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ORIGINAL ARTICLE

Elimination is not the end: experience in handling the last residual filariasis focus in China

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Background: A residual focus of bancroftian filariasis was found in Fuchuan County, Guangxi Zhuang Autonomous Region, China in 2007, and the response measures were implemented with participation and guidance from the National Institute of Parasitic Diseases at the Chinese Center for Disease Control and Prevention (China CDC). This study aims to assess the infection sources and summarize the management processes of the residual focus to fill the gap of the re-emergence of focus after elimination as a public health problem.

Methods: The assessment of the infection sources in the residual filariasis focus was conducted by on-site investigation and review of the database that was created and maintained by the China CDC. Historical records that were created by the China/Fuchuan CDC and maintained by the China CDC were retrospectively reviewed to summarize the experience of the handling process for filariasis. Statistical tests and logistic regression were performed to analyse the epidemic characteristics of the residual filariasis focus.

Results: A total of 7308 test records were reviewed, of which 919 were from the focus's natural village while 6389 were from other affected populations. Age and sex significantly affect filariasis infection, and the high-risk population was the 50–69 y age group and males in this focus. The on-site evaluation result and database monitoring showed that the focus did not spread locally or to neighbouring places and thus did not pose a public health threat. The emergency response process (ERP) for residual filariasis focus was developed and the rapid report and survey of the first case serves as the pre-trigger signal for ERP. Implementation of the ERP should account for local technical resource availability, representing the optimal approach under capacity-constrained conditions.

Conclusions: Maintenance of a sensitive and effective surveillance system and stockpiling of technologies and medicines are key to consolidating the elimination of filariasis and preventing its re-emergence. The disposal process is a systematic and scientific action that must follow epidemiological and medical principles according to local conditions.

Keywords: elimination, experience summary, filariasis, monitoring, residual focus

Introduction

Filariasis is caused by filarial worms that parasitize the lymphatic system, subcutaneous tissue and abdominal and thoracic cavities of vertebrate hosts. According to the World Health Organization (WHO), filariasis is prevalent in 72 countries and regions across Asia, Africa, the Western Pacific, the Caribbean and South America.[1] In 1997, the World Health Assembly passed the resolution 'Elimination of lymphatic filariasis as a public health problem' (WHA50.29), urging countries to take various measures to eliminate lymphatic filariasis (LF).[2] The WHO emphasizes that 'elimination' refers to reducing transmission below a threshold of public health concern (versus complete pathogen removal in eradication). According to the WHO, statistical thresholds were in areas where *Wuchereria bancrofti* is endemic, antigenemia is <2% where *Anopheles* and/or *Culex* are the principal vectors, antigenemia is <1% where *Aedes* is the principal vector, and antibody is <2% in areas where *Brugia* spp. is endemic. In areas where *W. bancrofti* and *Brugia* spp. are co-endemic, antigenemia and antibody results should be evaluated separately against cut-off points.[3]

In China, *W. bancrofti* and *Brugia malayi*[4] are parasitic filariae which infection in humans can cause LF. Acute filariasis, which is characterized by recurrent lymphangitis, lymphadenitis and fever, and chronic filariasis, which is characterized by lymphoedema and elephantiasis, pose a severe threat to the health and economic development of residents in endemic areas of China.[5] According to the administrative divisions of China in the 1980s, filariasis was endemic in 862 counties (cities) across 16 provinces (municipalities and autonomous regions) constituting 40% (862/2137) of China's county-level jurisdictions with 341 916 million people at risk.[6] Since 1983, endemic provinces have achieved the basic elimination of filariasis, and by 1994, filariasis was basically eliminated nationwide. Subsequently, monitoring and management of the remaining focuses were carried out. In 2006, all regions met China's 'Criteria for the elimination of filariasis' and the Ministry of Health of the People's Republic of China (PRC) submitted a national report on the elimination of LF to the WHO.[6] The following year, the PRC confirmed that filariasis had been eradicated as a public health problem, making it the first developing country to eliminate filariasis.

China's longitudinal monitoring results showed that the longest duration for bancroftian filariasis with microfilaremia cases to turn negative is 9 y.[6–8] Although numerous reports indicate that mass drug administration (MDA) is a necessary measure to eliminate filariasis,[9–12] it is still not guaranteed that filariasis will be eliminated in the short term.[13]

The Guangxi Zhuang Autonomous Region eliminated filariasis in 1995 and detected no new infections in the subsequent decade.[8,14] In 2007, an 18-year-old villager from Changtang administrative village, Chaodong Town, Fuchuan County, Guangxi Zhuang Autonomous Region, exhibited pain in the scrotum and testicles and fever while working in Shantou City, Guangdong Province. After returning home, he was diagnosed with bancroftian filariasis with microfilaremia, leading to the discovery of a residual focus through preliminary investigation.[15] This discovery, which occurred after China had submitted its national report on the elimination of LF, attracted the attention of the WHO and international community because filariasis in China might not have been eliminated in 2007. Therefore, the National Institute of Parasitic Diseases (NIPD) at the Chinese Center for Disease Control and Prevention (China CDC) coordinated with medical and disease control institutions in the Guangxi Zhuang Autonomous Region and related provinces to conduct high-quality investigations and management. Based on their results, both the WHO and Chinese experts concluded that the residual focus did not pose a public health problem. China's filariasis monitoring system was comprehensive and sensitive and the measures were prompt and appropriate. It was recommended to monitor similar remote areas with poor sanitary conditions and no treatment records and to strengthen the monitoring of cases imported from abroad.

According to the country status in implementing MDA for LF elimination as of 2023 reported by the WHO,[16] 19 countries were validated as having eliminated LF as a public health problem and were under surveillance, including Togo (2017), Egypt (2017), Sri Lanka (2016), Thailand (2017) and Wallis and Futuna (2018). However, in the post-elimination period, filariasis still spreads among livestock in Egypt,[17] a cross-sectional study carried out among schoolchildren <18 y of age suggests a resurgence of filariasis in Wallis and Futuna,[18] migrant group monitoring demonstrates that nomadic Peuhls pose a potential risk for reintroduction of filariasis into Togo,[19] there were 566 new lymphoedema case in Sri Lanka in 2022[20] and post-validation surveillance in 2022 demonstrated ongoing transmission in the province of Narathiwat in Thailand.[21] Compared with other countries validated as having eliminated filariasis, China has a large population, vast territory and a huge distance and scale of population mobility. China's experience can not only provide reference for individual countries, but also offer technical reference for cooperation policies among multiple countries in a region. While there is a substantial body of literature on LF surveillance, MDA, and transmission assessment surveys (TASs), few studies have specifically addressed the re-emergence of infection focus after elimination as a public health problem. In light of this gap, we conducted an infection sources assessment in 2017, a decade after the initial identification of this residual focus, and summarize China's experience in managing such a residual focus by combining a literature review, on-site assessment and database assessment.

Methods

Data collection

The study integrated three data sources, a field survey in 2017 in Changtang administrative village, Chaodong Town, Fuchuan County, Guangxi Zhuang Autonomous Region (for on-site assessment); suspected filariasis case data from January 2008 to December 2023 across the Chinese mainland except Changtang administrative village, Chaodong Town, Fuchuan County, Guangxi Zhuang Autonomous Region (for database assessment); and a literature/archival records review of the filariasis residual focus event discovered in 2007 (for historical review).

Data for on-site assessment

A field survey in 2017 in Changtang administrative village was conducted for on-site assessment, with demographic data of the population tested, blood samples and the test results. Unique identifiers linked all demographic data and test results.

Data for database assessment

The information on suspected cases outside the residual filariasis focus were downloaded from January 2008 to December 2023 from the Infectious Disease Reporting Information Management System (IDRMS) of the China CDC. The IDRMS is a national-level statutory infectious disease surveillance platform established in compliance with the Law of the People's Republic of China on the Prevention and Treatment of Infectious Diseases, administered by the China CDC. This system provides comprehensive coverage for 40 notifiable infectious diseases in China, with parasitic diseases such as echinococcosis, filariasis, malaria and schistosomiasis being specifically managed by the NIPD. There are

>70 000 medical and health institutions covered by the IDRMS across China. Among these, all with clinical testing capabilities are legally obligated to report notifiable infectious diseases identified during examinations. The China CDC is responsible for the verification, coordination, confirmation and aggregated analysis of reported data.

Data for historical review

The literature/archival records were collected from the archives of the NIPD and a literature search. Information was collected via a literature search that encompassed the China National Knowledge Infrastructure (CNKI), Wanfang Database, PubMed, Google Scholar and Web of Science. The search strategy used terms such as ('Fuchuan' or 'Guangxi') in combination with ('Filariasis'), and the publication date for the literature was set to 2007 or later. This search strategy yielded only two publications, both of which were directly relevant to our study.[15,22]

The archival materials consisted of extensive, heterogeneous paper-based records stored in dedicated archives at the NIPD, including The National Report on Lymphatic Filariasis Elimination in China (2006, English version submitted to WHO); provincial elimination reports (unpublished, May 2006); Annual Cumulative Filariasis Treatment in Communes of Fuchuan County (1958–1984, unpublished); county-level prevention data (January 1985, unpublished); socio-economic and geographical profiles of residual foci (unpublished); population screening registries (2007–2013, unpublished); a comprehensive report on residual focus discovery and management (2014, containing epidemiological surveys and treatment summaries, unpublished); interview transcripts with local health workers and residents (2007); blood test registration forms (2007–2014); microfilaremia case investigation forms (2007–2014); and case management tracking files (2007–2013). Some data were incomplete (e.g. microfilarial density for two cases diagnosed in 2008 and re-examinations).

Investigation and assessment in the residual filariasis focus

Full-coverage screening of the local population in the residual filariasis focus

The method of full-coverage screening, containing the preliminary investigation (in 2007) and the continuous investigation (after 2007), was summarized by reviewing the literature[15,22] and a comprehensive report on residual focus discovery and management in archive materials (see Supplementary material 1). The data for local screening of the population were obtained from blood test registration forms in archive materials. Adhering to the national standard 'Diagnosis and Treatment Principles for Filariasis' (GB15985-1995),[23] the treatment plan for cases and non-infected residents in the residual filariasis focus were made (see Supplementary material 2).

Re-examination of microfilaremia cases

According to archival records from the comprehensive report on residual focus discovery and management (2014, unpublished), individuals identified as microfilaremia-positive during population screening immediately received one round of drug treatment. After a minimum interval of 6 months, they underwent follow-up testing via immunochromatographic test (ICT). Those with positive ICT results were re-examined using pathogenetic detection methods. If microfilariae remained detectable, another treatment round was administered, followed by repeat testing after ≥6 months. This cycle continued until all follow-up results were negative and full coverage of initially identified cases was achieved.

Mosquito survey

The method of the mosquito survey in 2007 was summarized by reviewing the literature.[15,22] The mosquito vectors were surveyed within the theoretical flight radius (approximately 105 m) of *Culex quinquefasciatus*,[24] centred around infected homes. The lamp trapping method was used to trap mosquitoes indoors for 48 h in all infected homes at the end of August 2007 and the mosquito species were identified morphologically. Dissection of the head, chest and abdomen of each captured *C. quinquefasciatus* specimen were performed using dissecting needles and the natural infection of filarial larvae was examined using a microscope.[25] The data for mosquito surveys were obtained from a comprehensive report on residual focus discovery and management in archive materials.

On-site assessment in the residual filariasis focus

All the original microfilaremia cases, their cohabiting family members and residents within a 105-m radius (based on *C. quinquefasciatus* flight range[24]) were selected as the assessment samples in 2017. Blood samples were collected in their house one-by-one for examination, including aetiological, serological and polymerase chain reactions (PCR). No examination was conducted on people who were not in the village when the assessment was conducted. Written informed consent was obtained before any procedures.

Methods of blood sample collection and examination

Blood was taken from the earlobe or finger of selected people using a capillary tube from 21:00 to 02:00 for triple thick blood film for aetiological examination using morphological identification and/or PCR examination with MF/F (5′-ATGTCCGCA CAACTTTTGATTTTATCG-3′) and MF/R (5′-TTAAATTTCACGTTCCAGTTC ATCGAT-3′) primers to amplify the 1.5-kb glutathione peroxidase (*GSHPx*) gene[26] of *B. malayi* and *W. bancrofti* and/or immunochromatographic tests (ICTs). The examination method is detailed in Supplementary material 3. All experimenters participating in the examination received unified training in advance. Each examination was conducted for three rounds to ensure the accuracy of the results. The study protocol was approved by the NIPD Ethics Committee (2012ZX10004-220, 26 August 2012) with written informed consent obtained.

The population microfilaria rate (PMR) and average density of microfilaria in 60 μl of blood (ADM) were calculated in the aetiological examination by the equations:

$$\mathrm{PMR} = \frac{\mathrm{N_m}}{\mathrm{N_T}} \times 100\%,$$

where N_m is the number of people with microfilaria and N_T is the total number of people examined, and

$$ADM = \frac{N_{mf}}{2},$$

where N_{mf} is the total number of microfilaria observed in two thick blood films.

Risk factors analysis of the residual filariasis focus in 2007–2008

To gain a deeper understanding of local filariasis transmission, we conducted statistical analysis based on the data for local screening of the population in the residual filariasis focus using the χ^2 test or Fisher's exact test logistic regression analysis.

Investigation and assessment outside the residual filariasis focus

Investigation outside the residual filariasis focus

Based on established principles, a 5-km radius defined the area under relative filariasis threat.[27,28] Within this radius were the administrative villages of Chashan and Huangsha in Chaodong Town, Fuxi in Chaodong Town, Changchun in Malin Town, Mati in Xiachengpu Town and Shangcun and Huangjia in Lanxi Town, which were labelled as the areas at risk. The method of the population screening outside the residual filariasis focus can be found in Supplementary material 4. The aetiological examination, serological examination method and quality control were the same as the examination methods.

Database assessment outside the residual filariasis focus

A retrospective analysis in 2024 was conducted for the suspected cases from the IDRMS database.

Experience summary

Historical work review

We reviewed filariasis prevention and control in the counties and towns where the residual focus was located to find the reason for the focus by examining historical literature, annual filariasis prevention and control reports up to 2007 and interviews with village doctors, township health clinic doctors and older residents in the focus villages. The materials were summarized by county, town and village.

The emergency response process (ERP) summary

The ERP was summarized from the work from discovery to the assessment in the residual filariasis focus. By assuming the removal of one step and applying epidemiological principles to analyse the impact of this removal on the entire process, the necessity or non-necessity of this step could be confirmed or refuted.

Data organization and statistical analysis

We used Excel 2016 (Microsoft, Redmond, WA, USA) for data organization and cleaning; Excel 2016 and PowerPoint 2016 (Microsoft, Redmond, WA, USA) were used for drawing figures. Statistical tests (the chisq.test and fisher.test functions from the stats package) and the logistic regression analysis (glm functions from the stats package) were performed using R 4.3.3 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Epidemiological characteristics of the residual filariasis focus

A total of 919 screening records were reviewed for the investigation in the Changtang administrative village, Chaodong Town, Fuchuan County, Guangxi Zhuang Autonomous Region. In the preliminary investigation (in 2007), 17 of 603 people living in the village were infected, for an infection rate of 2.82% (Table 1). Morphological identification of microfilaria showed that all cases were caused by *W. bancrofti*. The ADM in the 17 microfilaremia cases identified in the preliminary investigation was 19.29 microfilariae. Among these, 10 cases had an ADM $\leq$15 microfilariae (average 8.20), whereas 7 cases had an ADM $>$15 microfilariae (average 35.14) (Figure 1). The continuous screening was conducted from 2008 to 2013, in which a total of 316 residents of the residual filariasis focus were investigated, of which 2 cases were found in 2008, for an infection rate of 0.63% (Table 1). As of the end of 2013, the screening of all individuals required to be screened in the area was completed. The findings confirmed ongoing transmission of bancroftian filariasis, based on the established transmission threshold of bancroftian filariasis (PMR of 1.71%[29] or 1%[30], ADM of 3–10 microfilariae[29] and 15 microfilariae[31]), indicating the persistence of a residual filariasis focus in the area.

Effect analysis of age and sex on microfilariae infection of the residual filariasis focus

The PMRs of the residents ages 10–29, 30–49, 50–69 and $\geq$70 y were 1.79% (5/280), 0.98% (3/305), 4.03% (10/248) and 1.16% (1/86), respectively. A significant difference was observed between infection rates of the residents ages 30–49 y and 50–69 y (Fisher's exact test, p=0.023, odds ratio [OR] 0.237 [95% confidence interval {CI} 0.041 to 0.934]) (Table 3). There were 4 female cases (21.05%) and 15 male cases (78.95%) in 919 residents, with a PMR 0.98% (4/409) and 2.94% (15/510), respectively. No significant difference was observed between infection rates of the sexes (Fisher's exact test, p>0.05, OR 0.326 [95% CI 0.078 to 1.035]) (Table 2).

Logistic regression analysis showed that compared with the 30–49 y age group, the 50–69 y age group showed a significantly higher risk of infection (OR 4.824 [95% CI 1.447 to 21.790], z=2.359, p=0.018), and compared with males, females showed a significantly lower risk of infection (OR 0.294 [95% CI 0.083 to 0.823], z=2.359, p=0.018) (Table 3).

Re-examinations of the cases

Re-examination of the cases was conducted between 2008 and 2014. A total of 43 re-examinations records were reviewed, with 8 instances of continued positive results in 2008, 2011 and

Table 1. Full-coverage screening of residents of the residual filariasis focus.

Year	Local screening			Screening of people leaving from or returning to the residual focus			Total		
	People screened, n	Positive cases, n	Rate of positive cases, %	People screened, n	Positive cases, n	Rate of positive cases, %	People screened, n	Positive cases, n	Rate of positive cases, %
2007	556	14	2.52	47	3	6.38	603	17	2.82
2008	7	0	0.00	221	2	0.90	228	2	0.88
2009	1	0	0.00	54	0	0.00	55	0	0.00
2010	0	0	NA	15	0	0.00	15	0	0.00
2011	0	0	NA	13	0	0.00	13	0	0.00
2012	0	0	NA	4	0	0.00	4	0	0.00
2013	0	0	NA	1	0	0.00	1	0	0.00
Total	564	14	2.48	355	5	1.41	919	19	2.07

NA: not available.
A total of 17 cases were detected in 2017 (including 14 microfilaremia cases identified during population screening in residual endemic villages from 17 to 20 August 2007, and 3 microfilaremia cases detected among migrant workers from residual endemic villages during population screening from 12 to 19 September 2007). In 2008, 2 microfilaremia cases were detected (both identified among migrant workers from residual endemic villages during population screening from 31 January to 16 February 2008).

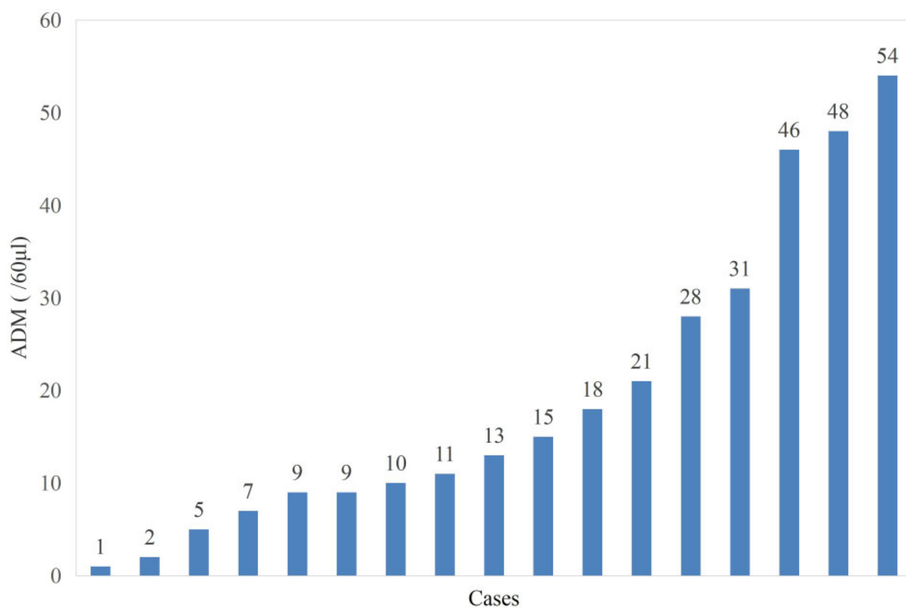

Figure 1. ADM of cases in preliminary investigation.

2012. By 2014, all original microfilaremia cases were re-examined completely and all final re-examination results were negative (Table 4). The records indicated that among 19 microfilaremia cases, 12 were retested in spring 2008 (the remaining 7 worked outside the locality and were unavailable for testing that year), with 5 testing positive (ADM lost). Of the 7 untested cases in 2008, 5 were re-examined in 2009 (exceeding the 6-month standard interval), all with negative results. No follow-ups were conducted in 2010. In 2011, one previously untested case in 2008–2009, 5 cases persistently positive and 3 previously negative cases retested in 2008 were retested; 2 remained positive (both from the 2008 positive cohort; ADM lost). By 2012, all 19 initial cases had been covered: 8 were tested (including 1 previously untested case in 2008–2011, 2 persistent positives and 5 negatives in the re-examinations in 2008–2011), with 1 positive (a 34-year-old female with the highest initial density in 2007 [54 microfilaria/60 μl], consistently positive in 2008 and 2011; ADM lost). No follow-ups occurred in 2013. In 2014, 9 cases (the consistently positive female and 8 negatives retested in 2008–2012) were retested, all with negative results.

Table 2. The descriptive analysis of microfilariae infection.

Groups	Subgroups	Subgroups 2	People tested, n	Cases		PMR, %	Fisher's exact test for infection rate			
				n	%		OR	2.5% CI	97.5% CI	p-Value
Age group (years)	10–29	NA	280	5	26.32	1.79	NA	NA	NA	NS
	30–49	NA	305	3	15.79	0.98				
	50–69	NA	248	10	52.63	4.03				
	≥70	NA	86	1	5.26	1.16				
Single group comparison of age groups (years)	10–29	30–49	NA	NA	NA	NA	1.828	0.352	11.884	NS
	10–29	50–69	NA	NA	NA	NA	0.433	0.115	1.415	NS[a]
	10–29	≥70	NA	NA	NA	NA	1.544	0.169	73.923	NS
	30–49	50–69	NA	NA	NA	NA	0.237	0.041	0.934	0.023
	30–49	≥70	NA	NA	NA	NA	0.845	0.067	44.843	NS
	50–69	≥70	NA	NA	NA	NA	3.562	0.493	156.693	NS[b]
Sex	Female	NA	409	4	21.05	0.98	0.326	0.078	1.035	NS
	Male	NA	510	15	78.95	2.94				
Total			919	19	NA	2.07	NA	NA	NA	NA

NA: not applicable; NS: not significant.
[a]p-Value (0.198) of Pearson's χ^2 test with Yates' continuity correction with a χ^2 value 1.660.
[b]p-Value (0.065) of Pearson's χ^2 test with Yates' continuity correction with a χ^2 value 3.405.

Mosquito distribution and natural infection survey in the residual filariasis focus

A total of 140 trapped mosquito records in 2007 were reviewed, in which 54 mosquitoes (38.57%) were *Culex quinquefasciatus*, 8 mosquitoes (5.71%) were *Anopheles sinensis*, 32 mosquitoes (22.86%) were *Culex pipiens pallens* and 46 mosquitoes (32.86%) were *Aedes vexans*. Upon dissecting the *C. quinquefasciatus* samples, no larval filarial infection records were found.

On-site assessment of the residual filariasis focus

The on-site assessment was conducted in the residual filariasis focus in 2017. Among the 19 original microfilaremia cases identified in 2007–2008, 6 had left the focus, 2 had died, and the remaining 11 had no filariasis-related symptoms. Night-time blood collection was performed for these 11 individuals, along with 65 family members and neighbours, and no positive test results were found (Table 5), indicating a good effect of the integrated intervention in the residual filariasis focus.

Population screening outside the residual filariasis focus

A total of 6 389 population Screening outside the residual filariasis focus were reviewed and no case was found (for details, see *Supplementary material 5*, Table 6).

Database assessment outside the residual filariasis focus

From January 2008 to December 2023, 455 suspected cases of filariasis were reported by the IDRMS. After review and verification, 452 cases were excluded, leaving 3 cases: 1 confirmed and 2 clinically diagnosed cases. The confirmed case was a 49-year-old male with a work history in Africa, diagnosed with *Loa loa* filariasis in 2019. Both clinically diagnosed individuals (with no microfilariae in peripheral blood) were male. One was a 34-year-old overseas Chinese who came from Africa to Beijing and was diagnosed in 2008. The second was a 35-year-old man with a travel history to Africa, diagnosed in Sichuan Province in 2011 based on a diagnostic approach for *Loa loa* filariasis. Thus no local focus was found from 2008 to 2023 outside the residual focus.

Historical review of intervention and monitoring of filariasis

A review of past filariasis prevention and control records, as well as interviews with village doctors, township health clinic doctors and older residents of the focus village regarding local filariasis prevention and control efforts, showed there was no intervention or monitoring of filariasis in Changtang administrative village after 1990.

Historical work in Fuchuan County

Filariasis work in Fuchuan County before 2007 mainly went through four stages (Table 7). The first stage (before 1970)

Table 3. The logistic regression analysis of ages and sexes on microfilariae infection.

Variables	Coefficients: Estimate	SE	z-Value	p-Value	OR	2.5% CI	97.5% CI
(Intercept)	−4.322	0.586	−7.372	<0.001	0.013	0.003	0.035
10–29 y	0.772	0.739	1.045	NS	2.163	0.522	10.685
50–69 y	1.574	0.667	2.359	0.018	4.824	1.447	21.79
≥70 y	0.269	1.163	0.231	NS	1.308	0.064	10.414
Female	−1.225	0.57	−2.148	0.032	0.294	0.083	0.823

SE: standard error; NS: not significant.
Reference group is 30- to 49-y age group and male.

Table 4. Re-examination results of microfilaremia cases.

	Re-examined microfilaremia cases, n			Cases that remained positive, n			
Year	First re-examined	Re-examined (not first)	Total	First re-examined	Re-examined (not first)	Total	Rate of positive (total), %
2008	12	0	12	5	0	5	41.67
2009	5	0	5	0	0	0	0.00
2010	0	0	0	0	0	0	NA
2011	1	8	9	0	2	2	22.22
2012	1	7	8	0	1	1	12.50
2013	0	0	0	0	0	0	NA
2014	0	9	9	0	0	0	0.00

NA: not applicable.

Table 5. On-site assessment of infection sources in the residual filariasis area.

Group	Screening method	People screened, n	Positive or microfilaremia cases, n	Rate of positive or microfilaremia cases, %
Original microfilaremia cases	ICT	11	0	0.00
	Pathogenic examination	11	0	0.00
	PCR	11	0	0.00
Family members and other residents	ICT	65	0	0.00
	Pathogenic examination	65	0	0.00
	PCR	65	0	0.00
Total		76	0	0.00

involved determining the epidemic situation. The second stage (1971–1980) consisted of a county-wide survey and administering medication to the entire population in epidemic villages. In 1976 and 1980, two county-wide campaigns were carried out to administer 0.3% diethylcarbamazine (DEC)-supplemented salt (3 g of DEC per 1 kg of salt).[29] The third stage (1981–1990) focused on treatments in weak-performing areas, identifying remaining infection sources and continued monitoring. In 1990, the county was assessed by the Guangxi Zhuang Autonomous Region and met the standard for filariasis elimination as a public health problem. The fourth stage (after 1990) involved post-elimination monitoring.

Table 6. Screening results of other affected populations.

Screened area	Screening method	People screened, n	Positive cases, n	Rate of positive cases, %
People residing in other natural villages in the administrative village where the outbreak was located	Pathogenic examination	92	0	0.00
Migrant workers from other natural villages in the administrative village where the outbreak area was located	Pathogenic examination	150	0	0.00
People from other natural villages in the administrative village where the outbreak area was located, who were near the migrant working area	Pathogenic examination	830	0	0.00
Migrant workers from other administrative villages in Chaodong Town	Pathogenic examination	159	0	0.00
People residing in Chaoshan administrative village, Chaodong Town	Pathogenic examination	342	0	0.00
People residing in Huangsha administrative village, Chaodong Town	Pathogenic examination	266	0	0.00
People residing in Fuxi administrative village, Chaodong Town	ICT	473	0	0.00
People residing in Changchun administrative village, Mailing Town	ICT	974	0	0.00
Chaodong Town Junior High School	ICT	1429	0	0.00
Chaodong Town Centre Primary School	ICT	635	0	0.00
People residing in Mati administrative village, Xia Lianpu Town, Jiangyong County	ICT	533	0	0.00
People residing in Shangcun administrative village, Xia Lianpu Town, Jiangyong County	ICT or pathogenic examination	169	0	0.00
People residing in Huangjia administrative village, Lanxi Town, Jiangyong County	ICT	337	0	0.00
Total	—	6389	0	0.00

Historical work in Chaodong Town

According to the Annual Cumulative Filariasis Treatment in Communes of Fuchuan County (1958–1984), Chaodong Commune (now Chaodong Town) conducted a cumulative total of 37 125 blood examinations, treated 1131 cases and administered medicated salt to 47 590 individuals. A pilot project using 0.3% DEC-supplemented salt was carried out in 1976 in Chaodong and two other communes, lasting 9 months.

Historical work in Changtang administrative village

According to the Fuchuan County Filariasis Prevention and Control Data (January 1985), Changtang Brigade (now Changtang administrative village) administered a 3-day regimen of 3 g DEC in December 1971 to 33 microfilaremia cases. In September 1972, the same treatment was reapplied to 26 individuals. In August 1976, the Changtang Brigade implemented the widespread administration of 0.3% DEC-supplemented salt (totalling 9 g DEC over 9 months), covering 936 people. In October 1980, a second round (totalling 6 g DEC over 6 months) was carried out, covering 966 people. In the post-eradication monitoring phase, Changtang administrative village had no record of filariasis monitoring. The interviews with village doctors, township health clinic doctors and older residents of Changtang administrative village showed that some residents preferred regular salt during the phase of administering 0.3% DEC-supplemented salt and no monitoring of filariasis was conducted in the Changtang administrative village after 1990.

ERP roadmap

An ERP was developed, encompassing case detection, epidemiological investigation, interventions, assessment, and surveillance in a residual filariasis focus, based on historical review and assessments (Figure 2). The ERP consists of four parts. Part 1 is discovering and confirming the focus. Part 2 is confirming the scope and characteristics of the focus. Part 3 is interventions based on the results of parts 1 and 2. Part 4 is evaluating the interventions of the focus, summarizing the experience and performing long-term monitoring afterward. For the significance analysis of the four parts of the ERP, see Supplementary material 6.

Table 7. The filariasis control stages in Fuchuan County prior to 2007.

Stage	Periods	Main work/achievement
First	Before 1970	Grasping the epidemic situation
Second	1971–1980	County-wide survey to understand the distribution and intensity of the epidemic, administering medication to the entire population in epidemic villages. In 1976 and 1980, two county-wide campaigns were carried out to administer 0.3% DEC-supplemented salt
Third	1981–1990	Treatments in weak-performing areas, identifying remaining infection sources and continued monitoring. In 1981, the former Health Department of Guangxi Zhuang Autonomous Region conducted an assessment for the basic eradication of filariasis in the county, surveying 8 townships and 4 administrative villages and examining 11 646 individuals, among whom 5 had microfilaremia. The highest microfilaria rate per village was 0.20%, confirming the county had reached the standard for baseline eradication of filariasis. From October 1985 to 1990, an expert group convened by the Ministry of Health conducted a spot-check re-examination and found no microfilaria-positive cases and no larval filarial infections in mosquito vectors. In 1990, the county was assessed by the Guangxi Zhuang Autonomous Region and met the standard for filariasis elimination as the public health problem
Fourth	1991–2006	Post-elimination monitoring

Discussion

After eliminating an infectious disease in an area, it is impossible to rule out the re-emergence or importation of cases, and there may even be the discovery of a missed epidemic point during the elimination process, such as the residual focus described in this report, in which the first case was an 18-year-old villager with the clinical manifestations and symptoms of acute filariasis. Among the 17 cases found in 2007, 7 cases exceeded the density of transmission threshold of 15 microfilariae.[31] *C. quinquefasciatus* accounted for approximately one-third of all captured mosquitoes, making it the dominant species. Compared with the 3- to 49-year-old age group and females, higher risk was observed in the 50- to 69-year-old age group and males, respectively. A retrospective analysis of historical records indicated potential issues of missed diagnoses or incomplete treatments since the 1970s in this focus, especially after 1990. The screening of nearby individuals identified no microfilaremia cases, suggesting no epidemic spread from this focus site to other locations.[8,14,15,22] Based on these findings, the Changtang administrative village has been identified as a residual endemic focus within the formerly filariasis-prevalent area, demonstrating focal transmission characteristics. However, dissected *C. quinquefasciatus* in 2007 did not show larval filarial infections. The specific reasons for the discrepancy between the epidemiological status of filariasis in human populations and the mosquitos require further investigation.

Chinese prevention and treatment practices, along with long-term longitudinal monitoring results, indicate that the longest duration for bancroftian filariasis with microfilaremia to turn negative is 9 y,[6–8] making a 10-y post-elimination monitoring period appropriate.[8,32–40] The assessment of the infection source 10 y later showed effective management of the residual focus. The database assessment showed that only one confirmed filariasis case was reported through the IDRMS after 2008. The confirmed case with a work history in Africa was diagnosed in 2019 with *Loa loa* filariasis, which is primarily endemic in Africa,[41] making this a case of imported disease. Therefore, since 2008, no further filariasis focus has been reported in mainland China.

The ERP framework was built by reviewing the response process of the filariasis focus. The assessment results show that the interventions in the residual filariasis focus have been very effective. It is crucial to rapidly identify the index case, quickly screen both local and migrant workers in the epidemic area and treat based on the screening results.

The fast and accurate action is due to a large number of skilled grassroots prevention and control technicians in China and decades of effective prevention and control experience. For example, although the combination of albendazole and DEC does not significantly improve the effectiveness of DEC,[42] it can avoid causing biliary ascariasis and reduce adverse reactions. Providing 0.3% DEC-supplemented salt is another proven effective measure in China, typically used in highly prevalent areas of bancroftian filariasis to quickly reduce the population's microfilaria rate. In the actual operation process, it should be separately formulated based on the amount of salt consumed by local people and the course of treatment, and it is necessary to ensure effective supply to the population.

Data loss and bias were inevitable, as the focus records were dated and mostly retrieved from paper-based archives. Based on comparisons with data from published papers,[15,22] data loss and bias did not significantly impact this study's scientific validity and experiential conclusions. However, since all dissected mosquito specimens were collected exclusively from human dwellings, the potential presence of infected vectors in animal shelters, outdoor environments and other undomesticated habitats cannot be entirely excluded, which might facilitate epidemic recrudescence. Thus control of the vector (mosquito) should be added to the ERP framework. The control measures include but are not limited to monitoring and residual insecticide spraying.

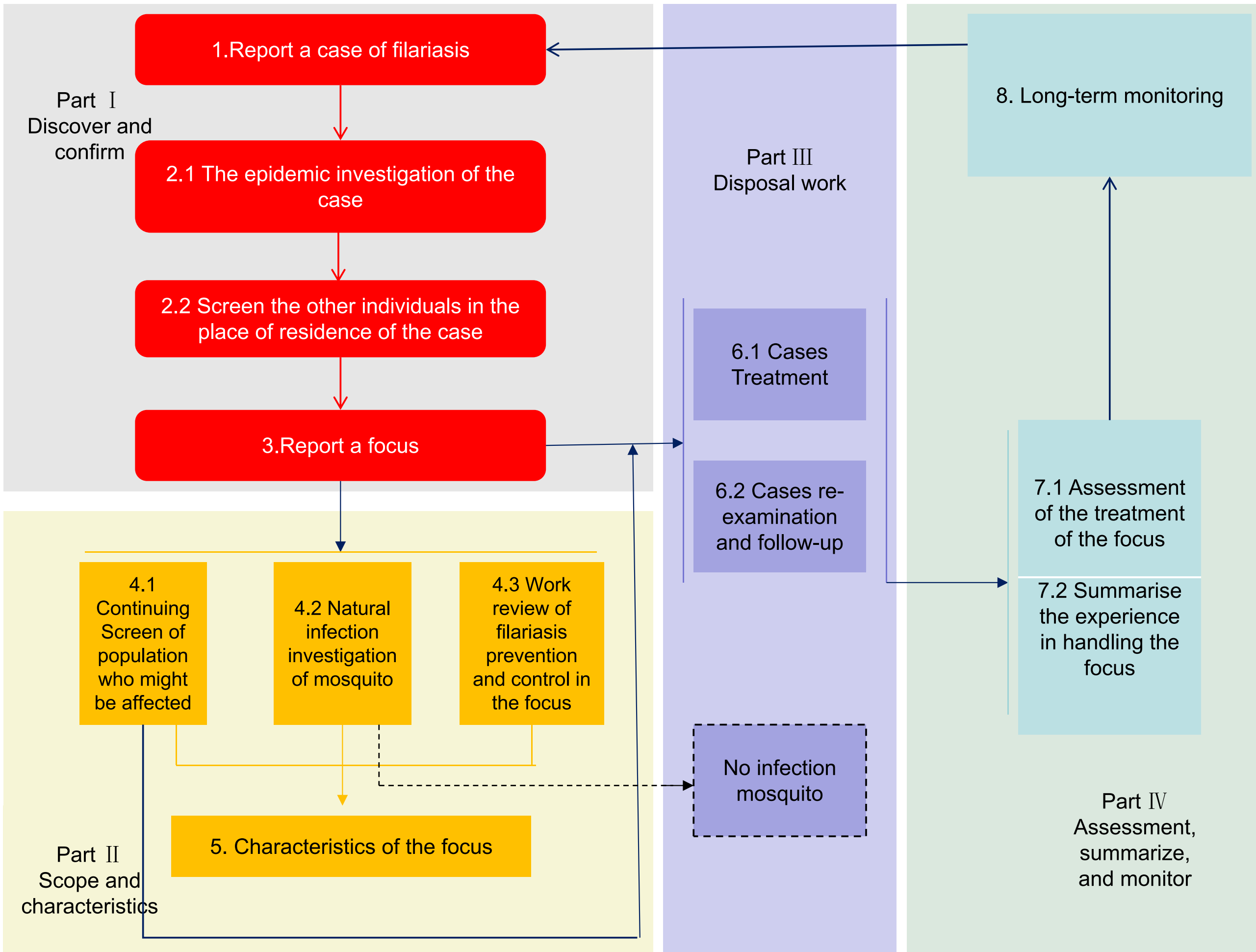

Figure 2. ERP of the focus.

Through a literature review, we found that some regions, including China, have different measures taken after the elimination of LF and the discovery of new cases. Although the WHO announced the elimination of filariasis in Futuna in 2018, Sri Lanka in 2016 and Togo in 2017, there were still prevalent and clustered cases of LF in Futuna in 2024;[18] 566 new cases of lymphoedema in Sri Lanka in 2022, including 15 cases <20 y of age;[20] a confirmed case of microfilaremia was reported in a migrant population of nomadic Peuhl and an investigation was conducted on the family members of the case in Togo in 2018.[19] Notably, China has established a distinctive closed-loop ERP encompassing case detection, epidemic characterization, outbreak management with outcome evaluation and continuous surveillance—a model unparalleled in global public health practice.

In China, monitoring is based on a case reporting system that maintains contact with all county-level hospitals in China and even with the vast majority of grassroots township health centres in real time. Therefore, in China, due to the sensitivity of case reporting, mosquito vector monitoring is often less common in current surveillance for LF. For some countries and regions with incomplete construction of grassroots medical institutions, mosquito vector monitoring is a convenient and economical alternative. Many countries do not monitor filariasis through the surveillance of human health. Entomological methods are also often used to assess and surveil the transmission of filariasis, such as in Ecuador[43] and northern Cameroon.[44] A program for post-validation surveillance for LF based on the nominal group technique has been reported in the Pacific Islands, but the implementation effect of the program has not been found.[45]

Based on these experiences, the following recommendations are proposed for post-elimination control of filariasis: have at least one sensitive and effective post-elimination surveillance strategy; vigilant monitoring and thorough investigation in remaining outbreak foci, particularly in historically endemic regions with limited medical resources; encourage reporting of remaining filariasis cases by individuals and institutions; regularly assess the global epidemiological situation and the risk of imported cases; and include filariasis testing for individuals returning from endemic areas abroad and strengthen health education for international travellers. In countries and regions with a lack of funding, poor motivation, poor program sustainability planning and a lack of drugs at health facilities, it is obviously impossible to maintain such expensive programs. However, certain actions should be taken at key nodes, such as conducting training for community doctors in key areas rather than the whole country and fully communicating with international institutions to obtain global risk information, which is also an effective way to supplement their own resource shortages. In the future, investigating the epidemiological characteristics of residual foci or evaluating the cost-effectiveness of different surveillance strategies should be studied to meet the needs of more countries.

Conclusions

This study evaluated the effectiveness of the disposal of a residual focus that occurred in Changtang Town, Fuchuan County, Guangxi Zhuang Autonomous Region, PRC in 2007, supporting the conclusion that the WHO and Chinese experts recognized in 2007 that the residual focus did not pose a public health threat. On this basis, we have summarized the ERP and the experience of handling the rediscovery of a focus after the elimination of filariasis, revised the ERP further based on the study results, providing references for global monitoring and focus disposal after the elimination of infectious diseases.

Supplementary data

Supplementary data are available at *Transactions* online.

Authors' contributions: CX contributed to the conceptualization, investigation, software, validation, visualization, writing the original draft and review and editing. YW contributed to the investigation, methodology and supervision. YS and BT contributed to data curation and resources. WW contributed to the investigation and project administration. SH contributed to funding acquisition, investigation, project administration, resources and supervision.

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Data availability: The data underlying this article cannot be shared publicly due to the privacy of individuals who participated in the study. The data will be shared upon reasonable request to the corresponding author.

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