

Schistosomiasis control in China: the impact of a 10-year World Bank Loan Project (1992–2001)

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Abstract China has been carrying out large-scale schistosomiasis control since the mid-1950s, but in the early 1990s, schistosomiasis was still endemic in eight provinces. A World Bank Loan Project enabled further significant progress to be made during the period 1992–2001. The control strategy was focused on the large-scale use of chemotherapy — primarily to reinforce morbidity control — while at the same time acting on transmission with the ultimate goal of interrupting it. Chemotherapy was complemented by health education, chemical control of snails and environmental modification where appropriate. A final evaluation in 2002 showed that infection rates in humans and livestock had decreased by 55% and 50%, respectively. The number of acute infections and of individuals with advanced disease had also significantly decreased. Although snail infection rates continued to fluctuate at a low level, the densities of infected snails had decreased by more than 75% in all endemic areas. The original objectives of the China World Bank Loan Project for schistosomiasis control had all been met. One province, Zhejiang, had already fulfilled the criteria for elimination of schistosomiasis by 1995. The project was therefore a success and has provided China with a sound basis for further control.

Keywords Schistosomiasis japonica/epidemiology/drug therapy/prevention and control; Program evaluation; World Bank; China (source: MeSH, NLM).

Mots clés Schistosomiase artérioveineuse/épidémiologie/chimiothérapie/prévention et contrôle; Evaluation programme; Banque Mondiale; Chine (source: MeSH, INSERM).

Palabras clave Esquistosomiasis japónica/epidemiología/quimioterapia/prevenición y control; Evaluación de programas; Banco Mundial; China (fuente: DeCS, BIREME).

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Voir page 47 le résumé en français. En la página 47 figura un resumen en español.

يمكن الاطلاع على الملخص بالعربية في صفحة 48.

Introduction

Schistosomiasis caused by *Schistosoma japonicum* has long been a major public health problem in China. Sustained control efforts had reduced the number of infected people from 11.8 million in the 1950s (1) to 1.6 million in 1989 (2). Four out of 12 provinces had eliminated schistosomiasis by that year, but the disease was still endemic in 240 counties in eight provinces, and 44 million people were estimated to be at risk. *Oncomelania* snails were still present in numerous areas covering a total of 3.6 billion m², and the animal reservoir of *S. japonicum* — thought to play a major role in transmission — was still considerable. Approximately 0.2 million cattle and buffaloes were estimated to harbour the infection. Schistosomiasis control therefore faced a serious challenge at the end of the 20th century. There was

a consistent gap between the available funding and the financial resources required to make further progress. In response to this situation, the Chinese Government obtained a long-term World Bank loan to boost schistosomiasis control.

The objective of The World Bank Loan Project (WBLP) for schistosomiasis control was to boost morbidity control according to the strategy recommended by the WHO (3, 4), while, at the same time acting on transmission with the ultimate goal of interrupting it. The main control tool was large-scale chemotherapy; this was complemented by health education, chemical control of snails and environmental modification where appropriate. The specific operational targets set were as follows:

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- to reduce the prevalence of infection in humans by 40%;
- to reduce the prevalence of infection in cattle and buffaloes by 40%; and
- to reduce the snail infection rate and the density of infected snails by at least 50%.

Materials and methods

The project area covered eight provinces containing 219 counties in which schistosomiasis was still endemic in 1992. Three operational strata were defined on the basis of disease prevalence in humans as recorded during a nationwide epidemiological survey conducted in 1989 (2), and different control strategies were applied in each of these strata. Large-scale chemotherapy was the main control tool used to reinforce morbidity control in areas of high endemicity (i.e. prevalence >15%) and medium endemicity (i.e. prevalence between 3% and 15%), whereas in areas of low endemicity (i.e. prevalence < 3%) the transmission control component was reinforced by environmental management. The technical approaches are described below.

Chemotherapy in human populations

In areas of high endemicity, all individuals between 6 and 60 years old were given yearly treatment. In areas of medium endemicity, half of the residents were screened by examination of a stool examination (using the Kato–Katz technique) or a serological test (enzyme-linked immunosorbent assay (ELISA), circumoval precipitin test or indirect haemagglutination test) every year (i.e. each person was tested every other year) and those with positive results were treated. In areas of low endemicity, all 7–14-year-old children were screened in the same way as in areas of medium endemicity every other year and treated if their results were positive. The treatment in all areas consisted of a single dose of praziquantel, at a dosage of 40mg/kg body weight.

Chemotherapy in livestock

In areas of high endemicity, all cattle and buffaloes were treated once a year without preliminary screening. In areas of medium endemicity, approximately one-third of cattle and buffaloes were treated once a year, primarily those that had been pastured on areas with transmission potential. In areas of low endemicity, cattle and buffaloes imported from other provinces in which schistosomiasis was endemic and those under 2 years of age pastured on snail-infested land were examined and treated with praziquantel if infected.

Snail surveillance and control

In areas of high endemicity of schistosomiasis, random snail surveys were carried out in approximately 40% of the snail infested areas each year. Mollusciciding with niclosamide, at a concentration of 2 ppm by immersion or 2 g/m² when sprayed, was carried out in areas where infected snails were found. In areas of medium endemicity, yearly snail surveys were carried out around villages and in half of the areas with high transmission potential. Wherever infected snails were found, molluscicide treatment was carried out. In areas of low endemicity, 50% of the snail habitats were surveyed annually and areas with infected snails treated with niclosamide. Chemical molluscicide treatment in all the above-mentioned localities was generally done annually. Environmental modification was primarily carried out in areas of low endemicity with the aim of permanently interrupting transmission. Environmental modifications included the digging of new ditches and filling of old

ones, lining of irrigation canals with concrete, and the alteration of sluice gates to prevent snails from spreading into other sections of an irrigation system (e.g. by adding a sedimentation pool) (1).

Health education

Healthy behaviours were encouraged through health education. The tools used included comic-style booklets, radio and television spots and other innovative techniques. By the end of the WBLP, more than 80% of residents in areas in which schistosomiasis was endemic were expected to understand the aim of schistosomiasis control; more than 70% of the target population were expected to modify their behaviour, reduce contact with infested water or adopt preventive measures (such as the use of repellents or the impregnation of clothes with niclosamide) if contact with infested water was inevitable; and more than 90% of the target population were expected to fully cooperate with anti-schistosomiasis professionals in the screening and/or treatment activities.

Disease surveillance

To monitor epidemiological changes and trends during implementation of the programme, a system was set up in which 3% of villages in areas with high endemicity were randomly selected as surveillance sites every year, and 1% of villages in areas with medium and low endemicity. On the basis of the surveillance data collected (on humans, livestock and snails), the level of endemicity in the villages was regularly reclassified (every 1–2 years), and the control strategy adapted accordingly. Once a township (including from several to 20 villages) had reached a low level of endemicity, it was also regularly evaluated against a different set of criteria, aimed at determining whether it had reached the stage of “transmission control” or “transmission interruption” (1, 5). Monitoring of the implementation process was also part of the surveillance system.

Training and operational research

Regular training courses were provided for schistosomiasis control staff and programme managers to improve their technical and management skills. Operational research was guided by a joint research management committee (JRMC), involving both Chinese and foreign experts. The responsibilities of the JRMC were to define the priorities for operational research, to gradually increase the research capacity of Chinese professionals working in schistosomiasis control, to check the quality of research proposals and approve funding for them, and to monitor progress in research (6).

Results

The total investment in schistosomiasis control by the WBLP has been 890 million RMB yuan (approximately US\$ 152 million), of which 416 million RMB yuan (US\$ 71 million) was a loan provided by The World Bank and 474 million RMB yuan (US\$ 81 million) came from counterpart funds provided by the Chinese Government. The WBLP started in eight provinces in 1992, was finalized in five of them (Anhui, Jiangsu, Jiangxi, Sichuan and Zhejiang) at the end of 1998, and continued until the end of 2001 in the three remaining provinces (Hubei, Hunan and Yunnan). However, the five provinces that completed the project in 1998 continued to carry out schistosomiasis control with their own funds according to the operational plan set out by the WBLP.

Table 1. The World Bank Loan Project for schistosomiasis in China: operational indicators 1992–98

Indicator	Year		Reduction rate (%)
	1992	1998	
No. of infected people	1 733 981	874 515	49.57
% of positive results of faecal examination	6.93	3.14	54.69
No. of infected cattle + buffaloes	104 764	47 115	55.03
% of positive results of faecal examination	6.38	3.17	50.31
Density of infected snails (no. per 0.1 m²) in areas of:			
High endemicity	0.0078	0.0019	75.64
Medium endemicity	0.0060	0.0006	90.00
Low endemicity	0.0008	0.0001	87.50

During the 10-year implementation period of the WBLP, more than 63 million people were screened, and almost 19 million treatments were given, both in mass chemotherapy and selective treatment campaigns. A total of 1.7 million cattle and buffaloes were screened and those infected were treated with praziquantel. An additional 2.2 million animals received mass chemotherapy. In 1998, when the WBLP came to an end in five of the eight provinces, the number of infected people in China had been reduced by 50% from 1.7 million (in 1992) to 874 500 (Table 1). This number had further decreased to 828 000 in 2001. The average number of patients diagnosed per year with acute schistosomiasis decreased from 6386 during the period 1989–91, to 1093 cases during the period 1996–2000, despite severe floods in 1998–99. In 2001, only 573 acute cases were reported (7). The number of patients with advanced hepatosplenic disease decreased from 55 000 in 1989 to 25 664 in 2001, a decrease of 53.3% (7). All other operational targets appeared also to have been reached in 2001: the percentage of humans who had positive results of stool examination had decreased by 55%, the number of infected cattle and buffaloes by 55% and the percentage of animals with positive results of stool examination by 50%. The density of infected snails in areas of high, medium and low endemicity had decreased by 76%, 90% and 87.5%, respectively (Table 1).

Although the density of infected snails had substantially decreased, the total area of snail habitats fluctuated during the period 1992–98, from 3.3 billion m² to 3.5 billion m² (8). In 2000, the percentage of humans and animals with positive results of faecal examination had increased to 4.15% and 3.36%, respectively, following the 1998–99 floods (9).

Approximately 9.6 billion m² of snail habitats were regularly surveyed and snail control was carried out on an area of 3.9 billion m². Environmental modification projects were carried out on 1.1 billion m², and the remaining area (2.8 billion m²) was regularly treated with molluscicide. Between 1996 and 2001, a total of 1167 projects for environmental modification (at an estimated cost of between 50 000 and 200 000 RMB yuan each) were carried out. A health education network was established. Various types of video and broadcasting material, information pamphlets, posters, slogans and textbooks were developed and distributed during the project period. The coverage rate for health education in the field of schistosomiasis control was very high in school-age children. In villagers living in areas where the disease was endemic, knowledge about schistosomiasis increased, resulting in decreased contact with

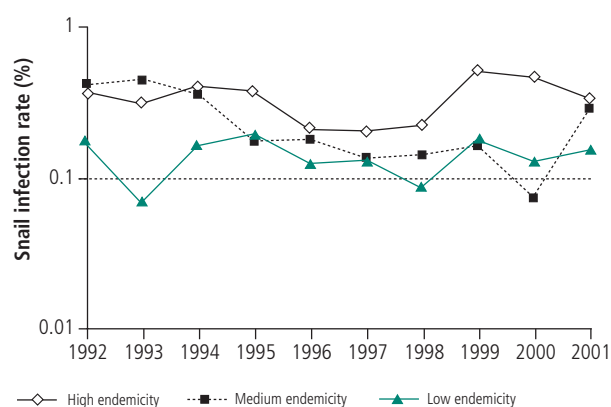
infested water and increased individual protection when contact with infested water was unavoidable. As a result of health education, the adherence rate for screening and treatment activities approached 90%.

In a total of 3669 villages under surveillance, 1 445 800 people and 154 907 cattle and buffaloes were randomly screened, and of those screened 62 978 people (4.3%) and 6439 animals (4.1%) were found to be infected. A total of 6 720 075 quadrats (0.1 m² each) of land potentially inhabited by snails were surveyed. A total of 3 669 720 snails were collected and dissected, and 9637 (0.26%) were found to be infected. Snail infection rates remained below 0.76% over the whole duration of the project, with slight year-to-year fluctuations, presumably reflecting the varying intensity of yearly flooding or due to sampling variation (Fig. 1). The density of infected snails decreased sharply in areas of high and medium endemicity during the first 5 years of implementation of the control programme, and was thereafter maintained at a level below 0.003/0.1 m² (Fig. 2).

The number of villages and people in the three epidemiological strata, as well as the average prevalence of schistosomiasis in each stratum, changed substantially over the project period, with a gradual shift towards a lower level of endemicity (Table 2). Villages with a high level of endemicity were only reclassified as “medium” once the transmission was judged to have permanently decreased.

Out of a total of 409 endemic counties in the 1950s, 238 had reached the criteria of transmission interruption, 56 the criteria of transmission control, and 115 were still considered

Fig. 1. Changes in snail infection rate in the three strata between 1992 and 2001



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to be endemic in 1999 (10). During the period of the WBLP (1992–2001), out of a total of over 200 countries initially involved, 47 had met the criteria of transmission control and 82 had met the criteria of transmission interruption. Zhejiang Province had reached the target of elimination in 1995 (5). Although substantial progress in transmission control was made during the WBLP period, the potential for transmission remains considerable in counties around the Dongting and Poyang Lakes, in the Yangtze River Basin, and in some mountainous areas in the provinces of Sichuan and Yunnan (10).

Professional training courses were held on topics such as epidemiology, control strategies, health economics, social medicine and communication strategies, immunology and immunodiagnosis, and improving computer skills. Between 1992 and 2001, 7 160 501 trainees participated in such courses. In order to improve the capacity of young researchers to carry out operational research and develop research proposals, special training was also provided in study design and research methodology.

Over 37 million RMB yuan (about US\$ 5.3 million) has been provided for operational research by the JRMC, complemented by 21 million RMB yuan (about US\$ 3 million) in counterpart funds provided by the provinces taking part in the project. From 1992 to 1998, more than 800 research proposals were submitted to the JRMC, of which 245 were granted funding and provided valuable information for improving control activities. Particular achievements were made in the field of fast and easy diagnostic techniques, and the development of prophylactic drugs (artemether and artesunate) against schistosomiasis. A total of 1083 papers were published in scientific journals.

All of the project data were collected in the peripheral project offices, and systematically aggregated both at the district and provincial level. A computerized information management system was set up from the central level down to the provinces.

Discussion

The 10-year China WBLP for schistosomiasis control was a success. The large-scale use of chemotherapy has facilitated morbidity control in humans (3, 4, 11). The number of cases of acute schistosomiasis and of hepatosplenic disease — good indicators for the prevailing morbidity due to schistosomiasis — have all substantially decreased. Moreover, it is believed that the systematic treatment of livestock has substantially contributed to the reduction of transmission. The relative contamination index in cattle and water buffaloes may be as high as 70–90% in China (12).

The targets set at the beginning of the WBLP have been reached or exceeded. The estimated number of people infected with schistosomiasis had decreased by over 50% by the end of 2001. The prevalence in humans and livestock had also decreased by over 50%. Although the snail infection rates have continued to fluctuate at a low level, the densities of infected snails in the different epidemiological strata had all decreased by more than 75% by the end of the project. One province that took part in the project, Zhejiang Province, was able to fulfil the national criteria for schistosomiasis elimination during the course of the project. Furthermore, many counties have fulfilled the criteria for interruption of transmission.

The achievements were severely challenged by two successive years of heavy flooding (1998–99) in the Yangtze River basin. However, although some impact on schistosomiasis was noted, it was quite limited.

Fig. 2. Changes in the density of infected snails from 1992 to 2001

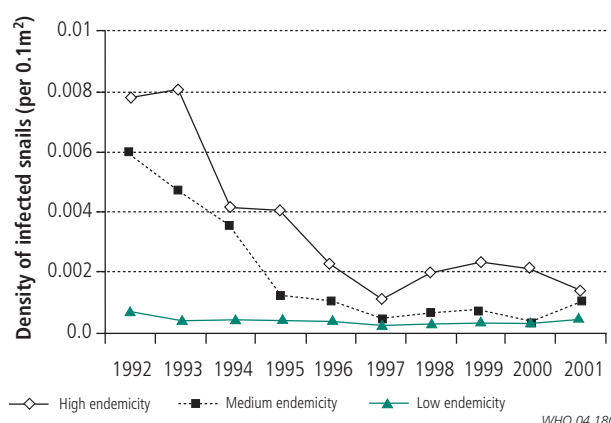


Table 2. Population data and human infection rates in the different epidemiological strata 1992–98

Year	1992			1998		
	High	Medium	Low	High	Medium	Low
No. of villages	4058	9519	26834	2552	6759	30850
Population (millions)	2.656	9.806	32.306	1.520	7.391	44.584
Infection rate (%)	17.06	6.51	1.23	8.52	3.42	0.64

The achievements of the WBLP are not limited to an improvement in epidemiological indicators of schistosomiasis. The capacity of project managers and scientific institutions has also been strengthened, and the technical expertise of the professionals involved has been improved.

Although a sound basis for schistosomiasis control has been laid, the disease is far from being eliminated in China. Considerable transmission of schistosomiasis persists in the five provinces situated around the Yangtze River Basin and its lakes, as well as in two mountainous provinces. Difficulties in stabilizing the water level in the Yangtze River Basin, the complicated environmental topography of the mountainous areas, and the lack of economic development in some of the remaining areas of endemicity, all contribute to the continuing challenge of schistosomiasis control. Because of the mobility of populations and the frequent trade of livestock, some fluctuation in the prevalence of schistosomiasis is to be expected. During the WBLP period, large-scale use of chemotherapy kept the prevalence and incidence low. However, since the end of the WBLP, the funding for schistosomiasis control has been reduced. With less funds, it will be difficult to make further progress in the control of schistosomiasis in China. Furthermore, as the project paid limited attention to control of the *Oncomelania* snail, the environment for its transmission has not been changed substantially. A schistosomiasis control programme mainly based on chemotherapy with health education can certainly reduce prevalence and morbidity, but the control effect cannot be sustained. This has been seen following the control projects in Brazil and in the Lao People's Democratic Republic. In Brazil,

the use of chemotherapy had greatly reduced morbidity due to *S. mansoni* infection from 1977 to 1994, and in the Lao People's Democratic Republic, the prevalence of *S. mekongi* decreased sharply after repeated chemotherapy with praziquantel in the Khong District, i.e. from 40% in 1989 to only 1% in 1997 (13). However, as the chemotherapy campaign has been relaxed, prevalence has increased again in both Brazil and the Lao People's Democratic Republic.

For the sustainable control of schistosomiasis, the experiences of China and Japan indicate that at the same time as other control approaches are used, the control of the intermediate host snail (mainly with environmental modification complemented with molluscicide treatment) should be given priority (1, 14). China's experience in elimination of schistosomiasis in large areas in five provinces with sustainable effect during the past half decade has repeatedly confirmed this. However, this important point was not sufficiently addressed in the planning and execution of the WBLP. This is a lesson that should be taken into account. It has been noted that since the end of the WBLP, as the commitment to schistosomiasis control has weakened, the prevalence (especially the number of acute infections) had increased again in 2003 (unpublished data from

the Chinese Ministry of Health). This is because the basis for the transmission, i.e. the snail habitats, has not been changed greatly through the implementation of the WBLP. The "God of Plague" has slowly returned to China, a cause of great concern for the Government of China, and a new project for sustainable control has been formulated that includes chemotherapy, health education and transmission control. This new project stresses the need for environmental sanitation, mainly focusing on snail control, by reducing large areas of snail habitats in the forthcoming decade. It can be expected that the achievements of the WBLP, China's own wealth of experience on schistosomiasis control, the significant attention paid by the Government combined with the rapid development of China's economy, will ensure a bright future for schistosomiasis control by eliminating the disease from more areas, county by county, and province by province. ■

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Conflicts of interest: none declared.

Résumé

Lutte contre la schistosomiase en Chine : impact du Projet de prêt de la banque mondiale sur 10 ans (1992-2001)

La Chine mène une lutte à grande échelle contre la schistosomiase depuis le milieu des années 50, mais au début des années 90, cette maladie était encore endémique dans huit provinces. Un projet de prêt de la Banque mondiale a permis la réalisation de progrès importants sur la période 1992-2001. La stratégie de lutte contre la maladie était axée sur l'utilisation à grande échelle de la chimiothérapie dans l'objectif principal de maîtriser davantage la morbidité, tout en agissant simultanément sur la transmission dans le but ultime de l'interrompre. La chimiothérapie était complétée par une éducation sanitaire, une lutte chimique contre les escargots et des modifications de l'environnement le cas échéant. Une évaluation finale réalisée en 2002 a montré que les

taux d'infection chez l'homme et les animaux d'élevage avaient diminué respectivement de 55 et 50 %. Le nombre d'infections aiguës et d'individus à un stade avancé de la maladie avait aussi notablement diminué. Bien que les taux de contamination des escargots continuent de fluctuer à un faible niveau, les densités d'escargots infectés ont diminué de plus de 75 % dans l'ensemble des zones d'endémie. Les objectifs de départ du Projet de prêt de la Banque mondiale en faveur de la lutte contre la schistosomiase ont été remplis. Une province, le Zhejiang, était parvenu à satisfaire les critères d'élimination de la schistosomiase dès 1995. Le projet a donc été un succès et a fourni à la Chine une base solide pour poursuivre la lutte.

Resumen

Control de la esquistosomiasis en China: impacto de un Proyecto de préstamo del Banco Mundial a 10 años (1992-2001)

China lleva tomando medidas en gran escala contra la esquistosomiasis desde mediados de los años cincuenta, pero a comienzos de los noventa esa enfermedad era todavía endémica en ocho provincias. Un Proyecto de préstamo del Banco Mundial permitió hacer grandes progresos durante el periodo 1992-2001. La estrategia de control se centró en la administración de antibiototerapia en gran escala -principalmente para reforzar el control de la morbilidad- unida a intervenciones paralelas contra la transmisión, a fin de interrumpirla. Como complemento de la antibiototerapia se adoptaron medidas de educación sanitaria, control químico de los caracoles y modificación ambiental cuando fue necesario. Una evaluación final realizada en 2002 mostró que las tasas de infección en seres humanos y en el ganado habían

disminuido en un 55% y un 50%, respectivamente. El número de infecciones agudas y de individuos con signos de enfermedad avanzada también había disminuido significativamente. Aunque las tasas de infección de los caracoles siguieron fluctuando a niveles bajos, las densidades de caracoles infectados habían disminuido en más de un 75% en todas las zonas endémicas. Todos los objetivos originales del Proyecto de préstamo del Banco Mundial en China para el control de la esquistosomiasis fueron alcanzados. Una provincia, Zhejiang, consiguió cumplir ya en 1995 los criterios de eliminación de la enfermedad. El proyecto fue por tanto un éxito, y ha proporcionado a China una base sólida para aplicar nuevas medidas de control.

ملخص

مكافحة داء البلهارسيا في الصين: أثر مشروع قرض من البنك الدولي لعشر سنوات (1992-2001)

نقص بمقدار 55% فيما نقص معدل العدوى بين حيوانات الماشية بمقدار 50%، كما نقص عدد الحالات الحادة من العدوى والحالات الفردية المتفارقة من المرض نقصاً ملحوظاً. ورغم استمرار معدلات العدوى بين الحلزونات في التماوج في المستوى المنخفض، فإن كثافات الحلزونات المصابة بالعدوى قد نقصت بمقدار يزيد على 75% في جميع المناطق الموطونة. لقد تحققت جميع الأهداف الأصلية لمشروع القرض الذي قدّمه البنك الدولي للصين هو مكافحة داء البلهارسيا، وقد حققت إحدى الولايات وهي ولاية زيجانغ معايير التخلص من داء البلهارسيا عام 1995، لذا فإن المشروع يُعدُّ ناجحاً وقدّم للصين أساساً راسخاً لمزيد من المكافحة.

الملخص: ينفذ في الصين مكافحة لداء البلهارسيا على نطاق واسع منذ منتصف الخمسينيات، ومع ذلك استمر داء البلهارسيا في التوطن في ثمان من الولايات. وقد أتاح مشروع قرض مقدّم من البنك الدولي المزيد من التقدم الملحوظ أثناء الفترة بين 1992 و2001. وقد ركزت استراتيجية المكافحة على استخدام المعالجة الكيميائية على نطاق واسع، وبشكل رئيسي للتأكيد على مكافحة المراضة، مع العمل في الوقت نفسه على مكافحة السراية والحرص على تحقيق الهدف النهائي بقطعها، وقد استكملت المعالجة الكيميائية بالتحقيق الصحي والمكافحة الكيميائية للحلزونات وتعديل البيئة كلما كان ذلك ملائماً. وقد أظهر التقييم النهائي لعام 2000 أن معدل العدوى بين الناس قد

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