Acta Tropica 164 (2016) 208–215

Contents lists available at ScienceDirect

Acta Tropica

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

Schistosoma mansoni infection and related knowledge among schoolchildren in an endemic area of Minas Gerais, Brazil, prior to educational actions

Rocio Karina S.A.A. Cabello[a], Lilian C.N.H. Beck[a], Cristiano L. Massara[b], Felipe L.G. Murta[a], Ricardo J.P.S. Guimarães[c], Otávio S. Pieri[a,*], Virginia T. Schall[d,1], Tereza C. Favre[a]

[a] Laboratory of Environmental and Health Education, Oswaldo Cruz Institute, Fiocruz, Rio de Janeiro, Brazil
[b] Research Group on Helminthology and Medical Malacology, René Rachou Research Centre, Fiocruz, Minas Gerais, Brazil
[c] Laboratory of Geoprocessing, Evandro Chagas Institute, Ministry of Health, Pará, Brazil
[d] Group of Transdisciplinary Studies in Education on Health and Environment, René Rachou Research Centre, Fiocruz, Minas Gerais, Brazil

ARTICLE INFO

Article history:
Received 31 March 2016
Received in revised form 13 July 2016
Accepted 15 September 2016
Available online 16 September 2016

Keywords:
Schistosomiasis
Schistosoma mansoni
Schoolchildren
Health education
Brazil

ABSTRACT

As a signatory to World Health Assembly Resolution WHA65.21 on eliminating schistosomiasis, the Brazilian Ministry of Health (MoH) recommends early identification and timely treatment of the infection carriers for morbidity control, plus complementary preventive measures, such as health education, for transmission control. This study reports infection and awareness of schistosomiasis among schoolchildren before the implementation of school-based educational actions in an endemic municipality with persisting moderate prevalence levels despite successive control campaigns since the late 1990s. A questionnaire was applied in April 2013 to schoolchildren in the middle years of schooling (6th to 8th year) of Malacacheta municipality to assess baseline knowledge and risk behaviour related to schistosomiasis. A stool survey was conducted in May/June 2013 in 2519 schoolchildren from all years of fundamental education (first to 9th year) to identify the infection carriers, as well as to assess baseline prevalence and intensity of infection using the Kato-Katz method (one sample, two slides). The infected schoolchildren were treated promptly with single-dose praziquantel 60 mg/kg and followed up after 45 days for treatment efficacy. Relevant outcomes from baseline stool survey, treatment and follow-up were statistically evaluated in relation to area of residence (rural/urban), gender, age group (<11/≥years) and infection. Adherence to baseline survey was 81.2%, and prevalence of infection was 21.4%. Of the 539 positives, 60 (11.1%) had ≥400 eggs per gram of faeces (heavy-intensity infection). Prevalence of infection was significantly higher among rural residents and ≥11 year olds, whereas intensity of infection was higher among rural residents, ≥11 year olds and boys. Adherence by the positives to treatment was 93.3% and adherence by the treated children to 45-day follow-up was 72.2%. At 45 days after treatment, 97.0% of the 363 children surveyed were egg-negative; the egg reduction rate was 99.4%. Of the 924 children who responded to the questionnaire, 95.5% showed awareness of schistosomiasis, although 76.2% reported contact with natural, unsafe bodies of water. Reported contact with water was significantly more frequent among infected than non-infected, and boys than girls. The results show persisting infection and risk behaviour among schoolchildren, regardless of their basic knowledge about schistosomiasis. These are grounds for implementing specific educational actions to improve awareness and behavioural change, jointly with other control measures, to attain the MoH goals.

Abbreviations: CAPES, coordination for the improvement of higher education personnel; CNPq, National Council for Scientific and Technological Development; EPG, eggs per gram of faeces; ERR, egg reduction rate; Fiocruz, Oswaldo Cruz Foundation; IBGE, Brazilian Institute of Geography and Statistics; IDH-M, Municipal Human Development Index; IOC, Oswaldo Cruz Institute; OR, odds ratio; MDA, mass drug administration; MoH, Ministry of Health; PAPES, Programme to Support Strategic Research in Health; PCE, Schistosomiasis Surveillance and Control Programme; SISPCE, Information System for the Schistosomiasis Surveillance and Control Programme; SUS, unified health system; WHA, World Health Assembly; WHO, World Health Organisation.

* Corresponding author at: Laboratory of Environmental and Health Education, Oswaldo Cruz Institute, Fiocruz, Rio de Janeiro, Brazil.
E-mail addresses: opieri@ioc.fiocruz.br, otavio.pieri@gmail.com (O.S. Pieri).
[1] Deceased.

http://dx.doi.org/10.1016/j.actatropica.2016.09.015

1. Introduction

Schistosomiasis is a major infectious disease of poverty, with more than 700 million people living in endemic areas worldwide (WHO, 2016). In the Americas, Brazil has the largest endemic area and accounts for 95% of cases of schistosomiasis mansoni (WHO, 2010). Ministry of Health (MoH) records indicate that, since 2004, the percentage of positive cases obtained through active-search surveys in endemic municipalities has decreased gradually to 4.5% in 2012 (Ministério da Saúde, 2014).

As a signatory to World Health Assembly Resolution WHA65.21 of May 2012 on eliminating schistosomiasis (WHO, 2012), the MoH is under a commitment to meet the goals of the World Health Organisation (WHO) Strategic Plan 2012–2020 (WHO, 2013a). These goals are to reduce the prevalence of heavy-intensity infections, that is, the percentage of positives with 400 or more eggs per gram (EPG) of faeces to less than 5% by 2020 (control of morbidity) and to less than 1% by 2025 (elimination of schistosomiasis as a public-health problem).

Given Brazil's epidemiological peculiarities and public health policies, the MoH guidelines for morbidity control rely mainly on early identification and timely treatment of the infection carriers, rather than mass drug administration (MDA) (Ministério da Saúde, 2014; Favre et al., 2015). In addition, in order to eliminate schistosomiasis transmission, the MoH considers it essential to implement preventive measures including health education, environmental sanitation and community mobilisation, all framed by the Unified Health System (SUS) (Ministério da Saúde, 2014).

Despite the advances of the MoH's Schistosomiasis Surveillance and Control Programme (PCE), data from the Schistosomiasis Control Programme Information System (SISPCE) for 2013–2014 show that, in 165 (30.7%) of the 537 municipalities surveyed, more than 5% of positives had heavy-intensity infections ($EPG \geq 400$) (Ministério da Saúde, 2016). This fails to meet the goal set by the WHO for control of morbidity. In addition, prevalence exceeded 5% in 144 (26.8%) of municipalities, disqualifying them from progressing from the control to the surveillance stage under the PCE guidelines (Ministério da Saúde, 2014).

School-age children (6–15 years old) are the main target for the WHO recommendations, because they account for the highest prevalence and intensity of infection (WHO, 2011). Schistosomiasis control is also associated with changes in risk behaviour; accordingly, health education and the introduction of education activities into schools in endemic municipalities is one way of building knowledge and thus encouraging preventive practices and attitudes in communities (Schall and Diniz, 2001; Landsdown et al., 2002; Mwanga et al., 2008; Rollinson et al., 2012).

This study surveyed *S. mansoni* infection prevalence and intensity, basic knowledge about the disease and risk factors for infection among schoolchildren in an endemic municipality in Minas Gerais, Brazil, prior to introduction of a participatory educational strategy based operationally on schools and with teachers as knowledge multipliers and active health promotion agents. It is assumed that health education should be prioritised as an integral component of schistosomiasis control strategies in the municipality, in order to ensure that schoolchildren are better informed and more involved in health prevention and promotion. It is hoped that the information gained from this study will help to improve the actions prescribed by the MoH (Ministério da Saúde, 2014), with a view to meeting the WHO (2013a) goals.

2. Materials and methods

2.1. Study area

The study was carried out in the municipality of Malacacheta (Geocode 313920), in the schistosomiasis endemic area of Minas Gerais at coordinates 17°50′33″S; 42°4′22″W. Malacacheta was chosen because it has displayed moderate prevalence levels (15%–25%) despite being subjected to successive control campaigns by the PCE since 1997. In addition, it has been one of the 222 municipalities considered priorities for schistosomiasis elimination by the MoH in line with the "Brazil without Extreme Poverty" governmental initiative (Ministério da Saúde, 2012). Between 2010 and 2012, of the 7114 tests carried out by the PCE, 1646 (23.1%) were positives, 105 (6.4%) of which were heavy-intensity infections (Ministério da Saúde, 2016). The snail host species for *S. mansoni* in the municipality is *Biomphalaria glabrata* (Carvalho et al., 2008).

According to the most recent national census by the Brazilian Institute of Geography and Statistics (IBGE, 2016), the municipality had a population of 18,776 in 2010, of whom 6947 (37%) lived in the rural area and 3943 (21%) are of school age. The main socio-economic activities in the rural area are cattle ranching and agriculture, including subsistence farming; and in the urban area, commerce. In 2010 the Human Development Index (IDH-M) was 0.618 and the extreme poverty rate, 17.3%.

2.2. Study design and target group

This study was a descriptive cross-sectional survey carried out before implementation of a longitudinal intervention study to evaluate health education actions, combined with selective treatment, in a public school setting. Thus, all pupils from the 18 Malacacheta's public schools of fundamental education (primary + lower secondary) were considered for study (first to 9th year), with the following information: name, date of birth, gender, school, year and residential address. This information served as the basis for collecting baseline information about schistosomiasis-related knowledge and risk behaviour among pupils in the middle years of schooling (6th to 8th year) by applying a questionnaire of closed questions, and for conducting a parasitological survey to assess the schistosomiasis infection status (first to 9th year). The residential address enabled to ascertain whether the pupil lived in a rural or urban area of the municipality, as characterized by the IBGE (2016). The date of birth allowed determining the age at the baseline survey and categorizing two age groups, <11 years and ≥11 years, which respectively correspond to the initial years (first to 5th) and the final years (6th to 9th) of fundamental education.

To be included in the study the children should have: (a) enrolled in a public school of fundamental education by the Municipal Education Department in March 2013; (b) written informed consent from parent or guardian; (c) willingness to respond to a questionnaire (6th to 8th year) and to provide stool samples (first to 9th year). Children enrolled in the three private schools of fundamental education, totalling 78 (IBGE, 2016), were excluded from the study.

2.3. Sample size

The minimum sample size was calculated at 567, for an estimated prevalence not exceeding 25%, 95% confidence interval (CI), precision of ±5 percentage points and applying a design effect of 2 (Lwanga and Lemeshow, 1991). This sample was increased by 20% to 961 to account for refusals or absences. However, all pupils enrolled in the public fundamental schools were invited to participate.

2.4. Data collection

2.4.1. Questionnaire

Application of the questionnaire was restricted to pupils enrolled in classes of the 6th, 7th and 8th years of fundamental education at eight of the 18 schools included in the study. These groups were chosen on the criteria that the subject of "water-borne diseases" is covered in the Science classes of those years and that pupils in the chosen age range are sufficiently discerning to understand and answer the questions. For that reason, only the eight schools were contemplated for application of the questionnaire, as the others did not have classes for those years. When the questionnaire was applied, in April 2013, the pupils' *S. mansoni* infection status was unknown.

In developing the questionnaire, the study team collected information on the epidemiological dynamics and history of schistosomiasis in Malacacheta, and considered three types of categorical variables: awareness, knowledge, and water contact. The following demographic information were obtained from each respondent: school, age, gender and area of residence (rural/urban).

Awareness of schistosomiasis was assessed through questions on whether the subjects had heard of the disease (yes/no), whether they knew about from school (yes/no), whether they knew of people who had, the disease (yes/no), and whether they had the disease (yes/no). Respondents were considered aware of the disease if they responded "yes" to any of those questions.

Knowledge of schistosomiasis was assessed through questions on where transmission occurs (water/land/air), what was the agent of transmission (snail/mosquito/kissing bug), where the agent of transmission lives (water/land/air) and which body material is collected for diagnosis (faeces/urine/blood). The subjects responding correctly to any of those questions were considered as having basic knowledge about the disease.

Water contact was assessed through questions on whether the subjects had contact with local water bodies (yes/no) and what type of contact (multiple yes/no responses: washing animals, washing vehicles/car/bicycle, washing clothes/dishes, swimming, fishing, taking sand, and bathing). The subjects responding "yes" to any of those questions were considered as exhibiting risk behaviour.

2.4.2. Parasitological information

The baseline parasitological survey, which covered all pupils attending classes between May and June 2013, was conducted by stool sampling using the Kato-Katz quantitative method on two slides from one sample (Katz et al., 1972). The survey involved distributing stool containers at schools, collecting the samples the next day and preparing and examining slides, which was done by experienced technicians the day after sample collection. For quality control purposes, 10% of samples were examined by an experienced microscopist and discussed in the event of discrepancy (WHO, 2013b).

From the survey it was possible to identify the children infected with *S. mansoni*, determine prevalence and estimate individual parasite load. Children testing positive were treated with tablets of 600 mg praziquantel (Farmanguinhos/Fiocruz) administered at school under medical supervision in a single dose of 60 mg/kg, as recommended by the MoH (Ministério da Saúde, 2014), and were followed up after 45 days for parasitological re-assessment.

The Kato-Katz method also made it possible to identify eggs of soil-transmitted helminths, and children detected as having roundworm (*Ascaris lumbricoides*), whipworm (*Trichuris trichiura*) or hookworms (*Necator americanus* and/or *Ancylostoma duodenale*) received one tablet of albendazol (400 mg) to be taken at home under parental supervision.

2.5. Geoprocessing data

The geographic coordinates of the schools were obtained using a handheld Global Positioning Systems receiver (Garmin Etrex Vista) and imported into a Geographic Information System for display.

Remote Sensing images were used to visualize topographical aspects of the spatial distribution of the schools. RapidEye multispectral orthoimages (5-m resolution) were obtained from the Geo Catalogue on the Brazilian Environment Ministry website and Landsat Operational Land Imager (30-m resolution) images were obtained from the United States Geological Survey EarthExplorer (both in natural-colour images). Minas Gerais state and Malacacheta municipal boundaries were obtained from the IBGE (2016).

2.6. Data management and analysis

The following indices were calculated for *S. mansoni* infection. Prevalence of infection was estimated as the percentage of egg-positives among the subjects tested; intensity of infection was expressed as arithmetic mean EPG; positive individuals were categorized into classes of egg counts: light (1–99 EPG), moderate (100–399 EPG) and heavy (≥400 EPG) (WHO, 2011). Cure rate was estimated as the percentage of egg-positive subjects at baseline who became negative at 45 days after treatment. Egg reduction rate (ERR) in children found positive at baseline and who returned a stool sample at 45 days after treatment was calculated by the formula: ERR (%) = 100 × (1- (arithmetic mean EPG at follow up/arithmetic mean EPG at baseline)) (WHO, 2013b).

Adherence to testing was calculated as the percentage of schoolchildren provided with collection containers who then returned stool samples. Adhesion to treatment with praziquantel was calculated as the percentage of *S. mansoni*-positive schoolchildren who took the medication.

Data were double entered into Microsoft Office Excel 2013, crosschecked for accuracy and exported to Systat 13 for statistical analysis. Continuous variables, such as EPG and age, were expressed as arithmetic means (AM) with 95% confidence intervals (CI). Categorical variables, such as adherence to testing and to praziquantel treatment, presence of parasite eggs, gender (male/female), area of residence (rural/urban), *S. mansoni* intensity classes (light/moderate/heavy), age group (<11 years/≥11 years) as well as questionnaire outcomes on awareness, knowledge and water contact were expressed as frequencies and percentages with 95% CI. Questionnaire respondents were not divided into age groups because they were in the middle years of schooling. A two-sample *t*-test was used to evaluate significance of differences in $\log_{10}(x+1)$-transformed EPG. Binary logistic regression analysis with multiple predictors was used to assess the independent effect of the area of residence, age group and gender on the following outcomes: adhesion to baseline survey and follow-up, adhesion to treatment, prevalence and cure rate. School clustering was accounted for and robust standard errors were used. Odds Ratio (OR) and 95% CI were used to evaluate significant effects of each of the variables; if the 95% CI did not contain unity, the effect was considered as significant. Our assumption was that *p*-values below 5% indicate statistical significance. The same analysis was used to assess the independent effect of the area of residence, gender and prevalence of infection in relation to awareness, knowledge and water contact among questionnaire respondents.

2.7. Ethical considerations

The study protocol was approved by the Ethics Committee of the René Rachou Research Centre – Fiocruz Minas (protocol No.

18/2011). The protocol was discussed with the local health and education staff, including health professionals, school directors and teachers, and sanctioned by the Municipal authorities.

Before the study began, parents and guardians of the children at the 18 schools were invited to attend a meeting at their school, where they received clarifications about the study's goals and procedures and how it would benefit their children, as well as the freedom to withdraw from the study at any time without detriment. Once informed and satisfied as to the terms of the study, they were asked to sign a declaration of free and informed consent to their child's inclusion in the study. It was made certain that the participants understood this information and gave their assent freely.

The parents/guardians were informed that, in case of any concern or doubt, they could contact the principal investigator, the Ethics Committee, or the local health and education authorities, whose addresses and phone numbers were provided in the declaration of informed consent.

3. Results and discussion

3.1. Study adherence and demographic characteristics

In March 2013, a total of 3102 (mean age: 11.2 years; 95% CI: 11.1 years–11.3 years) schoolchildren were enrolled at the municipality's 18 public schools of fundamental education; 47.5% (95%CI: 45.5%–49.5%) resided in the rural area, 49.7% (95%CI: 48.3%–52.4%) were females, and 46.2% (95%CI: 44.2%–48.2%) were <11 years of age. Of the total enrolled, 2519 (81.2%; 95CI: 79.6%–82.7%) adhered to the baseline parasitological survey; the remaining 583 refused to be tested or were absent during the days of stool collection.

Table 1 shows the frequencies, percentages and respective confidence intervals of adherence to baseline survey, to praziquantel treatment and to follow-up survey, compared by area of residence, age group and gender. Adherence to baseline survey did not differ significantly between rural and urban residents (OR: 1.232; 95%CI: 0.879–1.727) or between girls and boys (OR: 1.203; 95%CI: 0.997–1.452). However, it was significantly higher among schoolchildren in the age group <11 years than in the age group ≥11 years (OR: 1.588; 95%: 1.231–2.047). The lower adherence of older schoolchildren may be due to lower school attendance and higher absenteeism in this age group, as well as to adolescent embarrassment at having to hand over stool samples in the presence of classmates.

MoH targets consider adherence to treatment with praziquantel satisfactory at percentages of 80% or more (Ministério da Saúde, 2014). In this study, that target was surpassed as 93% (95% CI: 90.4–95.5) of the infected schoolchildren were treated (Table 1). Adherence to treatment did not differ significantly between residents in the rural area and urban area (OR: 1.437; 95%CI: 0.467–4.424), between the two age groups (OR: 2.0601; 95%CI:0.769–5.524), or between girls and boys (OR: 1.365; 95%CI: 0.632–4.424).

Of the 503 positive schoolchildren who were treated in July 2013, 363 (72.2%; 95%CI: 67.2–76.3) adhered to testing for assessment 45 days after treatment (Table 1). There was no significant difference between the rural and urban residents (OR: 1.355; 95%CI: 0.670–2.743), between the two age groups (OR: 1.577; 95%CI: 0.898–2.770), or between girls and boys (OR: 1.193; 95%CI: 0.784–1.815). However, overall adherence to stool survey for assessing cure (72.2%) was lower than for the baseline survey (81.2%). This may have to do with the fact that some schoolchildren reported there being no need for providing stool samples for re-testing because they were cured by the medication and felt well.

Table 1
Schoolchildren's adherence and parasitological characteristics in Malacacheta, Minas Gerais State, Brazil. N, number of individuals; EPG, eggs per gram of faeces; CI, confidence interval.

Characteristics		Value	95% CI
Adherence to parasitological survey at baseline, N (%)			
Area of residence	Rural	1286 (87.3)	85.2–89.2
	Urban	1233 (75.7)	73.2–78.0
Age group	<11 years	1233(86.0)	83.8–88.0
	≥11 years	1286 (77.1)	74.6–79.3
Gender	Female	1266 (82.2)	79.9–84.3
	Male	1253 (80.2)	77.8–82.4
Arithmetic mean *S mansoni* infection at baseline, EPG			
Area of residence	Rural	60.8	45.8–75.7
	Urban	20.4	14.1–26.8
Age group	<11 years	27.9	18.9–36.8
	≥11 years	53.6	39.9–67.4
Gender	Female	34.3	22.8–45.8
	Male	47.8	35.8–59.7
Positives for *S. mansoni* infection at baseline, N (%)			
Area of residence	Rural	326 (25.4)	22.6–28.2
	Urban	213 (17.3)	14.9–19.8
Age group	<11 years	207 (16.8)	14.4–19.3
	≥11 years	332 (25.8)	23.1–28.6
Gender	Female	249 (19.7)	17.2–22.3
	Male	290 (23.1)	20.5–25.9
Adherence to praziquantel treatment, N (%)			
Area of residence	Rural	301 (92.3)	88.2–95.2
	Urban	202(94.8)	90.1–97.6
Age group	<11 years	196 (94.7)	89.8–97.5
	≥11 years	307(92.5)	88.4–95.3
Gender	Female	232 (93.2)	88.5–96.2
	Male	271 (93.5)	89.2–96.2
Adherence to follow-up testing at 45 days from treatment, N (%)			
Area of residence	Rural	226 (75.1)	68.9–80.4
	Urban	137 (67.5)	59.4–74.5
Age group	<11 years	149 (76.0)	68.2–82.4
	≥11 years	214 (69.5)	63.0–75.2
Gender	Female	170 (73.)3	66.0–79.4
	Male	193 (71.0)	64.2–76.9
Egg-negatives for *S. mansoni* at 45 days from treatment (cure), N (%)			
Area of residence	Rural	218 (96.5)	92.3–98.6
	Urban	134 (97.)8	92.5–99.6
Age group	<11 years	142 (95.3)	89.4–98.2
	≥11 years	210 (98.1)	94.5–99.5
Gender	Female	167 (98.2)	93.4–99.7
	Male	185 (95.9)	91.1–98.3

Such behaviour may be explained by lack of a proper knowledge of the concept of health.

3.2. Baseline parasitological data

Of the 2519 pupils surveyed at baseline 539 (21.4%) tested positive for *S. mansoni*. Among the positives, 341 (63.3%; 95%CI: 58.0%–68.1%) had light infections, 138 (25.6%; 95%CI: 21.2%–30.3%) had moderate infections and 60 (11.1%; 95%CI: 8.1%–14.7%), heavy infections.

Light infections were more frequent than moderate infections, whereas heavy infections were less frequent than the other two. This pattern is also seen in other endemic areas (Odiere et al., 2012; Mwinzi et al., 2015; Olsen et al., 2015). However, of the 539 schoolchildren found here to be infected with *S. mansoni*, 198 (36.7%) excreted more than 100 EPG (moderate to high infections).

That finding is of concern, because the clinical manifestations and complications in general are associated with high parasite loads (WHO, 2011).

The overall arithmetic mean of EPG among the pupils surveyed at baseline was 41.1 (95% CI: 32.7–49.3). Table 1 shows the EPG values and 95% CI by area, age group and gender. It was significantly higher in the rural residents than in the urban residents ($t = 6.160$; $p = 0.000$), in the age group ≥11 years than in the age group <11 years ($t = 6.002$; $p = 0.000$) and in boys than in girls ($t = 2.750$; $p = 0.006$).

The *S. mansoni* prevalence at baseline by area, age group and gender is also given in Table 1. It was not significantly different between boys and girls (OR: 1.206; 95%CI: 0.985–1.478). However it was significantly higher in the rural residents than in the urban residents (OR: 1.790; 95%CI: 1.239–2.857), and in the age group ≥11 years than in the age group <11 years (OR: 1.693; 95%CI: 1.316–2.177).

The overall prevalence of 21.4%, obtained here by surveying the large majority of the school population, places the municipality in the intermediate (15–25%) prevalence range, for which the MoH recommends treating positives and their cohabitants (Favre et al., 2015). That percentage agrees with the figure registered by the SISPCE in 2010–2012 (23.1%); however, the overall percentage of heavy infections (EPG ≥ 400) found in this study (11.1%) was almost twice the 6.4% registered by SISPCE in that period (Ministério da Saúde, 2016). This discrepancy underscores the WHO (2013a) recommendation to use school-age children, and not the community, as the reference group for gauging success in controlling morbidity and eliminating the disease as a public health problem. To judge from the results of this study rather than SISPCE figures, a great deal of effort will be required for this municipality to attain the closest goal, which is morbidity control by 2020.

It should be noted that infection rates estimated both here and by the SISPCE were based on only one stool sample. Different studies show that the number of eggs varies from day to day and among samples and, accordingly, estimates based on a single sample underestimate prevalence and overestimate the intensity of infection (Mutapi et al., 2003; Enk et al., 2008; Bergquist et al., 2009).

Prevalence and intensity of infection were higher among schoolchildren resident in the rural area and in the later years of schooling, following a profile commonly found in the endemic areas of Minas Gerais (Massara et al., 2004; Enk et al., 2010). Schistosomiasis tend to be more frequent among residents of rural areas, where environmental sanitation and water supply conditions are generally more precarious and where there is greater proximity and contact between the local population and foci of transmission (Gazzinelli et al., 2009).

Higher intensity of infection found here among male schoolchildren can be explained by the fact that the boys engage in more water contact than the girls, both in leisure activities, such as fishing and swimming, and in occupational activities, with many helping out with farm work in activities that involve more frequent and/or longer exposure to infection. Similar findings have been described in other endemic communities (Berhe et al., 2007; Assaré et al., 2015; Jejaw et al., 2015; Masaku et al., 2015).

Children ≥11 years old had higher prevalence and intensity of infection probably because of their more intense contact with bodies of water than children <11 years old. Similarly, Odiere et al. (2012) found higher prevalence by *S. mansoni* in the age group of 11–16 years than in the age group of 5–10; however, Mugono et al. (2014) showed a lower prevalence in children 11–15 years old than in children aged 4–10 years. One explanation for lower infection rates being found here in the age group <11 years than in the age group ≥11 years is that the younger schoolchildren spend more time under their parent's eye and thus their contact with bodies of water tends to be more sporadic.

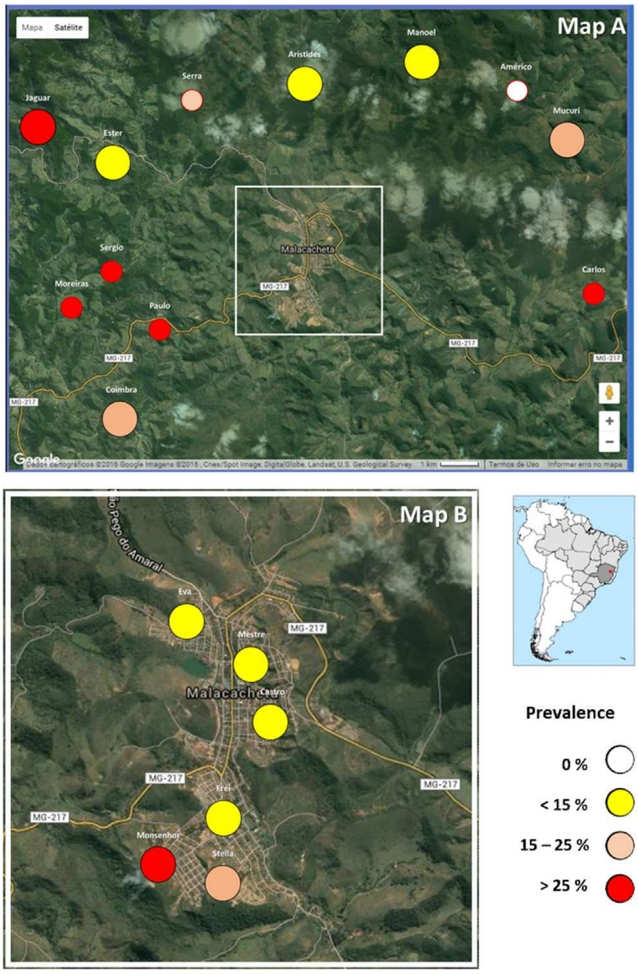

Fig. 1. Spatial distribution of public schools of fundamental education in Malacacheta, Minas Gerais, Brazil. Map A – rural schools; Map B – urban schools. Coloured circles indicate classes of *Schistosoma mansoni* prevalence according to 2014 Brazilian MoH guidelines. Small circles indicate schools with fewer than 50 students enrolled/tested.

Table 2 shows pupils enrolled, surveyed and tested positive, by school. Fig. 1 shows the spatial distribution of the schools in rural and urban areas (Maps A and B, respectively), as well as classes of prevalence. Of the 18 schools, 12 are in the rural area of the municipality and six, in the urban area. Adherence to baseline survey ranged from 63% (in the *Mestre* School) to 100% (in three small rural schools). In five of the schools adherence to baseline survey was less than 75%. In order to raise coverage to acceptable levels, active detection of children not enrolled in school should be intensified with the participation of community health workers, teachers and the community generally (Favre et al., 2009).

Although overall adherence to parasitological survey among rural schoolchildren was highly satisfactory (87.3%), the estimated prevalence of six of the rural schools was based on the fewer than 50 children tested (Fig. 1, Map A, small circles), which is below the number recommended by the WHO (2011) for monitoring purposes. These schools, however, serve only a small number of children, in the lower years and who live in small rural localities distant from the municipal centre. Nonetheless, some studies designed to make a quick assessment of infection prevalence and intensity using limited resources have employed protocols that permit testing of a small number of schoolchildren, while covering a large number of schools in a short space of time (Brooker et al., 2009).

Table 2
Adhesion to baseline survey and prevalence of *Schistosoma mansoni* according to school and area in Malacacheta, Minas Gerais, Brazil. The study was carried out in 2013. N, number of individuals; CI, confidence interval.

Abbreviated name	Area	N enrolled	N tested	% tested (95%CI)	N positives	% positives (95% CI)
Americo	Rural	13	13	100.0 (71.4–100.0)	0	0.0
Aristides[a]	Rural	159	149	93.7 (87.6–97.1)	20	13.4 (7.7–20.8)
Carlos	Rural	17	15	88.3 (56.7–98.7)	8	53.3 (21.7–80.1)
Castro	Urban	333	292	87.7 (82.9–91.3)	36	12.3 (8.3–17.2)
Coimbra[a]	Rural	167	147	88.0 (80.9–93.0)	36	24.5 (16.8–33.2)
Ester	Rural	64	51	79.7 (65.3–89.3)	2	3.9 (0.1–14.6)
Eva	Urban	147	124	84.4 (76.1–90.3)	15	12.1 (6.2–20.0)
Frei	Urban	176	139	79.0 (71.0–85.3)	19	13.7 (7.7–21.4)
Jaguar[a]	Rural	261	230	88.1 (82.7–92.1)	107	46.5 (45.7–60.8)
Manoel[a]	Rural	162	148	91.4 (84.8–95.5)	18	12.2 (6.7–19.3)
Mestre[a]	Urban	227	143	63.0 (55.3–70.0)	10	7 (2.9–13.2)
Monsenhor[a]	Urban	469	345	73.6 (68.6–78.0)	89	25.8 (20.6–31.4)
Moreiras	Rural	13	9	69.2 (32.0–91.6)	7	77.8 (31.1–97.5)
Mucuri*	Rural	261	237	90.8 (85.8–94.3)	44	18.6 (13.1–24.8)
Paulo	Rural	15	15	100.0 (74.7–100.0)	13	86.7 (52.2–98.5)
Sergio	Rural	20	20	100 (80.4–100.0)	6	30.0 (9.1–56.3)
Serra	Rural	36	25	69.4 (48.4–84.6)	5	20.0 (4.9–42.7)
Stella[a]	Urban	562	417	74.2 (69.8–78.2)	104	24.9 (20.3–30.0)

[a] Eight schools where the questionnaire has been applied among children in the 6th to 8th years.

Prevalence of *S. mansoni* per school ranged from 3.9% to 86.7%, and at only one school (*Américo*) were none of the 13 children tested found infected (Table 2). Six schools, five of them in the rural area of the municipality, had percentage of positives considered high (over 25%) by the MoH (Ministério da Saúde, 2014) (Fig. 1, red circles).

3.3. Treatment efficacy

The arithmetic mean EPG of the 363 egg-positives who were treated and provided stool samples at 45 days thereafter was 1.6 (95% CI: 0.2–3.0) in contrast with 168.5 (95% CI: 133.7–203.3) at baseline. The egg reduction rate was 99.4% (95% CI: 98.8%–99.9%). The overall egg-negative (cure) rate was 97% (95% CI: 94.1–98.6), and no significant difference was detected between the rural and urban residents (OR: 1.074; 95%CI: 0.175–6.586), between the two age groups (OR: 1.263; 95%CI: 0.276–5.774), or between girls and boys (OR: 1.114; 95%CI: 0.210–5.904). Furthermore, of the 11 treated schoolchildren who remained positive at 45 days, eight fell to a lower class of infection: three from heavy to light infection and five from moderate to light infection. One remained with light infection and two remained with moderate infection.

Parasitological cure (97%) and egg reduction rate (99.4%) 45 days after treatment were also satisfactory, surpassing WHO-recommended minimum values (75% and 90%, respectively) for children from 9 to 12 years old tested three weeks after treatment (WHO, 2013b). Although in this study cure rate and ERR were assessed over a broader age range, the results six weeks after treatment attest to the efficacy of praziquantel.

High adherence to treatment, accompanied by high cure and egg reduction rates, was particularly beneficial to the infected schoolchildren, considering that 36.7% showed moderate to heavy infections, which may lead to severe clinical forms of the disease in adulthood if not treated in time (WHO, 2011). However, it must be stressed that treatment, as an isolated measure, is insufficient to sustain reduced levels of prevalence and intensity of infection among schoolchildren. Studies carried out in different endemic areas show that the use of integrated control strategies is highly effective in reducing infection by *Schistosoma* (Uchoa et al., 2000; Kaatano et al., 2015; Xu et al., 2015).

The schoolchildren's high rates of adherence to testing (81.2%) and treatment (93.3%) suggest that the school environment is advantageous to control actions: it enabled almost the entire school population to be tested in one month and positives, to be treated in one week by the local doctor. This was made possible probably by the ease with which all the children could be concentrated in a space that was familiar to them and their families. That ease could open up a range of possibilities for conducting various health-related activities that would benefit from shorter time spans, greater care coverage and probably lower operating costs (Favre et al., 2009). Drake and Bundy (2001) point out that it is at school, by exploiting existing educational infrastructure, that health and nutrition programmes are most easily able to reach children over five years old, and can have impact on a wide range of outcomes in the children's health and education.

3.4. Questionnaire

In all, 924 schoolchildren responded to the questionnaire: respondents were of mean age 13.0 years (95% CI: 12.9 years–13.1 years), enrolled in the 6th to 8th years and totalled 36.7% of the schoolchildren surveyed. The schoolchildren surveyed and those selected to respond to the questionnaire did not differ substantially in any of the following variables: area of residence, gender, prevalence of *S. mansoni*, egg-count classes and adherence to treatment (data not shown here).

Overall, 95.5% (95%CI: 93.6%–96.8%) of the schoolchildren who responded to the questionnaire had some awareness of schistosomiasis. No significant difference was found between rural (95.6%; 95%CI: 92.9%–97.5%) and urban residents (95.3%: 95%CI: 92.4%–97.1%) (OR: 1.926; 95%CI: 0.635–5.843), between girls (97.0%; 95%CI: 94.5%–98.4%) and boys (93.9%; 95%CI: 90.8%–96.1%) (OR: 1.953; 95%CI: 1.000–2.809), or between egg-positives (94.1%; 95%CI: 89.6%–97.0%) and egg-negatives (95.9%; 95%CI: 93.8%–97.4%) (OR: 1.544; 95%CI: 0.771–3.094).

In total, 93.6% (95%CI: 91.5%–95.3%) of the respondents showed basic knowledge about schistosomiasis. There was no significant difference between rural (92.4%; 95%CI: 89.1%–94.9%) and urban residents (94.8%: 95%CI: 91.9%–96.8%) (OR: 1.850; 95%CI: 0.680–5.031), between egg-positives (94.6%; 95%CI: 90.2%–97.3%) and egg-negatives (93.3%; 95%CI: 90.7%–95.2%) (OR: 1.619; 95%CI: 0.805–3.258), or between boys (92.8%; 95%CI: 89.5%–95.2%) and girls (94.4%; 95%CI: 91.4%–96.5%) (OR: 1.302; 95%CI: 0.749–2.265).

Although no specific educational actions on schistosomiasis had been taken with the schoolchildren prior to this study, the questionnaire revealed high levels of awareness and basic knowledge. This may be because application of the questionnaire was preceded by information about the study objectives and procedures, contained in the declaration of free and informed consent.

That information made the participants aware of schistosomiasis, and enabled them to know that stool examination would be used to assess the disease, and medication, to treat it. Therefore, the responses given may have reflected both awareness and basic knowledge about the disease then acquired.

Water contact indicative of risk behaviour was reported by 76.2% (95¨CI: 72.9%–79.2%) of the respondents. It was significantly higher among egg-positives (81.7%; 95%CI: 75.3%–86.9%) than egg-negatives (76.2%; 95%CI: 72.9%–79.3%) (OR: 1.750; 95%CI: 1.180–2.595). Furthermore, there were significantly more reports of water contact among boys (80%; 95%CI: 76.4%–84.8%) than girls (71.5%; 95%CI: 66.4%–76.0%) (OR: 1.684; 95%CI: 1.221–2.322). However, no significant difference was found between rural residents (83.8%; 95%CI: 79.5%–87.4%) and urban residents (68.6%; 95% CI: 63.3–73.3) (OR: 1.384; 95%CI: 0.823–2.325).

The high frequency of water contact reported by schoolchildren shows how families are connected with, and dependent on, natural bodies of water. Although 74% of families have running water in their homes (IBGE, 2016), supply is not constant. Heads of rural families mentioned that water is frequently lacking, leading them to resort to streams, ponds and rivers as an alternative source for bathing and domestic uses. It cannot be disregarded that contact with unsafe water can also result from lack of leisure options.

Our findings compare with those of other studies that have found a strong association between prevalence for *S. mansoni* and children and adolescents reporting contact with bodies of water (Massara et al., 2004; Enk et al., 2010). However, it is important to note that the information about risk factors, particularly as relating to contact with water, may be unreliable if sourced from reports rather than direct observation (Sow et al., 2011).

4. Conclusions

The present study shows the moderate levels of both prevalence and intensity of infection by *S. mansoni* in the schoolchildren of Malacacheta. A considerable proportion of school-age children missed testing in the initial survey and failed to adhere to cure assessment after treatment. There was a high percentage of reported water contact indicative of risk behaviour, particularly in the rural area, as well as some gaps in the knowledge about the disease

It is thus fundamentally important to consider whether introducing schistosomiasis-related health education activities tailored to the local realities of schoolchildren with schools as the operational base and teachers as multipliers of knowledge and active health promotion agents would contribute to foster sustainable participatory actions in the school environment and reduce indicators of infection.

Competing interests

The authors declare that they have no competing interests

Funding

This study was supported by Papes VI - Fiocruz/CNPq (grant 407616/2012-8) and CAPES.

Authors' contribution

TCF, VTS, OSP and CLM conceived and designed the study. OSP, TCF and RJPSG analysed the data. TCF, OSP and RKSAC wrote the paper. TCF, LCNHB, CLM and RKSAC conducted the field surveys. TCF, LCNHB, CLM FLGM and RKSAC applied the questionnaire. CLM, FLGM and RJPSG provided detailed comment on the draft. All authors read and approved the final manuscript.

Acknowledgments

The authors wish to pay tribute to the memory of Dr Virginia T. Schall, who passed away shortly after this study was finalised. She will remain a source of inspiration for all those dedicated to fostering health education as an empowering component for combating diseases of poverty.

The authors wish to thank Dr Bárbara P. Gaspar for medical supervision, Marielly Gonçalves Abranches and Wilson da Silva Guimarães for technical support, and the municipal health and education staff for providing facilities. Special thanks go to the school directors, teachers and schoolchildren of Malacacheta. Thanks are also due to Dr Leonardo Soares Bastos, Public Health Researcher at the Scientific Computing Program, Oswaldo Cruz Foundation (PROCC/Fiocruz), for statistical assistance.

References

Assaré, R.K., Lai, Y.S., Yapi, A., Tian-Bi, Y.T., Ouattara, M., Yao, P.K., Knopp, S., Vounatsou, P., Utzinger, J., N'Goran, E.K., 2015. The Spatial distribution of *Schistosoma mansoni* infection in four regions of western Côte d'Ivoire. Geospat. Health (N. Y.) 10 (1), 69–79.

Bergquist, R., Johansen, M.V., Utzinger, J., 2009. Diagnostic dilemmas in helminthology: what tools to use and when? Trends Parasitol. 25 (4), 151–156.

Berhe, N., Myrvang, B., Gundersen, S.G., 2007. Intensity of *Schistosoma mansoni*, hepatitis B, age, and sex predict levels of hepatic periportal thickening/fibrosis (PPT/F): a large-scale community-based study in Ethiopia. Am. J. Trop. Med. Hyg. 77 (6), 1079–1086.

Brooker, S., Kabatereine, N.B., Gyapog, J.O., Stothard, J.R., Utzinger, J., 2009. Rapid mapping of schistosomiasis and other neglected tropical diseases in the context of integrated control programmes in Africa. Parasitology 136 (13), 1707–1717.

Carvalho, O.S., Scholte, R.G.C., Amaral, R.S., 2008. Distribuição dos moluscos hospedeiros intermediários Schistosoma mansoni no Brasil, Biomphalaria glabrata, B. straminea e B. tenagophila. In: Amaral, R.S., Thiengo, S.C., Pieri, O.S. (Eds.), Vigilância e Controle de Moluscos de Importância Epidemiológica. Diretrizes Técnicas: Programa de Vigilância e Controle da Esquistossomose (PCE). , 2nd edition. MS/SVS, Brasília, p. 111–126, http://bvsms.saude.gov.br/bvs/publicacoes/vigilancia_controle_moluscos_import_epidemio_2ed.pdf.

Drake, L.J., Bundy, D.A.P., 2001. 2001 Multiple helminth infection in children: impact and control. Parasitology 122 (Suppl), S73–S81.

Enk, M.J., Lima, A.C., Drummond, S.C., Schall, V.T., Coelho, P.M.Z., 2008. The effect of the number of stool samples on the observed prevalence and intensity with *Schistosoma mansoni* among a population in an area of low transmission. Acta Trop. 108 (2–3), 222–228.

Enk, M.J., Lima, A.C.L.L., Barros, H.S., Massara, C.L., Coelho, P.M.Z., Schal l, V.T., 2010. Factors related to transmission of and infection with *Schistosoma mansoni* in a village in the South-eastern region Brazil. Mem. Inst. Oswaldo Cruz 105 (4), 570–577.

Favre, T.C., Pereira, A.P., Galvao, A.F., Zani, L.C., Barbosa, C.S., Pieri, O.S., 2009. A rationale for schistosomiasis control in elementary schools of the rainforest zone of Pernambuco, Brazil. PLoS Negl. Trop. Dis. 3, e395.

Favre, T.C., Pereira, A.P.B., Beck, L.C.N.H., Galvão, A.F., Pieri, O.S., 2015. School-based and community-based actions for scaling-up diagnosis and treatment of schistosomiasis towards its elimination in an endemic area of Brazil. Acta Trop. 149, 155–162.

Gazzinelli, A., Velasquez-Melendez, G., Crawford, S.B., LoVerde, P.T., Correa-Oliveira, R., Kloos, H., 2009. Socioeconomic determinants of schistosomiasis in a poor rural área in Brazil. Acta Trop. 99 (2–3), 260–271.

IBGE, 2016. Minas Gerais. Malacacheta. (http://www.cidades.ibge.gov.br/xtras/perfil.php?lang=&codmun=313920&search=||infogr%E1ficos:-informa%E7%F5es-completas. (accessed 28.06.16.)).

Jejaw, A., Zemene, E., Alemu, Y., Mengistie, Z., 2015. High prevalence of *Schistosoma mansoni* and other intestinal parasites among elementary school children in Southwest Ethiopia: a cross-sectional study. BMC Public Health 15, 600.

Kaatano, G.M., Siza, J.E., Mwanga, J.R., Min, D.Y., Yong, T.S., Chai, J.Y., Ko, Y., Chang, S.Y., Kullaya, C.M., Rim, H.J., Changalucha, J.M., Eom, K.S., 2015. Integrated schistosomiasis and soil-transmitted helminthiasis control over five years on Kome Island, Tanzania. Korean J. Parasitol. 53 (5), 535–543.

Katz, N., Chaves, A., Pellegrino, J., 1972. A simple device for quantitative stool thicksmear technique in Schistosomiasis mansoni. Rev. Inst. Med. Trop. São Paulo 14, 397–400.

Landsdown, R., Ledward, A., Hall, A., Issae, W., Yona, E., Matulu, J., Mweta, M., Kihamia, C., Nyandindi, U., Bundy, D., 2002. Schistosomiasis, helminth infection and health education in Tanzania: achieving behaviour change in primary schools. Health Educ. Res. 17 (4), 425–433.

Lwanga, S.K., Lemeshow, S., 1991. Sample-size Determination in Health Studies: A Practical Manual. WHO, Geneva.

Masaku, J., Madigu, N., Okoyo, C., Njenga, S.M., 2015. Current status of *Schistosoma mansoni* and the factors associated with infection two years following mass drug administration programme among primary school children in Mwea irrigation scheme: a cross-sectional study. BMC Public Health 15, 739.

Massara, C.L., Peixoto, S.W.V., Barros, H.S., Enk, M.J., Carvalho, O.S., Schall, V.T., 2004. Factors associated with schistosomiasis mansoni in population from the municipality of Jaboticatubas, state of Minas Gerais, Brazil. Mem. Inst. Oswaldo Cruz 99 (Suppl. 1), 127–134.

Ministério da Saúde, 2012. Plano Integrado De Acões Estratégicas De Eliminacão Da Hanseníase, Filariose, Esquistossomose e Oncocercose Como Problema De Saúde Pública, Tracoma Como Causa De Cegueira e Controle Das Geohelmintíases: Plano De Acão, 2011-2015. MS/SVS/DVDT, Brasília http://bvsms.saude.gov.br/bvs/publicacoes/plano_integrado_acoes_estrategicas_2011_2015.pdf.

Ministério da Saúde, 2014. Vigilância da esquistossomose mansoni: diretrizes técnicas, 4th edition. MS/SVS/DVDT, Brasília http://bvsms.saude.gov.br/bvs/publicacoes/vigilancia_esquistossome_mansoni_diretrizes_tecnicas.pdf.

Ministério da Saúde, 2016. DATASUS: Programa de Controle da Esquistossomose, (http://tabnet.datasus.gov.br/cgi/tabcgi.exe?sinan/pce/cnv/pcebr.def. (accessed 28.06.16.)).

Mugono, M., Konje, E., Kuhn, S., Mpogoro, F.J., Morona, D., Mazigo, H.D., 2014. Intestinal schistosomiasis and geohelminths of Ukara Island, North-Western Tanzania: prevalence, intensity of infection and associated risk factors among school children. Parasite Vectors 7, 612.

Mutapi, F., Gryseels, B., Roddam, A., 2003. On the calculation of intestinal schistosome infection intensity. Acta Trop. 87 (2), 225–233.

Mwanga, J.R., Jensen, B.B., Magnussen, P., Aagaard-Hansen, J., 2008. Schoolchildren as health change agents in Magu, Tanzania: a feasibility study. Health Promot. Int. 23 (1), 16–23.

Mwinzi, P.N.M., Muchiri, G., Wiegand, R.E., Omedo, M., Abudho, B., Karanja, D.M.S., Montgomery, S.P., Secor, W.E., 2015. Predictive value of school-age children's schistosomiasis prevalence and egg intensity for other age groups in Western Kenya. Am. J. Trop. Med. Hyg. 93 (6), 1311–1317.

Odiere, M.R., Rawago, F.O., Ombok, M., Secor, W.E., Karanja, D.M., Mwinzi, P.N., Lammie, P.J., Won, K., 2012. High prevalence of schistosomiasis in Mbita and its adjacent islands of Lake Victoria, western Kenya. Parasite Vectors 5, 278.

Olsen, A., Kinung'hi, S., Magnussen, P., 2015. *Schistosoma mansoni* infection along the coast of lake victoria in mwanza region, Tanzania. Am. J. Trop. Med. Hyg. 92 (6), 1240–1244.

Rollinson, D., Knopp, S., Levitz, S., Stothard, J.R., Tchuenté, L.A.T., Garba, A., Mohammed, K.A., Schur, N., Person, B., Colley, D.G., Utzinger, J., 2012. Time to set the agenda for schistosomiasis elimination. Acta Trop. 128 (2), 423–440.

Schall, V.T., Diniz, M.C.P., 2001. Information and education in schistosomiais control: an analysis of the situation in the state of Minas Gerais, Brazil. Mem. Inst. Oswaldo Cruz 96 (Suppl. 1), 35–43.

Sow, S., de Vlas, S.J., Stelma, F., Vereecken, K., Gryseels, B., Polman, K., 2011. The contribution of water contact behavior to the high *Schistosoma mansoni* infection rates observed in the Senegal River Basin. BMC Infect. Dis. 11, 198.

Uchoa, E., Barreto, S.M., Firmo, J.O., Guerra, H.L., Pimenta Jr., F.G., Lima e Costa, M.F., 2000. The control of schistosomiasis in Brazil: an ethno-epidemiological study of the effectiveness of a community mobilization program for health education. Soc. Sci Med. 51 (10), 1529–1541.

WHO, 2010. Schistosomiasis. Wkly. Epidemiol. Rec. 18, 158–164.

WHO, 2011. Helminth Control in School-age Children: a Guide for Managers of Control Programmes, 2nd edition. WHO, Geneva.

WHO, 2012. Sixty-Fifth World Health Assembly: Elimination of schistosomiasis. 26 May 2012. http://www.who.int/neglected_diseases/mediacentre/WHA_65.21_Eng.pdf. (accessed 18.06.16.).

WHO, 2013a. Schistosomiasis: Progress Report 2001–2011 and Strategic Plan 2012–2020. WHO, Geneva http://apps.who.int/iris/handle/10665/78074.

WHO, 2013b. Assessing the Efficacy of Anthelminthic Drugs Against Schistosomiasis and Soil-transmitted Helminthiasis. WHO, Geneva.

WHO, 2016. Schistosomiasis, a major public health problem. http://www.who.int/schistosomiasis/en/. accessed: 28.06.16.

Xu, J., Xu, J.F., Li, S.Z., Zhang, L.J., Wang, Q., Zhu, H.H., Zhou, X.N., 2015. Integrated control programmes for schistosomiasis and other helminth infections in P.R. China. Acta Trop. 141 (Pt B), 332–341.