling survey was carried out on schistosomiasis before the full implementa-

tion of the World Bank Loan Control Program within the province. Findings from this survey revealed that the overall prevalence in the uncontrolled endemic area was 14.37% for humans and 17.57% for bovines (Su *et al*, 1993). An enhanced schistosomiasis control campaign supported by a World Bank Loan was initiated in 1991 in the province. A sum of US$16.70 million was allocated by the World Bank for the control efforts in the province together with a counterpart funding of US$16.74 million from the local governments. In order to highlight the progress made since the initiation of the control program and to plan for future post World Bank activities a follow-up region-wide survey was conducted in 1995 using the same sampling procedures that were utilized earlier. The results of this provincial survey are discussed and compared with those obtained in 1989.

MATERIALS AND METHODS

Target population and endemic areas

All the residents living within the schistosomiasis endemic area were considered as potential candidates in the sampling survey. Endemic villages were first categorized as either uncontrolled or controlled endemic areas for schistosomiasis. In order to be classified as a controlled area a village must have an overall prevalence of less than 1%, an absence of acute infections, no new reported cases in children under 12 years of age, and an infected snail density lower than 0.0001/0.11 m^2 (Zheng, 1996). If an endemic village did not meet all of these criteria it was considered an uncontrolled area in the study.

Uncontrolled endemic areas were further subdivided into four major subtypes: lake-fork, lake-beach, lake-embankment and inside-embankment according to their local endemic situation and ecological characteristics. In the "lake-fork" area residents are living along the smaller lake forks that connect to the lake or disconnect with the main lake by dams. In the latter situation the water level of the fork is not affected by that of the main lake which is beneficial for snail control. In the "lake-beach" area residents are living on islets or highlands on the lake where the snail density and risk of infection is high. In "lake-embankment" areas residential quarters are distributed along a huge embankment circle that separates the lake from farmland. Outside the embankment is a vast area of lake water and beach where snails breed. Finally, in the "inside-embankment" area people are living far away from embankment but limited snails are scattered around the residential quarters.

Sampling technique and study population

A stratified randomized cluster sampling technique was employed for data collection in the survey in the uncontrolled endemic areas with villages serving as the unit of cluster. Sample sizes were determined as approximately 1% of the total target population then the number of villages (clusters) were determined for each stratum (endemic subtypes). Study villages were then randomly selected from among the villages of each stratum. For each cluster there were usually 1,000-1,500 residents. If the number in the sampled cluster was less than 1,000 a neighboring village was surveyed and treated as a single unit. All the residents aged 3-60 and domestic animals in the sample villages were surveyed in the study.

In the endemic areas under effective control, two villages were selected from each county for the survey. All young children aged 10-14 in the sampled villages were subjects for the study. Informed consent was obtained from village leaders in each of the sampled villages. Ethical clearance for the study was obtained at both the provincial and county levels.

Schistosome infection survey

In the uncontrolled villages all the human subjects were asked to submit a fresh stool specimen. Nylon tissue bag concentrations and miracidium hatching techniques were performed first (MOPH manual, 1993). Observations were made every four hours for up to 24 hours in order to detect the appearance of miracidia. Those positive for hatching were subsequently asked to submit follow-up specimens for Kato-Katz thick smear stool egg quantification (MOPH manual, 1993). Two slides were prepared from each specimen per person. The eggs per gram of feces (epg) were calculated by multiplying the total number of eggs appearing on the two slides by 12. One drop of blood was obtained from each subject within the endemic villages under effective control for indirect hemagglutination assay (IHA) (MOPH manual, 1993). Those IHA positives were asked to submit follow-up stool specimens for Kato-Katz examination. If there are more than 100 head of pigs in a sampled village, 100 head of pigs, together with all of the bovines and available goats in the village within the uncontrolled areas were subjected to a miracidium hatching test.

Medical survey and physical examination

Physical examinations were performed on 30% of the subjects randomly selected from the study population in the uncontrolled endemic areas. Medical histories and physical examinations were carried by two experienced physicians and a nurse from the local anti-schistosomiasis station. Some of the questions asked on the medical history questionnaire were: the frequency of bowel movement, appearance of bloody stool in the past 24 hours and in the past two weeks, treatment history, date of the latest treatment etc. Liver and spleens were palpated in the supine position. The size and tenderness of the liver along the mid-clavicular line (MCL) and the mid-sternal line (MSL) were recorded. Spleen size was classified according to Hackett's gradation (I-III) (Hackett, 1944).

Data analysis

The data were checked for consistency and accuracy and encoded prior to entry. Chinese Foxbase version 4.0 was used for data entry and the Statistical Program for the Social Sciences version 7.5 was used for statistical analysis. To evaluate the statistical significance of differences between frequencies, the Mantel-Haenszel Chi-squared test was used. Analysis using linear regression was used to evaluate the relationship between liver size and fecal egg counts in the different age groups.

RESULTS

Sampling and surveyed subjects

A total of 52 villages were selected for this survey of which 43 were classified as uncontrolled endemic areas and nine as controlled. The total number of subjects residing in the uncontrolled areas was 46,791 accounting for 1.38% of the entire population. 44,518 subjects received parasitological examination with a coverage rate of 95.14%. The mean age of the subjects was 29.1 years and the sex ratio was 54% in the favor of males. According to the 1995 registration list there were 127,865 bovines in the uncontrolled areas. In the nine villages under effective control 1,072 human subjects aged 10-14 were examined.

Prevalence and intensity of schistosome infection in 1995

Both the prevalence and intensity of infection increased with age until it reached a peak in the 40-49 year old age group and declined thereafter. The overall human prevalence of *S. japonicum* infection in the uncontrolled endemic villages as determined by the miracidium hatching technique was 7.81% (95% CI = 7.59-8.09%). In the villages under effective control 1,072 individuals were examined by IHA only one individual was positive (0.09%) but no stool eggs were seen by the Kato-Katz method. The prevalence in the four geographical subtypes varied significantly from each other ($p = 0.001$). The lake-beach subtype had the highest prevalence (22.51%), followed by lake-fork (11.22%), lake-embankment (9.22%) and inside-embankment areas (2.47%). The mean intensity of infection (EPG) of the population strongly correlated ($r_s = 0.98$; $p = 0.02$) with the prevalence in the corresponding geographical subtypes. However, the intensity profile among infected individuals was highest in the inside-embankment subtype (GM = 36.65 epg), and this was followed by lake-embankment (GM = 24.73 epg), lake-beach (GM = 11.05 epg) and lake-fork (GM = 8.95 epg). A higher proportion of moderate to heavily infected individuals (>100 epg) were observed in the lake-beach and lake-embankment areas. Furthermore, higher proportions of zero egg counts were seen in the inside-embankment and lake-fork subtypes (Table 1). In all four geographical subtypes males had a higher prevalence of active schistosomiasis infections than their female counterparts. An overall prevalence ratio (PR_{MH}) of 1.89

Table 1
Prevalence and intensity of schistosome infection in the uncontrolled endemic areas of Hunan as of 1995.

Ecological subtype	N	n	No. positive	Percent positive	EPG* population	EPG* infected	GM egg intensity (%)			
							0	1-99	100-399	>399
Lake-fork	145,449	5,180	581	11.22	1.28	8.95	93.01	6.74	0.19	0.06
Lake-beach	17,660	4,172	939	22.51	1.76	11.05	84.47	13.66	1.56	0.31
Lake-embankment	1,892,831	16,180	1,492	9.22	1.34	24.73	92.4	5.67	1.64	0.29
Inside-embankment	1,333,392	18,986	469	2.47	1.09	36.65	97.7	1.66	0.63	0
Total	3,389,332	44,518	3,481	7.81	1.25	17.71	93.99	4.84	1.03	0.14

*Geometric log output based on the results from Kato-Katz thick smear stool examination.

(95% CI = 1.77-2.02) in the direction of males was observed. It should be noted that the intensity of infection did not vary significantly between the sexes. Finally, upon closer examination of the major occupational profiles fishermen and boatmen had the highest prevalence of infection followed by government staff, farmers and school children. Boatmen and farmers had the highest GM intensity of infections (Fig 1).

Schistosomiasis morbidity

The prevalence of clinical symptoms associated with schistosomiasis (*ie* >3 spells of diarrhea in one day and bloody stools) were all significantly higher in the lake-beach geographical subtype when compared with the other endemic zones. Liver enlargement, especially of the left lobe, is rather common in the lake-beach (29.47%) and lake-embankment (28.90%) subtypes (Fig 2). Splenomegaly occurs less commonly (0.58%) in the lake-beach endemic area, while similar proportions were seen in the other three subtypes (2.37-2.96%). All of the symptoms and signs related to schistosome morbidity as well as one's history of past schistosome infection were positively correlated (r= 0.36; p= 0.0001) with current infection. Residents with schistosome infections are more likely to have diarrhea, bloody defecation, liver enlargement and spleen enlargement than the general population.

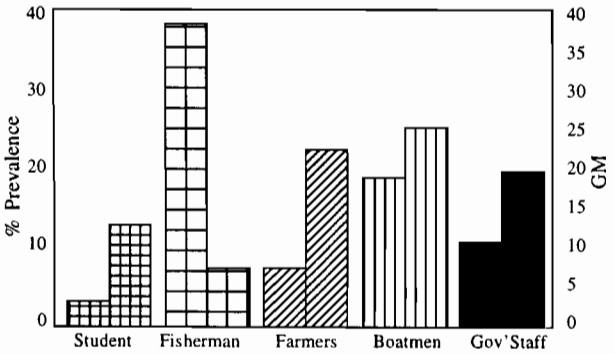

Fig 1–Prevalence (first coulumn) and GM (geometric mean log egg intensity) (second column) of *S. japonicum* grouped by occupation in the surveyed villages.

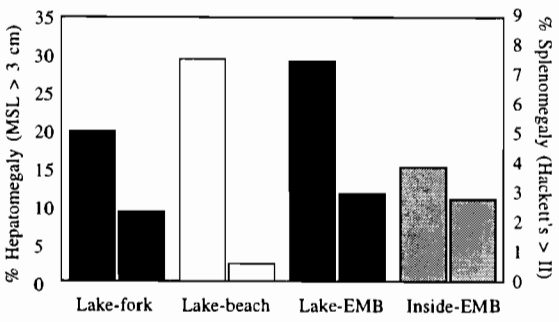

Fig 2–Hepatomegaly (>3 cm along the mid-sternal line; first column) and splenomegaly (Hackett's gradation >II; second column) grouped according to geographical subtype within the uncontrolled endemic areas. EMB = embankment.

Schistosome infections and animals

Only four species of domestic animals (*ie* cattle, water buffalos, pigs and goats) were surveyed in this study because of their importance in the transmission of *S. japonicum* and their numbers within the region. Water buffalos had the highest prevalence of schistosome infection (9.86%) and this was significantly higher (p= 0.001) than that of pigs (0.43%) but not significantly different (p=0.22) to that of cattle (5.55%). No comparison could be made with infected goats (56.25%) due to the small sample size (n=16) obtained. Finally, the highest observed prevalence for pigs and buffalos was seen in the lake-beach geographical subtype (Table 2). It is noteworthy that cattle were not examined in the lake-fork and lake-beach endemic areas as they are no longer raised in these areas due to the high intensity of transmission while they are more susceptible to the infection than water buffalos.

Trends in schistosome infection - 1989 *vs* 1995

The overall reduction in human prevalence was 45.65% in the uncontrolled endemic areas over the past five intervening years (Table 3). A significant reduction in schistosome infections within the uncontrolled endemic areas were evident among the inhabitants residing in the various geographical subtypes except the lake beach zone. Reduction were in the order of 8.08% in the lake-beaches, 24.75% in the lake-forks, 38.98% in the lake-embankments and 73.92% in the inside-embankment subtype respectively.

Significant reductions in animal schistosome infections, as determined by the stool egg hatching technique, were also observed between the two surveys. The overall schistosomiasis prevalence in both bovines and pigs dropped more than 40% in 1995 when compared with the retrospective data obtained in 1989 (statistically significant at p< 0.01). The biggest reduction (92.88%) was observed in pigs, followed by cattle (87.39%) and water buffaloes (41.79%). No significant change in prevalence was observed for water buffalos in the lake-beach

Table 2
Prevalence of schistosomiasis infection among domestic animals. Results from the 1989 and the 1995 provincial surveys.

Animal	Year	Lake-fork		Lake-beach		Lake-embankment		Inside-embankment		Total	
		n	%POS	n	%POS	n	%POS	n	%POS	n	%POS
Cattle	1989	0	0	0	0	28	71.42	22	9.09	50	44
	1995	0	0	0	0	55	7.27	17	0	72	5.55*
Buffalo	1989	121	13.22	10	60	1,495	20	487	7.59	2,113	16.94
	1995	111	14.11	157	52.23	836	8.73	827	2.18	1,913	9.86*
Pigs	1989	300	6	0	0	1,156	7.09	200	0	1,656	6.04
	1995	200	2	0	0	486	0.62	931	0	1,617	0.43*
Goats	1989	0	0	0	0	17	88.24	0	0	17	88.24
	1995	0	0	16	56.25	0	0	0	0	16	56.25

*Denotes a significant difference at $p < 0.01$ when compared with the results of 1989.

Table 3
Prevalence of schistosomiasis infection among humans. Results from the 1989 and 1995 provincial survey.

Ecological subtype	1989 survey		1995 survey		Percent reduction	p-value
	n	%POS	n	%POS		
lake-fork	4,126	14.91	5,180	11.22	24.75	< 0.0001
Lake-beach	2,005	24.49	4,172	22.51	8.08	0.084
Lake-embankment	23,924	15.11	16,180	9.22	38.98	< 0.0001
Inside-embankment	8,193	9.47	18,986	2.47	73.92	< 0.0001
Total	38,248	14.37	44,518	7.81	45.65	< 0.0001

and lake-fork subtypes. It should be noted that no pig infections were seen in the inside-embankment area during the two surveys. As mentioned above, no comparison could be made with infected goats due to the small sample size obtained from different geographical zones.

DISCUSSION

The national schistosomiasis control program in China during the eight year period of World Bank Loan support has made substantial gains in controlling this disease. On the national level the prevalence of both humans and domestic animals (*ie* bovines) was reduced by 47.19% and 49.89% respectively. This accomplishment not only reversed the worsening endemic situation of the late 1980s in terms of incidence but it also significantly reduced the morbidity attributable to schistosomiasis infections in China (Ross *et al*, 1998b). The results presented here from Hunan Province have confirmed this achievement. Surveillance data from the Dongting Lake region indicates that the overall snail infection rate and density of infected snails in 1997 were lowered by 27.02% and 90.91% respectively (Zhou *et al*, 1998). As a result, it is safe to conclude that the World Bank Loan schistosomiasis control program was successful in reaching its most basic objectives in Hunan.

The 1995 survey in Hunan Province has shown that schistosomiasis japonica remains low to moderately endemic in some foci even after intensive control efforts during this period of support. However, the prevalence and the level of morbidity remains high in the lake-beach geographical subtype where the ecological environment favors snail breeding and the spread of disease. In the vast lake-embankment area the endemicity remains at a relatively high level with approximately 10% of the exposed population infected. The residents in this locality live along the 6,406 km embankment which divides the residential quarters from the lake-beaches where most of the infections occur. The lake-fork area has a low to moderate prevalence but repre-

sents only a small portion of the population and endemic foci. However, the environment favors snail control so it would be possible to interrupt or even eradicate transmission if intense molluscicide and environmental modification were undertaken at the county level. Both the prevalence and morbidity were lowest in the inside-embankment area because residents are living far away from the snail-infested beaches, so that exposure is greatly reduced.

Unlike the other three schistosome species known to affect man, *S. japonicum* is a true zoonosis acting as natural parasite on humans and 45 species of mammals. Hence, mammals play an important role in maintaining the parasite and transmitting the disease within China. In some areas domestic animals, especially water buffalos, serve as the main reservoir of infection (Wu *et al*, 1993). Cattle are known to be more susceptible to schistosome infection than water buffalos but the latter are the predominant farm power animal and greatly outnumber farm cattle. It is noteworthy that in this survey the prevalence of infection between the two did not vary significantly. Additionally, buffalos are far more important as a transmission source due the sheer quantity of their feces and egg production. Pigs are important reservoirs for schistosome infection in some specific localities but overall their prevalence is generally low due to reduced exposure (*ie* living confines) and relatively short life span.

There now remains a great challenge to consolidate and maintain the current achievements attained primarily through repeated mass chemotherapy with praziquantel. Firstly, there is a need for uninterrupted chemotherapy during the transmission periods in most of the areas where the risk of infection remains moderately high (about 15%). However, with the expected reduction in resources for control purposes (*ie* the end of the World Bank loan in 1998) this will indeed pose a great challenge. Secondly, compliance to treatment will undoubtedly decrease due to fatigue after frequent participation in surveys and annual screening programs. As a result, further improvements in the treatment coverage will be difficult at the community level. Thirdly, the mobility of the rural population is increasing as the market-oriented economy continues to develop at an exponential rate thus, for example, supplying chemotherapy to the ever increasing number of migrant boatmen in the lake region will be difficult (Wu *et al*, 1993). Finally, long term annual mass chemotherapy may change the concomitant immunity profile of the elder population therefore increasing susceptibility to re-infection (Zhang *et al*, 1998). Furthermore, there is some evidence of praziquantel resistance in the other schistosome species but this has yet been observed in China (Ismail *et al*, 1996).

There is, however, still hope for the future for schistosomiasis control programs within China in the coming decades. Praziquantel is still the drug of choice and is proven to be an effective, safe and affordable prophylactive in controlling and preventing the spread of this disease. Enhanced health education programs that were sponsored by the World Bank within the endemic areas have greatly improved awareness of the schistosomiasis lifecycle which will surely ease the control work efforts in the long run. Continuous improvements in the socio-economic status of farmers may help revolutionize outdated agricultural modes of production thus ultimately replacing water buffalos with mechanized machinery. If this were to occur this would eliminate a major reservoir of human infection. Many studies are now being conducted in the search for a bovine and human vaccine against Asian schistosomiasis but to date no promising candidates have been announced, thus Chinese ingenuity will once again be tested severely, at least in the short term.

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