Parasitology International 63 (2014) 500–505

Contents lists available at ScienceDirect

Parasitology International

journal homepage: www.elsevier.com/locate/parint

Dynamics of spatial clustering of schistosomiasis in the Yangtze River Valley at the end of and following the World Bank Loan Project

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ARTICLE INFO

Article history:
Received 11 October 2013
Received in revised form 12 December 2013
Accepted 28 January 2014
Available online 14 February 2014

Keywords:
Schistosomiasis
Spatial clustering
World Bank Loan Project (WBLP)
Yangtze River

ABSTRACT

The 10-year (1992–2001) World Bank Loan Project (WBLP) contributed greatly to schistosomiasis control in China. However, the re-emergence of schistosomiasis in recent years challenged the long-term progress of the WBLP strategy. In order to gain insight in the long-term progress of the WBLP, the spatial pattern of the epidemic was investigated in the Yangtze River Valley between 1999–2001 and 2007–2008. Two spatial cluster methods were jointly used to identify spatial clusters of cases. The magnitude and number of clusters varied during 1999–2001. It was found that prevalence of schistosomiasis had been greatly reduced and maintained at a low level during 2007–2008, with little change. Besides, spatial clusters most frequently occurred within 16 counties in the Dongting Lake region and within 5 counties in the Poyang Lake region. These findings precisely pointed out the prior places for future public health planning and resource allocation of schistosomiasis.

1. Introduction

Schistosomiasis japonica, a disease caused by *Schistosoma japonicum*, has long been a major public health problem in China. It disabled and killed millions of Chinese before the national control program commenced in the 1950s [1]. The following sustained control efforts reduced the number of infected people from 11.8 million in the 1950s to 1.6 million in 1989[2]. In 1992, the Chinese Government obtained a 10-year (1992–2001) World Bank loan of US$ 71 million, complemented with US$ 82 million from the Chinese government, to further boost schistosomiasis control [3]. The main control tool of this World Bank Loan Project (WBLP) was large-scale chemotherapy, which was complemented by chemical control of snails, environmental modification where appropriate, and health education. The specific targets were: (1) to reduce the prevalence of infection in humans by 40%; (2) to reduce the prevalence of infection in cattle and buffaloes by 40%; and (3) to reduce the snail infection rate and density of infected snails by at least 50%. By the end of the WBLP in 2001, the number of infected people was reduced to less than 1 million [4,5] and the prevalence in humans and livestock had also decreased by over 50% [6] and the densities of infected snails in the different epidemiological strata had all decreased by more than 75% [6].

With the termination of the chemotherapy-based WBLP in 2001, however, the steady reduction in the prevalence of and morbidity due to *S. japonicum* pulled up and there were again clear signs of re-emergence of the disease in the lake and marshland areas of the Yangtze River Valley [5,7,8], with an estimate of up to 56% infection in some villages in 2004 [9]. Moreover, *S. japonicum* reemerged in previously controlled areas and snail-infested areas were found in formerly non-endemic provinces (e.g. Shanghai, Zhejiang and Fujian) in 2003[10]. This led us to question the long-term progress of the WBLP strategy though previous studies [6,11] confirmed that the original objectives of the WBLP strategy – to control schistosomiasis morbidity – had been met shortly after the termination of the WBLP. In response to this doubt, a comparison can be made of patterns of schistosomiasis during different periods. Analyzing spatial patterns of epidemics with time sequence can provide valuable clues to disease sources (and determinants) [12], future prediction [13], and control policies [14].

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http://dx.doi.org/10.1016/j.parint.2014.01.009
1383-5769/

One of the techniques to uncover spatial patterns of disease is cluster detection, which can further help to generate new information for further etiologic studies and identify risk areas to focus the surveillance and allocate the resources (e.g. antibiotics) [15,16].

In this study, we investigated the spatial pattern of schistosomiasis in the Yangtze River Valley at the county level between 1999–2001 and 2007–2008 to evaluate the long-term progress of the WBLP. The national database on schistosomiasis was used to perform two cluster detection methods to disclose the spatial cluster of the disease during two study periods. Then, the most frequently affected areas were identified. Finally, the potential implications of the findings for schistosomiasis control in the Yangtze River Valley were discussed.

2. Material and methods

2.1. Study area

The study was carried out in the lake and marshland regions of schistosomiasis in the middle and lower reaches of the Yangtze River, which included five provinces — Hunan, Hubei, Anhui, Jiangxi, and Jiangsu (Fig. 1). There were 261 schistosomiasis endemic counties in this area, out of which 115 reached the criterion of transmission interruption, 57 achieved transmission control, and 89 had ongoing transmission [17] (the criterion of transmission interruption, transmission control, and ongoing transmission can be found elsewhere [2]). Although the WBLP was terminated at the end of 1998 in Anhui, Jiangxi, and Jiangsu provinces, serials of follow-up control activities based on funding from the respective local governments were carried out until the end of 2001 according to the operational plan set out by the WBLP [17,18]. Therefore, these provinces underwent similar stages of the schistosomiasis control strategy with Hubei and Hunan which were continuously funded by the WBLP.

2.2. Parasitological data

The county-level prevalence data on schistosomiasis were obtained from the national annual report on schistosomiasis. These data were originally collected through village-based field surveys using a two-pronged diagnostic approach (screening by a serological test on all residents of 5 to 65 years old and then confirmation by a fecal parasitological test (Kato-Katz technique)), then reported to the townships and finally summed at the county level. Village- and township-based data were not available, so the county-level national databases for the study area during the two periods of 1999–2001 and 2007–2008 were obtained. Number of residents infected and population at risk in each county for the two periods were used to estimate the prevalence of schistosomiasis and to analyze the dynamics of spatial risk distribution and spatial heterogeneities of schistosomiasis-related risk.

2.3. Ethics statement

The study protocol was approved by the Ethics Committee of Fudan University (ID: IRB#2011-03-0295). Written informed consent was also obtained from all participants.

2.4. Statistical analysis

First, prevalence of schistosomiasis, together with preliminary descriptive statistics, for each year was calculated to compare change in prevalence during the epidemics. Second, to identify high risk areas of schistosomiasis, we searched for annual spatial clusters which were defined as groups of schistosomiasis cases occurring during the same year and situated closer together in space than would be expected from the random variation in population. Two cluster detection methods were used to uncover spatial clustering of schistosomiasis.

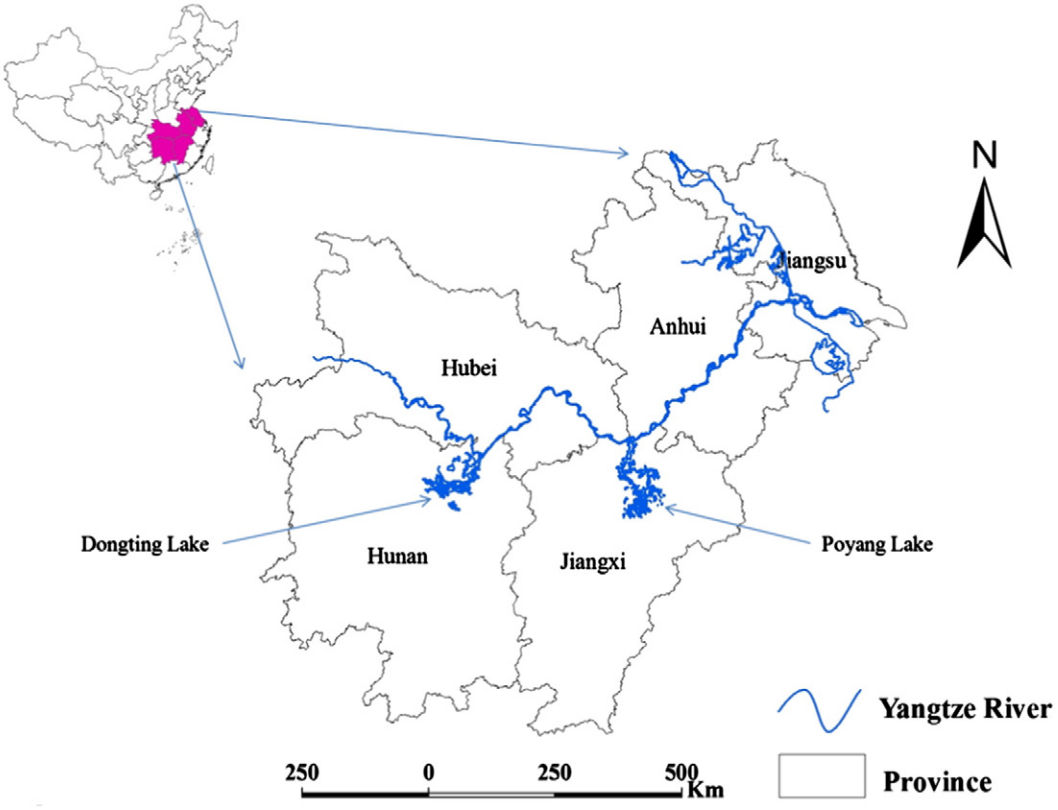

Fig. 1. Location of the five provinces in the Yangtze River Valley. Geographical layer of water body is overlaid.