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Integrated School-Based Surveillance for Soil-Transmitted Helminth Infections and Lymphatic Filariasis in Gampaha District, Sri Lanka

Sharmini Gunawardena, Nipul K. Gunawardena, Ganga Kahathuduwa, Nadira D. Karunaweera, Nilanthi R. de Silva, Udaya B. Ranasinghe, Sandhya D. Samarasekara, Kumara C. Nagodavithana, Ramakrishna U. Rao, Maria P. Rebollo, and Gary J. Weil*

Department of Parasitology, Faculty of Medicine, University of Colombo, Sri Lanka; Department of Parasitology, Faculty of Medicine, University of Kelaniya, Sri Lanka; Anti Filariasis Campaign, Ministry of Health, Sri Lanka; Department of Internal Medicine, Infectious Diseases Division, Washington University School of Medicine, St. Louis, Missouri; Centre for Neglected Tropical Diseases, Liverpool School of Tropical Medicine, United Kingdom

Abstract. We explored the practicality of integrating surveillance for soil-transmitted helminthiasis (STH, assessed by Kato-Katz) with transmission assessment surveys for lymphatic filariasis (LF) in two evaluation units (EUs) in Gampaha district, Sri Lanka (population 2.3 million). The surveys were performed 6 years after five annual rounds of mass drug administration with diethylcarbamazine and albendazole. Each transmission assessment survey tested children (N = 1,462 inland EU; 1,642 coastal EU) sampled from 30 primary schools. Low filarial antigenemia rates (0% and 0.1% for the inland and coastal EUs) suggest that LF transmission is very low in this district. The STH rates and stool sample participation rates were 0.8% and 61% (inland) and 2.8% and 58% (coastal). Most STH detected were low or moderate intensity *Trichuris trichiura* infections. The added cost of including STH testing was ~$5,000 per EU. These results suggest that it is feasible to integrate school-based surveillance for STH and LF.

INTRODUCTION

In recent years, health ministries, international donors, and non-governmental organizations have supported neglected tropical diseases (NTDs) control programs with independent, often parallel structures, with each maintaining its own planning, funding, monitoring, and evaluation strategies.[1–6] However, because control strategies and endemic areas for different NTDs often overlap, integrated programs may provide advantages over parallel programs in terms of cost and efficiency.[1–3,5]

Lymphatic filariasis (LF) due to *Wuchereria bancrofti* is endemic along the western and southern coastal belt in Sri Lanka, encompassing eight districts in three provinces, namely North-Western, Western, and Southern provinces.[7–9] Soil-transmitted helminth infections (STHs, caused by *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and *Necator americanus* (hookworm) occur in all districts within the country.[10] However, STH infection rates vary greatly between locations because of various factors associated with STH transmission.[11]

As part of the Global Program for Elimination of Lymphatic Filariasis (GPELF), the Anti-Filariasis Campaign (AFC) of the Sri Lankan Ministry of Health conducted five consecutive annual rounds of mass drug administration (MDA) with albendazole and diethylcarbamazine citrate between 2002 and 2006 in the eight-endemic districts, including Gampaha district. The program targeted a population of ~10 million.[12] This program may have also reduced STH infection rates, because albendazole has good activity against intestinal nematodes.[13,14]

The AFC has recently initiated transmission assessment surveys (TAS) to look for evidence of ongoing transmission of filariasis ~6 years after the last round of MDA was provided in 2006.[15] The TAS surveys use systematic sampling or cluster sampling to test primary school children 6 or 7 years of age for the presence of circulating filarial antigen (CFA) in capillary blood.[16] Because school-aged children are especially vulnerable to the effects of STH infections,[17] school surveys are often used as a convenient platform for assessing STH rates in communities.[18,19]

The TAS surveys for LF in the Gampaha district were conducted in late 2012, some 6 years after the last round of MDA in this district. However, no recent surveys have been conducted for STH infections in Gampaha district. The most recent survey (2006) suggested that MDA for LF had little effect on STH infection rates in this region, because STH rates were low before MDA.[20] Because school-aged children represent a useful sentinel population for both LF and STH, we took this opportunity to explore the practicality of integrating surveillance for STH infections with TAS for LF in the Gampaha district of Sri Lanka in a programmatic mode.

MATERIALS AND METHODS

Study area. Gampaha district lies within the wet zone of Sri Lanka on the western coast. It has a warm, wet, climate with ambient temperatures between 22°C and 37°C, a mean annual rainfall of about 1,750 mm, and altitudes that range from sea level to 450 m. With 2.3 million inhabitants, Gampaha has urban, semi-urban, and rural populations in 1,386.6 km^2 of land. Because TAS guidelines suggest a maximum of two million for evaluation units (EUs), the district was divided into two EUs for post-MDA surveillance, one coastal and one inland. These EUs met other criteria for TAS surveys by having completed five rounds of MDA in 2006 with coverage rates > 80% of the total population and post-MDA microfilaria prevalence rates of < 1% in all sentinel and spot check sites.[12] No recent STH prevalence data were available for Gampaha, but children in Sri Lanka and in this district benefit from school-based de-worming with mebendazole in grades 1, 4, and 7.

Sampling method. The TAS surveys in Sri Lanka tested primary school children for filarial antigenemia in cluster surveys. The TAS surveys in Gampaha district were initiated in 2012 in 30 randomly selected schools per EU; systematic selection of school children was performed according to

*Address correspondence to Gary J. Weil, Infectious Disease Division, School of Medicine, Washington University in St. Louis, St. Louis, MO 63110. E-mail: gweil@dom.wustl.edu

TABLE 1
Deliverables of integrated transmission assessment surveys (TAS) and soil-transmitted helminth (STH) surveys in Gampaha district

Description	LF*-TAS	STH
Monitoring and assessment LF and STH	Post-MDA surveillance	District-wide prevalence study
Study area	One district, 2 evaluation units	One district, 2 evaluation units
Study location	Primary schools	Primary schools
Study subjects	6–7 years of age	6–7 years of age
Survey design	Cluster survey	Cluster survey
Sampled schools	60	60
Sample size	~3,000	~3,000
Biological sample	Blood	Stool
Diagnostic test	ICT	Kato-Katz
Diagnostic measure	Antigen positive or negative	Ova positive or negative, egg counts
Assessment criteria	Critical cutoff value	Infection rates

*LF = lymphatic filariasis.

Survey Sample Builder, SSB.V.2.0[15] (http://www.ntdsupport.org/resources/transmission-assessment-survey-sample-builder). The sampling strategy and survey deliverables are shown in Table 1.

A total sample of 3,112 children from 60 schools was targeted for surveillance, and each TAS tested first and second grade schoolchildren (N = 1,556 / EU). The children tested in the LF survey were also recruited for the STH survey. Two teams conducted the surveys in each EU, i.e., an AFC team for the LF survey and a university team for the stool survey. The STH survey in the inland EU was conducted at the same time as the TAS by personnel from the University of Kelaniya (UOK). The STH testing was conducted several weeks after the TAS in the coastal EU by personnel from the University of Colombo (UOC).

After approval from the Education Ministries (both central and provincial), the AFC team met with the principal of each school to obtain permission to conduct the survey and to schedule a date for meeting with the parents. The UOK team joined the AFC team for parents' meetings in the inland EU; the medical officers of both teams explained the details of the surveys to the parents, distributed information sheets, and the consent forms. Containers for sample collection were also distributed by the UOK personnel and the children were requested to bring the signed consent forms (for both LF and STH testing) together with the stool samples the following day. In the coastal EU, UOC personnel met parents of children already tested for LF to provide information, consent forms, and the containers for sample collection. The signed consent forms and samples were collected the following morning. Information regarding deworming treatments for these children over the past 6 months was obtained through a question placed in the consent form.

Tests for filariasis and STH. The Binax NOW Filariasis card test (commonly called the ICT card test) (Alere Inc., Scarborough, ME) was used for detecting CFA, and the Kato-Katz test (Vestergaard-Frandsen, India) was used for detecting STH ova. All ICT tests were performed by AFC personnel immediately after collection of finger prick blood. The 100 μL of blood was obtained by the finger-prick method for the ICT card test, which was read at 10 minutes after closing the card as per the manufacturer's instructions. The name, class, and test result of each child tested for LF was recorded. Either on the day of the parents' meeting (inland EU) or on a day shortly after the LF assay (coastal EU), consented children were given wide-mouthed plastic containers with lids and other accessories for collection of stool samples. The containers were labeled with the name and an identification number for each child. Children were asked to bring their stool samples in these containers placed within provided plastic bags on the following day. A university team member visited the schools on the day of collection and transported the stool samples to a university laboratory for testing.

All samples were processed according to the modified Kato Katz technique as recommended by the World Health Organization (WHO) and examined on the same day of collection[21]; a single slide was examined per child, and slides were left to clear for 20–60 minutes before reading. Readers recorded positivity and egg counts were converted to eggs per gram (epg) according to instructions in the kits. Infection intensities were classified as heavy, moderate, or light using cut-off values recommended by WHO.[22]

In each university laboratory, two laboratory assistants were involved in processing the samples for the Kato-Katz test, and two senior technical officers examined the smears. All activities took place under the guidance and supervision of two experienced researchers.

Data entry and analysis. The geographical location of each school was recorded using a hand-held Garmin Etrex-h GPS receiver (Garmin, Olathe, KS), and coordinates were transferred to a computer using EasyGPS software (TopoGrafix, Stow, MA). The map of schools with their STH results was developed using ArcGIS 10.1 (ESRI, Redlands, CA).

The TAS enrollment data and test results from each EU were collected by the AFC. The STH data were entered into EpiData (Epidata Association, Odense, Denmark) and Microsoft Excel (Microsoft Corp, Redmond, WA) sheets and analyzed by university team members. The costs incurred for conducting the STH surveys including consumables, logistics, and personnel were estimated. Personnel costs for STH surveys were determined by tabulating the number of person days for each job category.

Ethical approval and consent procedures. Ethical clearance for the study was granted by the Ethics Review Committee of the Faculty of Medicine, University of Colombo (EC-12-136). Human studies protocols were also approved by the institutional review board at the Centre for Neglected Tropical Diseases, Liverpool, UK. Written informed consent was obtained from parents for their child's participation in the study. All children with STH infections were treated by Medical Officers of Health in each area.

RESULTS

The TAS surveys performed CFA testing for 1,462 children in 30 schools in the inland EU from a total population of 4,119 first and second grade children. The coastal EU TAS survey tested 1,642 children in 30 schools from a total population of 5,329 children. Only one ICT-positive child was identified in the TAS surveys (coastal EU). The ICT rates were 0% and 0.1% (0.01–0.3% 95% confidence interval [CI]) in the inland and coastal EUs, respectively. The single ICT-positive child identified in the study was amicrofilaremic by night blood testing.

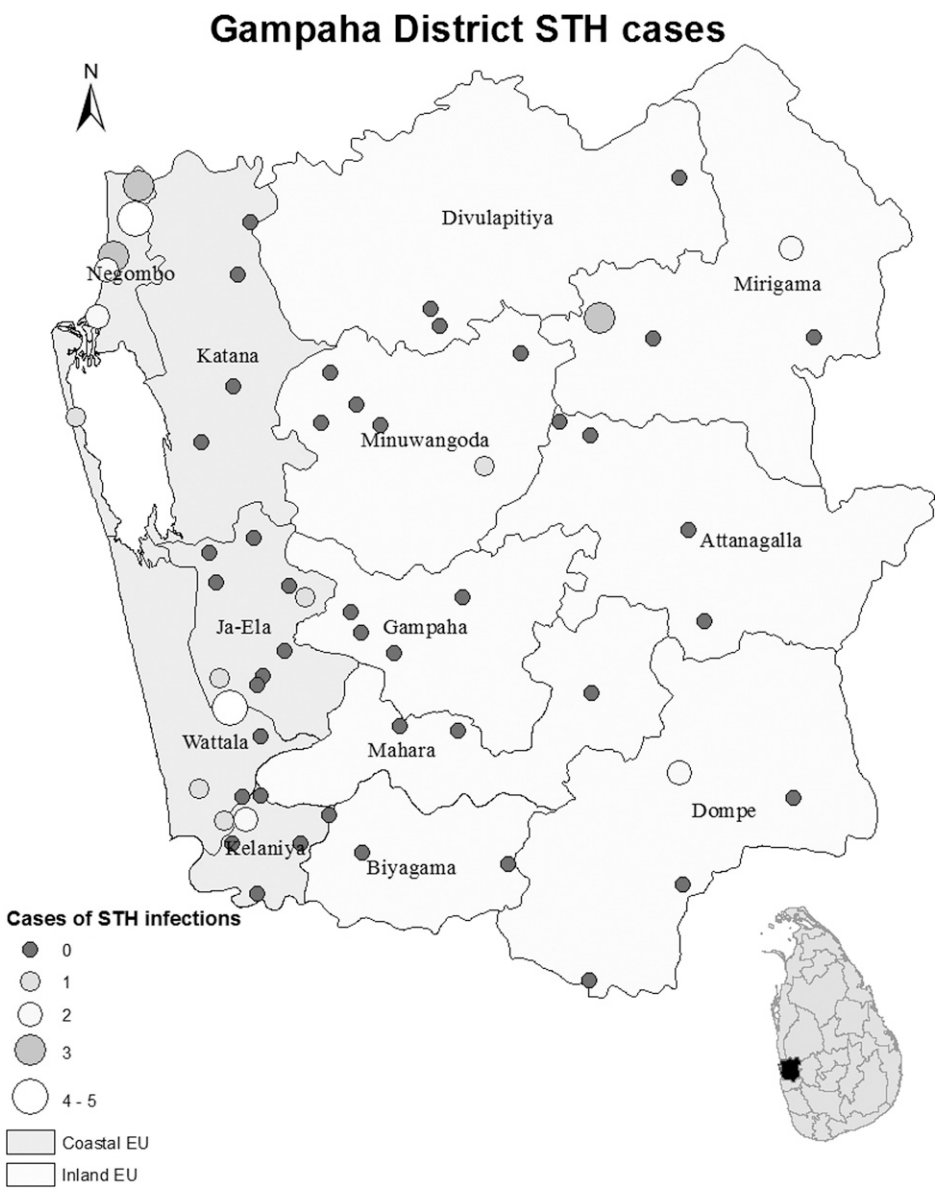

FIGURE 1. Presence of soil-transmitted helminth (STH) infections in primary grade school children from randomly selected schools located in the coastal and inland evaluation units (EUs) in Gampaha district, Sri Lanka.

A total of 955 stool samples from the inland EU (61% compliance for provision of stool samples) and 927 from the coastal EU (58% compliance) were submitted, and all were tested. The STH infection rates were 0.8% (0.43–1.64% CI) and 2.8% (1.92–4.08%) in the inland and coastal EUs, respectively (Figure 1; Table 2). Most of the STH infections detected were low-intensity *T. trichiura* infections (present in 73% of positive stools). One multiple infection with hookworms and

TABLE 2
Prevalence and intensity of soil-transmitted helminth (STH) infections in two evaluation units (EUs) in Gampaha District

	Number of positive tests (%)			STH intensity						
					Epg range			Epg range		
		Inland EU	Coastal EU	Light (n)	Inland EU	Coastal EU	Moderate (n)	Inland EU	Coastal EU	High (n)
A. lumbricoides	05 (0.27)	03 (0.31)	02 (0.22)	05	72–168	129.5–1073	0	0	0	0
Hookworms	05 (0.27)	04 (0.42)	01 (0.11)	05	96–168	120	0	0	0	0
T. trichiura	25 (1.33)	01 (0.10)	24 (2.59)	21	24	18.5–980.5	04	0	1868.5–6068	0
TOTAL (n)	34 (1.81)	08 (0.84)	26 (2.80)	31			04			0

The number of stool samples tested for the inland and coastal EUs were 955 and 927, respectively. *Ascaris lumbricoides*, *Trichuris trichiura*, and hookworm infections with egg counts < 5000, 1,000, and 2,000 eggs per gram (epg) stool, respectively, were categorized as light; those with egg counts of 5,000–49,999, 1,000–9,999, and 2,000–3,999 epg stool, respectively, were categorized as moderately heavy; those with eggs counts of ≥ 50,000, ≥ 10,000, and ≥ 4,000 epg stool, respectively, were categorized as heavy infections.

TABLE 3
Cost summary for soil-transmitted helminth infection surveys in two evaluation units (EUs) in Gampaha district

Item	Description	Expenditure (US$)	
		Inland EU	Coastal EU
Consumables and reagents	Kato-Katz kits, microscope slides, gloves, face masks, plastic containers with lid, lysol, malachite green	731.07	810.80
Personnel	Allowances and subsistence for technical officers, laboratory assistants, research assistants, consultants	2033.62	1894.27
Logistics	Transport, fuel	1341.00	1443.08
	Incidental expenses (consent form preparation and printing, communication costs)	157.14	119.61
	Institutional review board approvals		7.69
	University administration charges	746.21	792.54
Total		5009.04	5,068.00

T. trichiura was detected in the coastal EU. Twelve of 30 schools in the coastal EU and 4 of 30 schools in the inland EU had at least one STH positive child. More STH infections were observed in coastal EU schools located in Negombo and Ja-Ela educational divisions than in other divisions.

Almost 36% ($N = 342$) of children from the inland EU and 44% ($N = 408$) from the coastal EU stated that they had been de-wormed within the past 6 months. In the inland EU, only 6% stated that they had not been de-wormed, whereas the remainder (58%) did not respond to the question. In the coastal EU, 56% of the children stated that they had not been de-wormed in the past 6 months, and all of the children with STH infections belonged to this group.

The cost for STH testing was approximately US $5,000/EU with almost $1,000 for consumables, $2,000 for personnel, and the balance for logistics (Table 3). The cost was estimated for testing 1,500 samples per EU from 30 schools, making at least two visits to each school. The mean personnel totals per EU were 40 person days for research assistants, 31 person days for laboratory assistants, and 31 person days for laboratory technicians.

The cost for ICT testing was approximately US $6,520 per EU, excluding the cost of ICT devices that were donated by the WHO; the cost per ICT card is approximately US $3 per test including shipping). The personnel cost for conducting TAS in each EU was about US $3,400 for 40 person days for field staff and 7 person days for medical officers. The rest of the TAS cost was for collection of school demographic records, staff training, transportation, and fuel.

DISCUSSION

The WHO recommends using TAS as a primary tool for deciding when to stop MDA and for post-MDA surveillance in LF elimination programs. The AFC had conducted school-based post-MDA surveillance in 2008 according to earlier WHO guidelines, and they conducted TAS between 2012 and 2013 according to current WHO guidelines.[23] In addition, independent surveys have been conducted in some districts to evaluate the impact of MDA and to detect evidence of persistent LF in support of the national program.[24,25] However, there is currently no scheme for regularly assessing the prevalence of STH infections in the country. We performed this study as a pilot project to test the feasibility of integrating school-based surveillance for STH and LF. The AFC/university partnership was useful as the AFC does not currently have the laboratory facilities or trained staff required for STH testing. This was one of the first times that STH and LF surveillance has been integrated using TAS sampling guidelines.

Resource constraints (staff and finances) require that public health programs be as efficient and cost-effective as possible. Integration of activities is likely to reduce costs,[5] but it also carries some challenges. For example, when stool samples are collected on the day after collection of blood samples and distribution of containers (as in the inland EU), collection schedules need to avoid intervening weekends to maximize compliance. Furthermore, staff used to handling only blood samples may be reluctant to handle stool samples. However, our study has shown that integration is feasible in the Sri Lankan context. Improved tests like mini-FLOTAC that can test preserved stools[26] and involvement of additional university parasitology laboratories might be necessary if this program were to be expanded to cover the entire country. Unpublished draft WHO guidelines for integrating STH screening with TAS call for ~300 children to be tested for STH per EU, because this is sufficient for classifying areas for further treatment after cessation of MDA for filariasis. The larger sample size in our study provided more precise estimates of infection rates in these low prevalence areas along with information on clustering that may not have been evident with smaller samples.

Filarial antigenemia in young children is a marker for relatively recent transmission events, and ICT rates in children 6–7 years of age should be close to zero if MDA has successfully interrupted transmission.[15] The ICT card test results in this study were well below TAS critical values recommended for countries like Sri Lanka where MDA has been in place for several years and *Wuchereria bancrofti* is transmitted by *Culex* mosquitoes.[15] This suggests that LF transmission has been interrupted in Gampaha district.

The strong public health infrastructure and high literacy rates in Sri Lanka suggest that it may be feasible to eliminate STH infections as a public health problem in the country in the near future.[11] A single dose of mebendazole (500 mg) is offered routinely to school children of grades 1, 4, and 7 through school health programs, to preschool children through child welfare clinics, and to pregnant women through antenatal clinics. A single chewable tablet of 500 mg mebendazole has improved compliance compared with the alternative regimen of 100 mg twice daily for 3 days. The last nationally representative survey for STH conducted in 2003 among 2,173 attending 144 schools revealed an overall STH prevalence of 6.9% (ranging from 1.6% in the Southern Province to 12.3% in the Eastern Province).[10]

Draft WHO guidelines for integrated STH and TAS recommend de-worming of school-aged children every other year when post-MDA STH infection rates are between 1% and 10% and no routine de-worming for areas with rates < 1%, and these recommendations are consistent with those in published guidelines for preventive chemotherapy for STH after 5 or 6 years of preventive chemotherapy.[18] Thus, de-worming of school children in the coastal EU (prevalence of STH = 2.8%) could be reduced to once every 2 years, whereas the inland EU (prevalence of STH = 0.84%) does not require preventive chemotherapy at all. However, periodic sentinel site monitoring is recommended to detect recrudescence of infection.

Poverty, congested living conditions, poor sanitary facilities, an unsafe water supply, and poor personal hygiene are well-known risk factors for transmission of STH infections.[27,28] According to the national census and statistics data from 2011, < 5% of the residents of Gampaha district live in row houses or line rooms, < 6% use water from unprotected wells or other sources, and < 2% do not have toilets of their own.[29] Thus, the low prevalence rates of STH infection seen in our study are probably caused by the country's national school de-worming program and relatively good sanitation in the Gampaha district. Children with positive stools mostly had low intensity *T. trichiura* infections. This is not surprising, because mebendazole is more effective against *A. lumbricoides* and hookworm than *T. trichiura*. Furthermore, single-dose mebendazole distributed in schools is less effective against *T. trichiura* than a 3-day course of treatment.[30] However, multi-dose treatment schemes are not optimal for large-scale preventive chemotherapy, because they are likely to result in reduced compliance rates. *Trichuris trichiura* in school children may also reflect infections in portions of the population that are not reached with preventive chemotherapy (adults and some preschool children). Additional community-wide testing for STH, especially in the Negombo and Ja-Ela areas, may be useful for identifying reservoirs of infection in these areas.

Cost savings for separate surveillance programs with similar sampling strategies can be achieved when some of the costs for administration, personnel, transport, monitoring, and evaluation can support both the "platform program" (in this case, TAS) and the "add-on program" (in this case STH screening).[31,32] Person days and other costs for STH testing in this study could have been further reduced if the distribution of containers and collection of stool samples from the children had been carried out by the AFC. In some cases, it may be more beneficial for a single entity to conduct both types of surveys. The challenge is to integrate the two surveillance programs without compromising the integrity of either. Our results suggest that it is feasible for national NTD programs to integrate school-based surveillance for STH and LF. Further work is needed to streamline procedures and to determine optimal sampling strategies for STH surveys, because they may not require as many samples or sampling sites as TAS.

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Authors' addresses: Sharmini Gunawardena and Nadira D. Karunaweera, Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo, Sri Lanka, E-mails: sharminigunawardena@hotmail.com and nkarunaw@hsph.harvard.edu. Nipul K. Gunawardena and Nilanthi R. de Silva, Department of Parasitology, Faculty of Medicine, University of Kelaniya, Ragama, Sri Lanka, E-mails: gune1@yahoo.com and nrdesilva@gmail.com. Ganga Kahathuduwa, Regional Anti Filariasis Unit, Base Hospital Premises, Kiribathgoda, E-mail: gangakahathuduwa@yahoo.com. Udaya B. Ranasinghe, Sandhya D. Samarasekara, and Kumara C. Nagodavithana, Anti Filariasis Campaign, Ministry of Health and Nutrition, Colombo, Sri Lanka, E-mails: usbr65@gmail.com, dilhani_sm@yahoo.com, and chamilanagodavithana@yahoo.com. Ramakrishna U. Rao and Gary J. Weil, Infectious Diseases Division, Department of Medicine, Washington University School of Medicine, St. Louis, MO, E-mails: rrao@dom.wustl.edu and gweil@dom.wustl.edu. Maria P. Rebollo, Centre for Neglected Tropical Diseases, Liverpool School of Tropical Medicine, Pembroke Place, Liverpool, UK, E-mail: mrebollo@liv.ac.uk.

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