

# Re-emerging schistosomiasis in hilly and mountainous areas of Sichuan, China

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**Abstract** Despite great strides in schistosomiasis control over the past several decades in Sichuan Province, China the disease has re-emerged in areas where it was previously controlled. We reviewed historical records and found that schistosomiasis had re-emerged in eight counties by the end of 2004 — seven of 21 counties with transmission control and one of 25 with transmission interruption as reported in 2001 were confirmed to have local disease transmission. The average “return time” (from control to re-emergence) was about eight years. The onset of re-emergence was commonly signalled by the occurrence of acute infections. Our survey results suggest that environmental and sociopolitical factors play an important role in re-emergence. The main challenge would be to consolidate and maintain effective control in the longer term until “real” eradication is achieved. This would be possible only by the formulation of a sustainable surveillance and control system.

**Keywords** Schistosomiasis/epidemiology/prevention and control; China (source: MeSH, NLM).

**Mots clés** Schistosomiase/épidémiologie/prévention et contrôle; Chine (source: MeSH, INSERM).

**Palabras clave** Esquistosomiasis/epidemiología/prevenición y control; China (fuente: DeCS, BIREME).

## Arabic

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Voir page 143 le résumé en français. En la página 144 figura un resumen en español.

## Introduction

Schistosomiasis remains a major public health problem in many developing countries in tropical and subtropical regions, with the majority of the disease's impact in Africa. WHO estimates that globally, 600 million people are at risk of exposure to infection, more than 200 million people are infected with schistosomiasis and 120 million of these show clinical symptoms.<sup>1</sup> Of the three main disease-causing schistosome species, *Schistosoma japonicum*, also known as Asian or oriental blood fluke, is responsible for human and animal infections (in mammalian hosts such as cattle and wild rodents) in China, the Philippines and to a lesser extent, Indonesia.

Schistosomiasis was first documented in 1924 in Sichuan, China.<sup>2</sup> Its epidemiological pattern became evident only when a series of large-scale surveys were conducted in the early 1950s. Since then, schistosomiasis control has been a public health priority in China and

administrative and professional health organizations were established at varying levels of governance specifically for schistosomiasis control, such as a schistosomiasis control committee at the central level and anti-schistosomiasis stations at the county level. Commonly implemented control measures include snail control, chemotherapy, health education, and provision of sanitary water.

In China, over the past five decades, schistosomiasis has been eradicated in three provinces (Fujian, Guangdong and Zhejiang), the municipality of Shanghai, and the autonomous region of Guangxi Province. This reduced the number of endemic provinces to seven — five in the lower Yangtze lake region (Anhui, Hubei, Hunan, Jiangsu, Jiangxi), and two (Sichuan and Yunnan) in the mountainous regions of the upper reaches of the Yangtze river — where incidence and morbidity are now much lower than they were in the 1950s.<sup>3</sup> Despite this achievement, since the mid-1990s the disease has been resurging in previously

controlled areas in the seven provinces. Nearly 800 000 people are infected annually and 60 million people are at risk of infection in China.<sup>4,5</sup>

In Sichuan, by 1985, 20 counties had attained transmission control status and 16 had attained transmission interruption. By 2001, 21 counties had attained transmission control and 25 counties had attained transmission interruption.<sup>6</sup>

We reviewed survey data to describe the epidemiology of re-emerging schistosomiasis in the hilly and mountainous regions of Sichuan Province, the control strategies implemented by local public health professionals and the possible factors contributing to re-emergence of the disease in this province.

## Methods

### Setting

Located in south-western China (latitude 26.52° N to 34.32° N, longitude 97.35° E to 108.52° E (Fig. 1)), Sichuan Province is the fourth most populous (84 million in 2000) and the fifth largest

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(485 000 km<sup>2</sup>) of 22 provinces, five autonomous regions, and four national municipalities in China. It has 181 counties and districts. Sichuan is one of the most important agricultural bases in China. Most of the province (90%) is mountainous or hilly, with plains and plateaus covering the rest of the land area.

### Definitions

Progressive stages of disease control in the endemic areas have been described as *morbidity control*, *transmission control* and *transmission interruption* (the last two were formerly known as “basic eradication” and “eradication”, respectively).<sup>7</sup> See Box 1 for definitions.

### Disease surveys

Disease surveys are routinely carried out in Sichuan Province. On receiving reports of re-emergent human infections from the county, health workers at the anti-schistosomiasis stations and office of endemic disease control conduct site-specific, sometimes geographically extended, human and snail surveys to verify the existence of local transmission and to assess the degree of impact. The surveys include examination of infection status of inhabitants between the ages of 4 and 60 years, through enzyme-linked immunosorbent assay (ELISA), or Kato–Katz test.

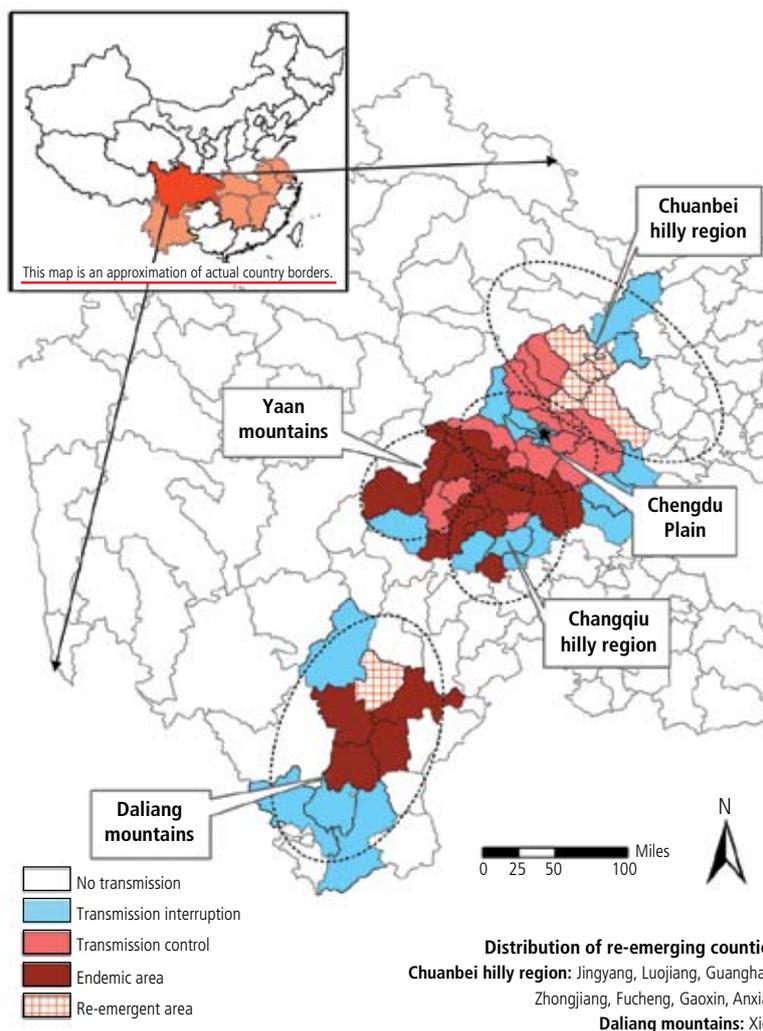
Veterinarians from the department of animal husbandry simultaneously examine cattle for infection. Cattle infection status is determined via hatch test.

Snail distribution and infection status are determined through systematic sampling. Such sampling was either exhaustive, with samples taken every ten metres, or stratified, with samples taken at different environmental points, such as irrigation ditches, grasslands, or orchards.

### Control activities

After local transmission is confirmed, interventions targeting humans and snails are initiated to contain the spread of the disease and reduce morbidity. Control measures usually include selective or mass administration of chemotherapy to the inhabitants of affected villages, as well as focal snail control using molluscicides and/or environmental modification. However, control measures are usually confined to places where humans are surveyed and infections confirmed, even while acute infections continue to occur at other locations.

Fig. 1. Distribution of schistosomiasis in Sichuan Province



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### Data collection

In late 2004, we visited all the eight affected counties in Sichuan Province and examined local records of surveys on humans, snails, and cattle, reports of acute human infection, and control activities. We collected the annual schistosomiasis report forms of the past 5–9 years at the township level. At anti-schistosomiasis stations in each county, we interviewed the staff involved in human and snail surveys, as well as reviewed the interventions following the occurrence of acute infections, and the planning and implementation of routine surveillance and control.

Report forms at the village level were retrieved in areas where acute cases, infected snails, or infected cattle were

reported. Clinical records of acute cases were obtained, where available. Clinical forms record basic epidemiological information, such as time of appearance of symptoms indicative of schistosomiasis infection, time of hospitalization, locality and duration of water contact, serological and/or parasitological examinations, as well as other clinical parameters. The disease and snail reporting forms record the human population examined (either through immunoassay or parasitological test) and treated, infection status (acute, sub-clinical, or chronic), numbers of cattle surveyed and treated, snail distribution and infection status, habitat type (irrigation ditch, paddy, or grassland, for example), and control activities (such as niclosamide spraying or pasting or environmental modification).

## Findings

Our analyses showed that by the end of 2004 schistosomiasis was endemic in 24 counties of Sichuan province including eight where the disease was re-emerging; 14 counties had attained transmission control and 24 had attained transmission interruption. Of the eight counties where schistosomiasis transmission had re-established itself, seven had previously attained transmission control and one had attained transmission interruption. The first seven counties were located in the *Chuanbei* hilly region to the north of Chengdu Plain, whereas the eighth (previously characterized by transmission interruption) was in the Anning river valley of the Daliang mountains (Fig. 1). Of the seven counties, Zhongjiang had attained transmission control in 1985, Guanhan in 1986, Anxian in 1987, Fucheng and Gaoxin in 1988, and Jingyang and Luojiang in 1995. The average “return time” (that is, time from disease control to the first report of local human infection) was 8.1 years, with the shortest return time at two years and the longest at 15. Xide county, which declared transmission control in 1986 and transmission interruption in 1995, was the first to report new cases of human infection in 2002. The re-emergence of schistosomiasis was often first signalled by a report of acute infection in humans and was confirmed by epidemiological surveys on humans and snails.

Re-emergent schistosomiasis infection in the eight counties mainly occurred among young people (age

### Box 1. Stages of schistosomiasis control

*Schistosomiasis morbidity control:* Prevalence of human and cattle infections less than 3%; acute cases of human infection occur with low frequency.

*Schistosomiasis transmission control:* Prevalence of human and cattle infections less than 1% by parasitological examination (e.g. miracidium hatch test or Kato–Katz egg count); no new infections in children ≤12 years old and in cattle ≤2 year-old; no acute cases of human infection; snail habitat reduced by 98% of pre-control level.

*Schistosomiasis transmission interruption:* Prevalence of human and/or cattle infections less than 0.2% by parasitological examination (e.g. miracidium hatch test or Kato–Katz egg count); no new infection of human and/or cattle found continuously for five years; no snails found for more than one year.

*Re-emergent schistosomiasis:* Infection reported since the declaration of disease control.

6–25 years), mostly males (Table 1). Symptoms indicative of acute schistosomiasis infection included fever, chills, fatigue, headache and gastrointestinal discomfort. Diagnosis was confirmed by positive ELISA and Kato–Katz egg count, as well as inquiry about history of water contact.

Table 2 summarizes the historical and current endemic villages, including villages with confirmed and probable transmission, acute cases reported, as well as the result of a cross-sectional sampling survey on human and cattle in the eight counties in 2004. Acute cases were reported in seven of the eight counties (there were no acute cases reported in Gaoxin). Villages were considered to have “confirmed transmission” if both infected definitive hosts (human and/or cattle confirmed by ELISA, Kato–Katz, or hatch test) and infected snails were found. Villages where either infected hosts or infected

snails were found were said to have “probable transmission”. We found that 39% of historically endemic villages had confirmed transmission (total villages with confirmed transmission divided by total historical endemic villages). Confirmed transmission was reported even in new villages (that is, historically non-endemic villages) of Anxian and Zhongjiang counties.

Kato–Katz test in selected villages with confirmed transmission indicated infection prevalence among humans, ranging from 0.9% to 12.7%, with the highest prevalence in Jingyang. ELISA test results revealed infection prevalence among humans between 1.4% and 18.34%, with the highest prevalence in Xide.

Prevalence of infection among cattle, examined via hatch test, ranged from 0 to 22.3%, with the highest prevalence in Luojiang.

Prevalence of infection in snails ranged from 0 to 0.16%, suggesting very low infection rates compared with other endemic areas in Sichuan (Table 2). We used a protocol developed by the Ministry of Health to determine snail habitat.<sup>7</sup> A plot of log-transformed snail habitat in the eight counties from 1997 to 2004 (Fig. 2), based on historical records at each county, showed an overall increase in snail habitat area in all counties except for Gaoxin. We opine that the construction of factories on former farmlands in Gaoxin in 1999 may be the reason for the greatly reduced snail habitats in the county. However, snails re-appeared in certain environments due to “incomplete modifications”, that is, alteration of environments that left them still suitable for snail breeding (unpublished data from Mianyang, CDC). In Xide, snails first re-appeared in 1999 and the annual surveys that followed indicated that snails were distributed in a much larger area than previous surveys had suggested.

Table 1. Report of the first case(s) of schistosomiasis infection in the eight re-emerging counties of Sichuan Province, China

County	Time reported/hospitalized	Male	Female	Age	Location (village)	Water contact
Jingyang	July 2000	1	0	7	Shuangdong	Swimming
Luojiang	July 1998	1	0	12	Wenxing	Playing
Guanhan	June–July 1995	2	1	6 ~ 25	2 - Shuangquan, 1 - Shimen	Playing, swimming
Zhongjiang	June 2000	1	0	31	Huipeng	Farming
Fucheng	July–August 1989	3	1	5 ~ 9	2 - Shipan, 2 - Wujia	Playing, swimming
Gaoxin	July 2000	1	0	7	Shiqiao	Playing
Anxian	July–August 1998	1	1	26 ~ 40	Qingquan Baoling	Farming
Xide <sup>a</sup>	October 2002	2	1	17 ~ 25	Donghe	Farming

<sup>a</sup> The three cases of human infections were detected through routine surveillance survey.

Table 2. Schistosomiasis in humans and cattle in the eight re-emerging counties of Sichuan Province, China (from sampling survey in 2004.)

County	Historical endemic villages	Population in endemic villages	Endemic villages <sup>a</sup>	Acute cases reported in 2004	People surveyed <sup>b</sup>	% people infected <sup>c</sup>	Surveyed (total cattle)	% cattle infected (cases)	% snail infected
Jingyang	199	382 200	169 (91)	4	(72 641; 765)	(9.7; 12.7)	9 056 (12 804)	8.3 (749)	0.11 (241/227 635)
Luojiang	89	213 900	86 (35)	7	(8 324; 1 200)	(1.4; 4.5)	1 200 (13 623)	22.3 (268)	0.022 (15/68 634)
Guanhan	264	475 496	264 (102)	1	(3 639; 1 007)	(8.7; 0.9)	10 394 (na <sup>d</sup> )	5.4 (559)	0.02 (76/380 150)
Zhongjiang	65	182 170	73 (44)	1	(25 685; 2 521)	(5.02; 3.01)	16 894 (na)	5.1 (861)	0.023 (20/86 900)
Fucheng	98	170 391	70 (25)	2	(44 250; 219)	(9.16; 3.24)	176 (9 738)	10.23 (18)	0.04 (38/10 097)
Gaoxin	20	36 000	15 (6)	0	(10 561; na)	(8.5; na)	50 (256)	0	0
Anxian	162	101 866	162 (47)	1	(24 469; 3 529)	(7.6; 12.5)	2 388 (12 435)	0.92 (22)	0.16 (15/9 373)
Xide	12	13 738	11 (3)	1	(1 126; 571)	(18.34; 11.98)	54 (5 400)	7.4 (4)	0.01 (1/10 030)

<sup>a</sup> Numbers of endemic villages that local health officials believe to have transmission, while numbers in parentheses represent villages with confirmed transmission based on the past four years' records.

<sup>b</sup> Numbers in parentheses = people who underwent ELISA and parasitological examination, respectively.

<sup>c</sup> Numbers in parentheses = proportion of infected people who underwent ELISA and parasitological examination, respectively.

<sup>d</sup> Not available.

## Discussion

Despite great strides in schistosomiasis control in Sichuan over the past several decades, the disease has become re-established in areas where it was previously controlled. The re-establishment of disease transmission was commonly signalled by the report of acute infections, since its control took about eight years. Actual disease transmission may have occurred prior to the occurrence of acute infections, but the exact times are unknown. However, from the human surveys immediately following the reports of acute infection, prevalence of infection was found to range from 2% to 4% (unpublished data; population size at each village being 200–300), suggesting that the “actual time” of re-establishment may not have preceded the first reports of acute infection. The strong immunological response and clinical manifestations of acute cases also make biological sense, due to diminishing immunity in formerly exposed adults or the lack of immunity in children in these controlled areas. As a result, the occurrence of acute cases is commonly regarded as marking the onset of re-emergence.

We believe that since snails reappeared in all villages before human infections occurred, “current endemicity”

as defined by local health authorities and being determined by the presence of infected snails, a positive ELISA or Kato–Katz test from human survey, or a positive hatch test result in cattle may result in overestimation of the number of villages with actual transmission (as shown in Table 2).

Results of our survey suggest that environmental and sociopolitical factors may play important roles in re-emergence, however these factors have to be systematically assessed before they are established. We summarize the following contributing factors underlying the re-emergence as abstracted from historical records and corroborated by staff interviews.

### Changes in sociopolitical climate

- Diminishing funding resulted in decreasing numbers of anti-schistosomiasis health workers, and poor or inconsistent surveillance and control efforts particularly on residual snails;
- Decreasing awareness among the local government and community of schistosomiasis and its existence since the goal of transmission control or interruption was achieved increased the possibility of re-emergence;

- Lack of efficient coordination between the public health, agricultural, hydrological, and husbandry departments in the aftermath of transmission control or interruption increased the possibility of re-emergence;

### Changes in local economic climate

- Increasing human mobility at local and regional levels increased the possibility of spreading the pathogen and/or the intermediate snail hosts (e.g. from endemic to non-endemic areas and vice versa), and missing control targets during the intervention (e.g. failed to treat infected people who were away but eventually came back);
- Increasing cattle mobility through trading and/or rental increased the possibility of spreading infectious sources;

### Changes in local environment and surveillance system

- Increasing local hydrological projects increased the possibility of pathogen spread and establishment of new snail habitats (e.g. spread of irrigation canal in the past years in Jingyang);
- Inappropriate surveillance systems led to inaccurate monitoring of post-control disease dynamics.

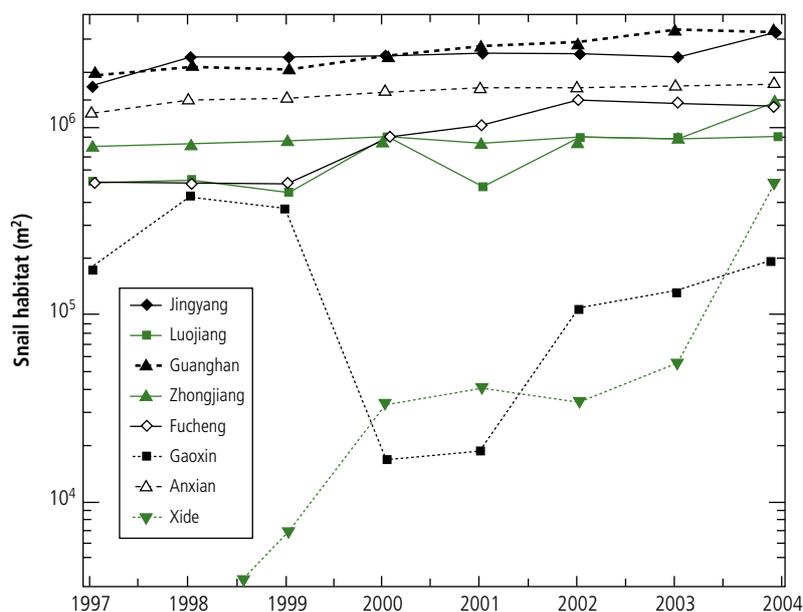
We found that, in some counties, lack of data sharing and coordination in field implementation between health workers from the anti-schistosomiasis station and veterinarians from departments of cattle husbandry made effective surveillance difficult.

The early implementation of an optimal surveillance system should be made a public health priority.

We emphasize that timely action in response to the first report of acute infection is very important in containing the spread of the disease. This is corroborated by the experience from Guanghan county. Two cases of acute human infection were first reported in Shuangquan village in 1995, well after the declaration of transmission control in 1986. No action followed, resulting in an outbreak of 45 acute human infection cases in this village alone in the following year (Guanghan Anti-Schistosomiasis Station, unpublished data). The enforcement of prompt action taken following the report of acute human infection was effective in containing the "local spread" of the disease.

Schistosomiasis has a complicated transmission process, involving humans, intermediate snail hosts, and the environment. We opine that effectively controlling schistosomiasis or even eradicating it in a county does not necessarily mean that it cannot re-emerge. The main challenge would be to consolidate and maintain effective control in the longer term, until "real" eradication is achieved.<sup>8</sup> After reaching the goals of transmission control or interruption, the formulation of a sustainable surveillance and control system is extremely important. In that regard, it is essential to understand the factors responsible for the re-emergence, how to monitor them, and how to use them to predict potential re-emergent transmission. An integrated assessment of re-emergent schistosomiasis, including

Fig. 2. Snail habitat area (log-scaled) in the eight counties in Sichuan Province, China, between 1997 and 2004



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the use of techniques of mathematical modeling, remote sensing, and geographical information systems, is currently under way.

We could not evaluate why the disease re-emerged in these areas; whether other areas now under control follow this trend; can the possible outbreak/re-establishment of the disease be predicted in time to allow for appropriate preventive measures; or what control/surveillance measures will be appropriate for areas of transmission control or interruption. It is hoped that these questions would be addressed in future studies. ■

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Guanghan, Jingyang, Luojiang, Xide and Zhongjiang. We would like to thank Dr Xueguang Gu for his helpful discussions, Professor Robert C Spear and Professor Peng Gong for providing valuable comments on the manuscript and Elena Conis for her help in revising the manuscript.

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## Résumé

### Réémergence de la schistosomiase dans les zones vallonnées et montagneuses du Sichuan, en Chine

Malgré les grands progrès réalisés dans la lutte contre la schistosomiase au cours des dernières décennies dans la province du Sichuan, en Chine, cette maladie a réapparu dans des régions où elle était auparavant sous contrôle. Après analyse des dossiers, on a constaté une réémergence de la schistosomiase dans huit pays à la fin de l'année 2004 : l'existence d'une transmission locale de la maladie a été confirmée dans sept des 21 pays dans lesquels la maladie était endiguée et dans l'un des 25 dans lesquels la transmission était interrompue d'après les notifications de 2001.

Le « temps de retour » moyen (de l'endiguement à la réémergence) était d'environ huit ans. L'apparition de la réémergence se manifestait habituellement par la survenue d'infections aiguës. Les résultats de l'enquête laissent à penser que des facteurs environnementaux et sociopolitiques jouent un rôle important dans le retour de la maladie. Le principal défi serait de consolider et de maintenir une lutte efficace à long terme jusqu'à obtenir une éradication « véritable ». Cet objectif ne serait réalisable qu'en organisant un système durable de surveillance et de lutte.

## Resumen

### Reaparición de la esquistosomiasis en zonas montañosas y accidentadas de Sichuan, China

A pesar de los grandes avances registrados en materia de control de la esquistosomiasis en los últimos decenios en la provincia de Sichuan, China, la enfermedad ha reaparecido en zonas donde ya había sido controlada. Examinando los registros históricos descubrimos que la esquistosomiasis había reaparecido en ocho cantones al final de 2004: se confirmó que siete de 21 cantones con control de la transmisión y uno de 25 con interrupción de la misma, según datos de 2001, presentaban transmisión local de la

enfermedad. El «tiempo de retorno» medio (el transcurrido entre el control y la reaparición) era de aproximadamente ocho años. Los resultados de nuestro estudio llevan a pensar que hay factores ambientales y sociopolíticos que tienen un papel importante en la reaparición de la enfermedad. El reto principal sería consolidar y mantener un control efectivo a más largo plazo hasta lograr la erradicación «real». Esto sólo será posible si se concibe un sistema de vigilancia y control sostenible.

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