



Control of soil-transmitted helminthiasis in Yunnan province, People's Republic of China: Experiences and lessons from a 5-year multi-intervention trial



Peter Steinmann^{a,b,*,1}, Peiling Yap^{a,b,1}, Jürg Utzinger^{a,b}, Zun-Wei Du^c, Jin-Yong Jiang^c, Ran Chen^d, Fang-Wei Wu^d, Jia-Xu Chen^e, Hui Zhou^{a,b}, Xiao-Nong Zhou^e

^a Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland

^b University of Basel, P.O. Box, CH-4003 Basel, Switzerland

^c Helminthiasis Division, Yunnan Institute of Parasitic Diseases, Pu'er 665000, People's Republic of China

^d Menghai Center for Diseases Control and Prevention, Menghai 666200, People's Republic of China

^e National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai 200025, People's Republic of China

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ABSTRACT

The current global strategy for the control of soil-transmitted helminthiasis emphasises periodic administration of anthelmintic drugs to at-risk populations. However, this approach fails to address the root social and ecological causes of soil-transmitted helminthiasis. For sustainable control, it has been suggested that improvements in water, sanitation and hygiene behaviour are required. We designed a 5-year multi-intervention trial in Menghai county, Yunnan province, People's Republic of China. Three different interventions were implemented, each covering a village inhabited by 200–350 people. The interventions consisted of (i) initial health education at study inception and systematic treatment of all individuals aged ≥ 2 years once every year with a single dose of albendazole; (ii) initial health education and bi-annual albendazole administration; and (iii) bi-annual treatment coupled with latrine construction at family level and regular health education. Interventions were rigorously implemented for 3 years, whilst the follow-up, which included annual albendazole distribution, lasted for 2 more years. Before the third round of treatment, the prevalence of *Ascaris lumbricoides* was reduced by only 2.8% in the annual treatment arm, whilst bi-annual deworming combined with latrine construction and health education resulted in a prevalence reduction of 53.3% ($p < 0.001$). All three control approaches significantly reduced the prevalence of *Trichuris trichiura* and hookworm, with the highest reductions achieved when chemotherapy was combined with sanitation and health education. The prevalence of *T. trichiura* remained at 30% and above regardless of the intervention. Only bi-annual treatment combined with latrine construction and health education significantly impacted on the prevalence of *Taenia* spp., but none of the interventions significantly reduced the prevalence of *Strongyloides stercoralis*. Our findings support the notion that in high-endemicity areas, sustainable control of soil-transmitted helminth infections necessitates measures to reduce faecal environmental contamination to complement mass drug administration. However, elimination of soil-transmitted helminthiasis will not be achieved in the short run even with a package of interventions, and probably requires improvements in living conditions, changes in hygiene behaviour and more efficacious anthelmintic drugs and treatment regimens.

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* Corresponding author at: Department of Epidemiology and Public Health, Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland.
Tel.: +41 61 284-8229; fax: +41 61 284-8105.

E-mail address: peter.steinmann@unibas.ch (P. Steinmann).

¹ These two authors contributed equally to the work reported here.

1. Introduction

Mass drug administration (MDA), more recently phrased “preventive chemotherapy” by the World Health Organization (WHO), refers to the periodic administration of anthelmintic drugs to populations at risk of morbidity and is the cornerstone of the current global strategy to control soil-transmitted helminthiasis and other neglected tropical diseases (WHO, 2006, 2010).

Soil-transmitted helminthiasis is caused by chronic infection with the nematode worms *Ascaris lumbricoides*, hookworm (*Ancylostoma duodenale* and *Necator americanus*) and *Trichuris trichiura* (Bethony et al., 2006; Hotez et al., 2008; Knopp et al., 2012). Morbidity is associated with the intensity of infection (commonly expressed as eggs per 1 g of stool (EPG)), the duration of infection and the degree of multiparasitism (Ezeamama et al., 2005; Hall et al., 2008; Steinmann et al., 2010). Hence, the primary goal of MDA is a reduction of the infection intensity with the aim of eliminating moderate and especially heavy infections among school-aged children, women of childbearing age and other vulnerable groups (WHO, 2006). However, the high reproductive capacity of soil-transmitted helminths means that in the absence of additional interventions to break the transmission cycle, transmission usually is not interrupted even if the infection intensity is greatly reduced (Jia et al., 2012).

Promising interventions to interrupt transmission include the provision and use of adequate sanitation to end open defecation, improved personal and food hygiene behaviour and access to clean water (Albonico et al., 2006). Recent systematic reviews and meta-analyses have shown the pivotal importance of water, sanitation and hygiene (WASH) interventions for sustainable control of soil-transmitted helminthiasis (Strunz et al., 2014; Ziegelbauer et al., 2012). However, few studies have endeavoured to demonstrate the feasibility and community-effectiveness of different interventions for the control of soil-transmitted helminthiasis, and longitudinal data spanning several years are scarce.

The People's Republic of China (P.R. China) has made huge investments towards expanding safe water supply and sanitation. In 2012, for example, 98% of the population in urban areas had access to both an improved water source and sanitation according to official data, while in rural areas, the respective coverage rates were 85% and 70% (WHO/UNICEF Joint Monitoring Programme, 2014). Although open defecation has officially been ceased throughout the country (WHO/UNICEF Joint Monitoring Programme, 2014), this unhygienic behaviour persists in remote rural and marginalised communities, including those where the current study has been implemented (Steinmann et al., 2008a). In P.R. China, the great progress made in WASH indicators over the past two decades—in 1990, 33% of the total population had no access to safe water and 69% used unimproved sanitation facilities—have certainly contributed to the impressive reductions in the prevalence of soil-transmitted helminths that have been documented through nation-wide surveys. Indeed, the first national survey undertaken between 1988 and 1992 found prevalences of 47%, 19% and 17% for *A. lumbricoides*, *T. trichiura* and hookworm (Yu et al., 1994), while the second national survey, completed in 2004, found respective prevalences of 13%, 5% and 6% (Ministry of Health, 2005). These declines are confirmed by a recent systematic review of soil-transmitted helminth surveys across P.R. China and geostatistical meta-analysis (Lai et al., 2013). Undoubtedly, MDA-based control programmes contributed to the reduction of soil-transmitted helminthiasis, although there is still no national control programme pertaining to soil-transmitted helminthiasis in P.R. China (Montresor et al., 2008).

High levels of soil-transmitted helminth infections and rapid reinfection patterns resulting in pervasive intestinal multiparasitism have been documented in villages in the south-west of Yunnan province that are inhabited by the Bulang ethnic minority (Steinmann et al., 2008a; Yap et al., 2012a, 2013). Our previous research in this area has prompted local interest in designing, rigorously implementing and evaluating different anthelmintic treatment regimens and intervention packages for the control of soil-transmitted helminthiasis that might guide regional control interventions. Three intervention packages were tested based on

epidemiological considerations and existing national guidelines for soil-transmitted helminthiasis control, with each intervention implemented in one community. The objective of this 5-year prospective community-based intervention study was to establish the feasibility and long-term community-effectiveness of different soil-transmitted helminthiasis control strategies in high endemicity settings.

2. Materials and methods

2.1. Ethics statement

The study was an integral part of a post-doctoral project for which ethical clearance was granted by the academic board of the National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention (IPD, China CDC; Shanghai, P.R. China). The study was approved by village leaders and doctors of each study village. Written or oral informed consent to join the study was obtained during the baseline cross-sectional survey and again prior to the first drug administration, as appropriate: adults signed an informed consent declaration, while parents or legal guardians signed on behalf of minors who had assented orally.

2.2. Rationale and interventions

The design of the different interventions targeting soil-transmitted helminthiasis was guided by the following considerations and hypotheses: (i) the current standard approach to control soil-transmitted helminthiasis in P.R. China is annual MDA to the entire population in heavily endemic communities; (ii) regular MDA reduces the prevalence and intensity of soil-transmitted helminth infections, but fails to suppress rapid re-infection; (iii) reductions in the prevalence and intensity of infection correlate with the frequency of MDA; (iv) the provision of locally acceptable latrines reduces open defecation, translating into a direct impact on the transmission of soil-transmitted helminthiasis; and (v) the frequency of drug administration can be lowered once incidence rates have decreased considerably.

The following three intervention packages were developed and rigorously implemented during the first 3 years of the study (phase 1): (A) initial health education at study inception and annual administration of a single 400 mg oral dose of albendazole to all individuals aged 2 years and above; (B) initial health education at study inception and bi-annual administration of albendazole; and (C) construction of an improved latrine for each interested family, regular health education and bi-annual administration of albendazole. In a second phase, lasting for 2 more years, annual MDA replaced the more intensive control efforts specified above and was implemented in all three communities.

2.3. Study area and design

The study was implemented in three villages (Nanwen upper, Nanwen lower and Mangguo new) in the mountainous part of Menghai county, Yunnan province, in the south-western part of P.R. China. The three study villages are situated within a few kilometres of each other on the slope of a mountain and share important geographic and infrastructure characteristics, are inhabited exclusively by the Bulang ethnic minority group and the socioeconomic conditions are comparable. Nanwen upper village (geographical coordinates 21°46'02.15"N latitude, 100°23'50.61"E longitude; elevation about 1650 m above sea level; intervention (A)) is a community of about 80 households with approximately 320 residents. Nanwen lower village (21°46'34.02"N, 100°23'56.89"E; elevation about 1500 m; intervention (B)) consists of about 60 households with 240 residents. Mangguo new village (21°45'09.01"N,

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