Prevalence and risk factors associated with the presence of Soil-Transmitted Helminths in children studying in Municipal Corporation of Delhi Schools of Delhi, India

Sobhana Ranjan · Santosh Jain Passi ·
Som Nath Singh

Received: 13 August 2013 / Accepted: 18 October 2013 / Published online: 1 November 2013
© Indian Society for Parasitology 2013

Abstract To determine the type, prevalence, intensity and the potential risk factors for helminths infection harboured by primary school aged children from selected schools of Delhi, India. Stool samples collected from 347 boys and girls studying in grades I–IV (aged 5–15 years) were examined by the semi-quantitative Kato-Katz method for presence of eggs of soil-transmitted helminths. Questionnaire data on the potential risk factors, associated variables and consequences of infection were categorized as individual, household, hygiene/sanitation related and behavioural factors. Associations between infection and these factors were assessed by multiple logistic regressions. The overall prevalence of infection with any of the helminths was 29.7 %. The prevalence of single infection with *Ascaris lumbricoides* was 8.1 % while that of hookworm

and *Trichuris trichiura* was 3.7 % each. Strongest predictors for the helminths presence were never deworming (OR = 1.76; 95 % CI: 1.05, 2.95), no facility for defecation (OR = 4.31; 95 % CI: 1.22, 15.22), using left hand for cleaning anal region (OR = 2.01; 95 % CI: 1.18, 3.43) and not reporting pain in stomach (OR = 1.93; 95 % CI: 1.14, 3.26). Though the infection intensities were low, we highlighted some of the potential risk factors that increase the susceptibility to these infections. Periodic deworming along with improvement in hygiene and sanitation practices through concerted efforts, not only from the school infrastructure but also the community at large, will help prevent helminths transmission and reinfection.

Keywords *Ascaris lumbricoides* · *Trichuris trichiura* · Hookworm · Soil-transmitted helminths · Risk factors · Kato-Katz technique

S. Ranjan · S. J. Passi
Department of Food and Nutrition, Institute of Home Economics, University of Delhi, F-4, Chaitanya Mahaprabhu Marg, Hauz Khas, New Delhi 110 016, India
e-mail: sjpassi@gmail.com

S. Ranjan (✉)
Department of Nutrition Sciences, College of Nursing and Health Professions, Drexel University, 245 N. 15th Street, Bellet Building, Philadelphia, PA 19102, USA
e-mail: sobhanaranjan@yahoo.com

S. J. Passi
NIHFW/ European Union/ Futures Group, National Institute of Health and Family Welfare, Baba Gang Nath Marg, Munirka, New Delhi 110067, India

S. N. Singh
Nutrition Division, Defence Institute of Physiology and Allied Sciences, DRDO, Lucknow Road, Timarpur, Delhi 110054, India
e-mail: divnutrition@yahoo.com

Introduction

Soil-transmitted helminths (STHs) are a major contributor to the malnutrition-infection cycle that adversely affects physical and cognitive development, thwart educational achievement thereby hindering economic growth. Although termed as neglected tropical diseases (NTDs), these ubiquitous problems affect individuals especially in the period of intense physical and intellectual development. Among the numerous species, *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), and the blood-feeding *Ancylostoma duodenale* or *Necator americanus* (hookworms) are the major species of intestinal nematodes that affect humans. Globally, about 48 % of the 5 billion or so people living in the developing world are infected with at least one worm species, while 10 % with at

least two species; and that *A. lumbricoides* infects 1.221 billion people (26 %), *T. trichiura* 795 million (17 %), and hookworms 740 million (15 %) (de Silva et al. 2003; Hall et al. 2008). Earlier estimate of the Disability Adjusted Life Years (DALY's) lost for these nematodes was a whopping 39.0 million life-years (Chan 1997).

Chemotherapy is the most cost-effective and easy to implement strategy. However, to prevent re-infection and development of drug resistance, non-chemotherapeutic-based options (like health education, improved sanitation and living conditions) must be adopted along with chemotherapy (WHO 1996; Geerts and Gryseels 2001).

Determining the prevalence and intensity of infection at baseline is fundamental to initiate parasitic control. In this cross-sectional study, we determine the prevalence, intensity and the type of helminths infection harboured by the school children. We also examine the relationship between STHs infection and their potential risk factors, associated variables and consequences.

Materials and Methods

Study area

The Municipal Corporation of Delhi (MCD) divides Delhi, the capital of India, into 12 zones and each zone into several wards. For this study, Civil Lines Zone was purposively short-listed. Among its ten wards, three schools within a distance of 5 km namely *Guru Teg Bahadur*, *Hakikat Nagar* and *Gopalpur Village M.C.* Primary Schools from the *Timarpur* and *GTB Nagar* wards were randomly selected. Necessary permissions from the Education Department and the school principals were obtained.

Design

Class-wise interactive discussions highlighting the causes, consequences and control of helminths were carried out wherein awareness about the helminths' eggs being invisible to the naked eyes but detectable by sophisticated instruments was also generated. Appropriate method of stool sample collection was demonstrated and necessary instructions given. Each child (aged 5–15 years) present on the days designated to the classes I–IV was given a stool sample collection vial containing 10 % formalin (an all-purpose fixative) and a wooden spatula. Each vial was labelled with a unique code, child's name, class and date. Children who brought their stool samples the following day were enrolled in the study while those reporting loss or breakage were given a fresh vial. The faecal samples were transported to laboratory at the National Institute of Communicable Diseases for further processing and examination.

Using the questionnaire, data on socio-demographic profile, potential risk factors, associated variables or consequences of helminth infection were gathered. Anthropometric measurements (weight and height) were taken employing standardized procedures. Weight-for-age (WAZ), Height-for-age (HAZ) and Body Mass Index-for-Age (BAZ) z-scores were then computed using the WHO AnthroPlus software version 1.0.2 that compares their distribution with the WHO Reference 2007 for 5–19 year olds (WHO 2009).

Sampling statistics

A sample size of 200–250 individuals is adequate to evaluate prevalence and intensity of STHs for each ecologically homogeneous area (Lwanga and Lemeshow 1991). Keeping this in mind, single faecal samples were collected from 347 children over a period of 3 months between November and January. In total, 167 boys and 180 girls participated in the study.

Parasitological examination

Faecal samples were examined for the eggs of *A. lumbricoides*, *T. trichiura* and hookworms using the semi-quantitative Kato-Katz technique (Martin and Beaver 1968; WHO 1993). The presence of single and multiple helminths were noted and their intensities of infection were measured as eggs per gram of faeces (epg). Presence of eggs of other species, if any, were noted without their egg counts.

Ethical consideration

The study was approved by the Institutional Ethics Committee, Institute of Home Economics, University of Delhi. After explaining the study procedure, verbal assent either from the subject or their parental permission was obtained. All the infected subjects were given a single dose of albendazole by the School Health Scheme ensuring that the tablets were properly chewed and swallowed.

Statistical analysis

A coding design formulated for each response was used for data entry into Microsoft Excel which was manually crosschecked. Statistical analysis was carried out using SPSS 11.5 (SPSS, Chicago, IL) and STATA 9.0 (College Station, Texas, USA) and the *p* values less than 0.05 were considered statistically significant.

The prevalence of infection with each parasitic species, the cumulative (prevalence of infection with at least one STH) and the multiple infection prevalence were computed. Subjects were categorized as having light, moderate or heavy STH's infections on the basis of threshold

concentrations of their faecal worm eggs load (WHO 1987, 2002). For *A. lumbricoides* infection, the presence of 1–4,999 epg (eggs per gram) was considered as light infection, between 5,000 and 49,999 epg as moderate and $\geq 50,000$ epg as heavy infection. In case of Hookworm (*A. duodenale* and *N. americanus*), 1–1,999 epg was regarded as light, between 2,000 and 3,999 as moderate and $\geq 4,000$ as heavy infection while for *T. trichiura*, 1–999 epg was categorized as light, between 1,000 and 9,999 epg as moderate and $\geq 10,000$ epg as heavy infection.

All the potential risk factors, associated variables and consequences of STH infection explored were categorized under four factors. The variables studied within each were:

- *Individual factors*: Age, Gender, Height, Weight, HAZ Scores, WAZ Scores, BAZ scores, History of excreting worms, Action taken on seeing worms, Anthelmintic usage.
- *Household factors*: Area, Family Size, No of rooms in the house, Place of defecation.
- *Hygiene/sanitation related factors*: Wash hands before eating, Wash hand before eating with, Hand used for cleaning anal region, Wash hands after defecation, Wash hands after defecation with, Nail biting habit.
- *Behavioural factors*: Pica behaviour, Stomach ache, Appetite, Participation in extracurricular activities, Peri-anal irritation, Footwear usage.

Number of subjects infected with a particular helminth being relatively small, the risk of infection with either was evaluated. Associations between parasitic infection and the variables within each factors were studied using Chi-square test and the potential factors associated with infection by multiple logistic regression. Factors significant at $p < 0.10$ in the bivariate analysis were considered in the multiple logistic regressions. The results are reported as OR (95 % CI). For analysis of the variables—age, height and weight, values below or above their means for the total sample have been used.

Results

Study population

Of the 544 children present on the day of vial distribution, 347 children providing their stool samples for examination were enrolled. Reasons for non-participation (36.2 %) were either self or parent's restrain. Mean age of the subjects computed from date-of-birth was 8.1 ± 1.8 years (5.1–15.6). 55.0 % of the subjects belonged to medium sized families with 6–8 members, 40.6 % to small families (3–5 members) while the rest had large families (9–12 members). Nearly 80 % of them lived in households with one room accommodation, 17.9 % in two while a meagre in three rooms' accommodation.

Table 1 Distribution of soil-transmitted helminths infection in children studying in MCD schools of Civil Lines Zone, Delhi

Type of infection	Total (N = 347)
<i>Ascaris lumbricoides</i>	28 (8.1)
<i>Trichuris trichiura</i>	13 (3.7)
Hookworm	13 (3.7)
<i>Enterobius vermicularis</i>	8 (2.3)
<i>Hymenolepis nana</i>	18 (5.2)
Any infection	103 (29.7)
Single infection	80 (23.1)
Double infection	21 (6.1)
Triple infection	2 (0.6)

N = Total number of study participants

Figures in parenthesis indicate percentages

Prevalence and intensity of infection

Stool examination revealed the presence of eggs of *A. lumbricoides*, *T. trichiura*, Hookworm, *Enterobius vermicularis* and *Hymenolepis nana* (Table 1). The overall prevalence of infection with any of the helminths was 29.7 %; single infection with *Ascaris* was 8.1 % while that of hookworm and *T. trichiura* (3.7 % each). Prevalence of infection (alone or co-infection) with *Ascaris* was 12.4 %, with hookworm or *T. trichiura* 6.3 % while with *E. vermicularis* and *H. nana* 4.0 % and 7.2 %, respectively. None harboured heavy infection, majority had light infections except few with moderate *A. lumbricoides* (2.3 %) and *T. trichiura* (0.6 %) infections.

Risk factors associated with infection

Bivariate logistic regression analysis of all the variables studied was carried out and only those significant at 0.10 level in the bivariate analysis were considered in the multivariate analysis.

Potential individual factors

Children aged 8 years or less ($5 \leq 8$ years) had 1.63 times higher odds (95 % CI: 1.03, 2.59; $p = 0.039$) of being infected as compared to those aged between 9 and 13 years. Also, never dewormed children had 1.75 times higher odds (95 % CI: 1.08, 2.82; $p = 0.023$) of being infected as compared to previously dewormed ones (Table 2).

Potential household factors

Children from peri-urban areas had 1.53 times higher odds (95 % CI: 0.96, 2.4; $p = 0.073$) of being infected as compared to those from urban area. Compared to those using own flush toilets, children with no facility for

Table 2 Univariate analysis of the potential risk factors for infection

Risk factors	Unadjusted OR (95 % CI)	<i>p</i> Value
<i>Potential individual factors</i>		
Age (years)		
>8	1.0	
≤8	1.63 (1.03, 2.59)	0.039*
Gender		
Female	1.0	
Male	1.02 (0.65, 1.62)	0.920
Height (cms)		
≥120	1.0	
<120	1.19 (0.75, 1.88)	0.465
Weight (kgs)		
≥20	1.0	
<20	1.26 (0.79, 1.99)	0.334
HAZ Scores		
<−2 SD	1.0	
≥−2 SD	1.07 (0.58, 1.95)	0.831
WAZ Scores		
<−2 SD	1.0	
≥−2 SD	1.08 (0.65, 1.82)	0.762
BAZ Scores		
<−2 SD	1.0	
≥−2 SD	1.38 (0.82, 2.34)	0.225
History of excreting worms		
No	1.0	
Yes	0.68 (0.41, 1.12)	0.131
Action taken on passing worms		
Doctor's consultation	1.0	
No action	1.39 (0.79, 2.49)	0.255
Anthelmintic usage		
Dewormed	1.0	
Never dewormed	1.75 (1.08, 2.82)	0.023*
<i>Potential household factors</i>		
Area		
Urban	1.0	
Peri-urban	1.53 (0.96, 2.4)	0.073
Family size		
<6 Members	1.0	
≥6 Members	1.11 (0.69, 1.78)	0.658
No of rooms		
>1 Room	1.0	
1 Room	1.25 (0.69, 2.3)	0.466
Place of defecation		
Own flush toilet	1.0	
Shared flush toilet	1.73 (0.59, 5.09)	0.319
Public flush toilet	1.68 (0.61, 4.64)	0.320
No facility/bush/field/drain	5.66 (1.71, 18.71)	0.005*

Table 2 continued

Risk factors	Unadjusted OR (95 % CI)	<i>p</i> Value
<i>Potential hygiene/sanitation related factors</i>		
Wash hand before eating with		
Soap and water	1.0	
Only water/no washing	0.90 (0.51, 1.59)	0.719
Hand used for cleaning anal region		
Right hand	1.0	
Left hand	1.88 (1.15, 3.06)	0.012*
Wash hand after defecation		
Soap and water	1.0	
Only water/mud water	0.72 (0.23, 2.26)	0.786
Habit of nail biting		
No	1.0	
Yes	0.69 (0.35, 1.39)	0.300
<i>Potential behavioural factors</i>		
Eat mud		
No	1.0	
Yes	0.64 (0.40, 1.0)	0.065
Reported stomach ache		
Yes (often/sometimes)	1.0	
No	1.86 (1.14, 3.01)	0.012*
Appetite		
Feels hungry often	1.0	
Doesn't feel hungry	1.24 (0.78, 1.96)	0.368
Participate in extracurricular activities		
Participates	1.0	
Doesn't participate	1.77 (0.89, 3.50)	0.103
Experience peri-anal irritation		
No	1.0	
Yes	0.88 (0.56, 1.41)	0.605
Footwear		
Wear footwear's when outdoors	1.0	
Barefoot when outdoors	1.27 (0.57, 2.84)	0.555

* $p < 0.05$

defecation/those defecating in the open had 5.66 times higher odds (95 % CI: 1.71, 18.71; $p = 0.005$) of being infected. Though statistically insignificant, children using shared or public flush toilets had nearly 1.68–1.73 times higher odds of being infected as compared to those using own flush toilet (Table 2).

Potential hygiene/sanitation related factors

The study indicate that children using left hand for cleaning their anal region had 1.88 times higher odds (95 % CI:

Table 3 Multivariate analysis of independent risk factors for infection

Risk factors	Adjusted OR (95 % CI)	<i>p</i> Value
<i>Potential individual factors</i>		
Age (years)		
>8	1.0	
≤8	1.60 (0.96, 2.68)	0.071
Anthelmintic usage		
Dewormed	1.0	
Never dewormed	1.76 (1.05, 2.95)	0.033*
<i>Potential household factors</i>		
Area		
Urban	1.0	
Peri-urban	1.41 (0.79, 2.50)	0.242
Place of defecation		
Own flush toilet	1.0	
Shared flush toilet	1.06 (0.33, 3.47)	0.917
Public flush toilet	1.61 (0.56, 4.65)	0.375
No facility/bush/field/drain	4.31 (1.22, 15.22)	0.023*
<i>Potential hygiene/sanitation related factors</i>		
Hand used for cleaning anal region		
Right hand	1.0	
Left hand	2.01 (1.18, 3.43)	0.010*
<i>Potential behavioural factors</i>		
Eat mud		
No	1.0	
Yes	0.73 (0.44, 1.20)	0.216
Reported pain in stomach		
Yes (often/sometimes)	1.0	
No	1.93 (1.14, 3.26)	0.014*

* $p < 0.05$

1.15, 3.06; $p = 0.012$) of being infected as compared to those using right hand for the same (Table 2). Surprisingly, subjects reporting pica behaviour of consuming mud had 64 % ($p = 0.065$) less chance of being infected as compared to their counterparts.

Potential behavioural factors

Compared to those who reported stomach ache, children who did not report experiencing pain in stomach had 1.86 times higher odds (95 % CI: 1.14, 3.01; $p = 0.012$) of being infected (Table 2).

Risk factors independently associated with infection

The independent predictors of infection identified from multiple logistic regression analysis are shown in Table 3.

Anthelmintic usage, place of defecation, hand used for cleaning anal region and reported pain in stomach remained the significant independent predictors. Compared to those who were previously dewormed, never dewormed ones had 1.76 times higher odds (95 % CI: 1.05, 2.95; $p = 0.033$) of being infected. Subjects with no facility for defecation/those defecating in the open had 4.31 times higher odds (95 % CI: 1.22, 15.22; $p = 0.023$) of being infected as compared to those using own flush toilets. Subjects using left hand for cleaning anal region had 2.01 times higher odds (95 % CI: 1.18, 3.43; $p = 0.010$) of being infected as compared to those using right hand for the same. Further, subjects who did not report experiencing pain in stomach had 1.93 times higher odds (95 % CI: 1.14, 3.26; $p = 0.014$) of being infected as compared to their counterparts.

Discussion

To our knowledge, this study is first to determine the prevalence along with potential risk factors of STH infection among children from the selected MCD schools of Delhi. Based on 2001 population census, the prevalence of Ascariasis in India was estimated as 14 % while of hookworm and Trichuriasis as 7 % each (de Silva et al. 2003). Although our sample represents only a small part of Delhi and not India, the slightly lower prevalence of infection in our sample could perhaps be by chance or may be due to improved hygiene/sanitation practices and access to health services to a certain extent.

Our study provides evidence for public health measures to counteract STH infection; however, the results must be interpreted in the light of certain limitations. Information on potential risk factors, associated variables and consequences of infection were based on the child's response and not validated by parents, possibly leading to recall and information bias. Infection with individual STHs being relatively small, risk of infection with either had to be evaluated which might have further diluted the true findings. Among the factors investigated, the present study highlighted anthelmintic usage, place of defecation; hand used for cleaning anal region and reported pain in stomach as important independent predictors of infection.

Although statistically insignificant in the multivariate analysis, our subjects aged 5–≤8 years had higher risk of being infected as compared to their elder counterparts presumably due to their greater participation in soil contact activities and lower personal hygiene. It has also been reported that *A. lumbricoides* and *T. trichiura* infections reach maximum prevalence and intensity in school-age years and then decline in adulthood (Asaolu et al. 1992; Bundy 1995).

We observed no gender differences for the risk of infection. However, studies show that men are more prone

to and also harbour more hookworm infection than women while females have higher levels of *Ascaris* infection owing to gender differences in exposure to contaminated soil (Holland et al. 1989; Kightlinger et al. 1998; Knopp et al. 2010). Growth deficits in children have been attributed to *Ascaris* while deficit in height to intense *T. trichiura* infections (Bundy and Cooper 1989; Hlaing et al. 1991). Although heaviest infections have most pronounced effects on growth, light infections also contribute to growth deficits if the nutritional status is compromised (Stephenson et al. 2000; Crompton and Nesheim 2002). We did not find any specific trend in the anthropometric parameters and indices studied. Perhaps, data on duration of infection would have given a better insight.

Children with a history of excreting worms and not being treated are more likely to be infected or re-infected. Child's recall bias could have led to our non-conclusive result. However, our never dewormed subjects had higher chances of being infected as compared to previously dewormed ones. Periodic deworming is by far the most cost-effective strategy for reducing the worm burden and transmission over time. Anthelmintics usage at least once every 3 years could significantly reduce the prevalence of *A. lumbricoides* 1.9 times (95 % CI: 1.2, 3.1; $p = 0.015$) and hookworms 1.8 times (95 % CI: 1.1, 2.9; $p = 0.018$), but had no effect on *T. trichiura* prevalence (Traub et al. 2004).

Although not a true classification, to account for their slight differences in geographical distribution, subjects enrolled from *Guru Teg Bahadur* and *Hakikat Nagar* M.C. Primary Schools were considered as urban slum dwellers while from *Gopalpur* Village M.C. Primary School as peri-urban slum dwellers. Possibly due to poor community services that increase the likelihood of infections, our peri-urban slum dwellers had higher chances of being infected as compared to their urban counterparts. While living in rural area is significantly associated with highest infections (Escobedo et al. 2008), poor living conditions and improper personal hygiene practices even in the urban areas have resulted in increased *A. lumbricoides* and *T. trichiura* infections (Atukorala and Lanerolle 1999).

Household crowding (number of co-residents per room) is a significant determinant of both the prevalence and intensity of STHs (Haswell-Elkins et al. 1989; Narain et al. 2000; Olsen et al. 2001). Unlike our findings, individuals living in households with more than six members had higher intensities of infection with all the three STHs and were 2.0 times more likely to be infected with *A. lumbricoides*, 1.6 times with *T. Trichiura* and 1.7 times with hookworms than individuals living in households with six or fewer members (Traub et al. 2004). Others too have highlighted that households not owning a toilet or the children not always using it had a higher percentage of

infected members (Holland et al. 1988; Yajima et al. 2009). Promiscuous defecation too increases faecal pollution and the risk of geohelminth infection (Haswell-Elkins et al. 1989).

Non-use of soap is a predictor of *Ascaris* infection and that households without soap had 2.6 times higher risk of being infected than their counterparts (Olsen et al. 2001). Washing hands after defecation is protective against *T. trichiura* infection (OR = 0.06; 95 % CI: 0.01, 0.26) (Knopp et al. 2010) and that relative to daily use, infrequent (at least once a week) and less frequent (less than once a week) use of soap has been associated with increased risk of infection (OR = 1.40, 1.66 respectively; p for trend = 0.018) (Belyhun et al. 2010). Although it remains unclear as to why we could not see the same correlation, one possible reason could be the child's recall bias. While it is logical to check on the habit of biting nails to prevent auto- and cross-infection, we observed no significant trend.

Due to faecal-oral route of transmission, use of right hand both for eating and cleaning the anal region (post defecation) could increase the risk of helminths infection. Subjects being rather young were asked to raise their hands used for each. Since washing hands with soap after defecation was universally reported, we couldn't observe this association. For better understanding, data should have been gathered for hand mostly used for eating.

Although pica behaviour, particularly geophagy, is a risk factor for helminths infection (Geissler et al. 1998; Saathoff et al. 2002), we couldn't find this because we studied the association between present infection and retrospective pica behaviour rather than their present behaviour.

Children reporting abdominal pain are 4 times (OR = 4.05; 95 % CI: 1.11, 13.18) more likely to have STHs infections and that *T. trichiura* infected subjects, in particular, have increased risk of stomach ache (OR = 3.31; 95 % CI: 1.05, 10.43) (Escobedo et al. 2008; Knopp et al. 2010). Absence of such correlation in our sample could be because majority had light infection which may be asymptomatic and the reported ache could be due to other underlying problems. Because helminth infection causes and/or aggravates malnutrition through several mechanisms, reduced food intake being one of them (Hall et al. 2008), we gathered data on their appetite. Conclusions could not be arrived at probably because this data was not supplemented by parental response.

Although non-significant, our study pointed that children not participating in extracurricular activities, perhaps due to lethargy and lack of vigour, had 1.77 times higher odds (95 % CI: 0.89, 3.50; $p = 0.103$) of being infected as compared to their counterparts. Iron deficiency among infected children can explain this association.

Cutaneous penetration of larvae explains the association between walking barefoot while outdoors with hookworm but the reason for *Trichuris* infection remains unclear (Traub et al. 2004). Though insignificant, our subjects who reported being barefoot when outdoors too had 1.27 times higher odds (95 % CI: 0.57, 2.84; $p = 0.555$) of being infected as compared to those wearing footwear's. Migration of female *E. vermicularis* worms before egg deposition leads to peri-anal sepsis in children (Mahomed et al. 2003). However, owing to its low prevalence; peri-anal irritation did not emerge as a consequence in our sample.

Conclusions

The consequences of STH's infection may not be alarmingly detrimental as other infectious diseases but due attention is required in view of its potential to affect young children and enormity. School children being a captive population, the school system offers a unique set-up for its successful treatment. Therefore, the STH control programme should be integrated and developed as an entry point for providing more comprehensive school health services. Further, the school curriculum should lay ample emphasis on intestinal parasites, their prevention and control so that by improved awareness, positive change in personal hygiene and environmental sanitation related habits as well as avoidance of certain behaviours aggravating infection can be achieved. The preventive and promotive behaviours learnt and adopted by these children (health messengers) can further be passed on to their parents, households and community at large.

Acknowledgments We thank the Director, Primary Education and the School Health Scheme, MCD for granting permission to carry out the study in the selected schools. We also thank the Department of Parasitic Diseases, National Institute of Communicable Diseases for the necessary training and permission to carry out the stool examination in their laboratory. We acknowledge the help by Mrs Kalaivani Mani, Biostatistician, AIIMS in the statistical analysis and interpretation of data. We thank the Headmasters, class teachers, children and their parents for their wholehearted cooperation throughout the study.

References

- Asaolu SO, Holland CV, Jegede JO, Fraser NR, Stoddart RC, Crompton DWT (1992) The prevalence and intensity of soil-transmitted helminthiasis in rural communities in Southern Nigeria. *Ann Trop Med Parasitol* 86:276–287
- Atukorala TM, Lanerolle P (1999) Soil-transmitted helminthic infection and its effect on nutritional status of adolescent schoolgirls of low socioeconomic status in Sri Lanka. *J Trop Pediatr* 45(1):18–22
- Belyhun Y, Medhin G, Amberbir A, Erko B, Hanlon C, Alem A et al (2010) Prevalence and risk factors for soil-transmitted helminth infection in mothers and their infants in Butajira, Ethiopia: a population based study. *BMC Public Health* 10:21
- Bundy DA (1995) Epidemiology and transmission of intestinal helminths. In: Farthing MJG, Keusch GT, Wakelin D (eds) *Enteric infection 2, intestinal helminths*. Chapman and Hall Medicine, London, pp 5–24
- Bundy DA, Cooper ES (1989) *Trichuris* and trichuriasis in humans. *Adv Parasitol* 28:107–173
- Chan MS (1997) The global burden of intestinal nematode infections—fifty years on. *Parasitol Today* 13(11):438–443
- Crompton DWT, Nesheim MC (2002) Nutritional impact of intestinal helminthiasis during the human life cycle. *Annu Rev Nutr* 22:35–59
- de Silva NR, Brooker S, Hotez PJ, Montresor A, Engels D, Savioli L (2003) Soil-transmitted helminth infections: updating the global picture. *Trends Parasitol* 19(12):547–551
- Escobedo AA, Canete R, Nunez FA (2008) Prevalence, risk factors and clinical features associated with intestinal parasitic infections in children from San Juan y Martínez, Pinar del Río, Cuba. *West Indian Med J* 57(4):378–382
- Geerts S, Gryseels B (2001) Anthelmintic resistance in human helminths: a review. *Tropical Med Int Health* 6:915–921
- Geissler PW, Mwaniki D, Thiong F, Friis H (1998) Geophagy as a risk factor for geohelminths infections: a longitudinal study of Kenyan primary schoolchildren. *Trans R Soc Trop Med Hyg* 92:7–11
- Hall A, Hewitt G, Tuffrey V, de Silva N (2008) A review and meta-analysis of the impact of intestinal worms on child growth and nutrition. *Matern Child Nutr* 4(Suppl 1):118–236
- Haswell-Elkins MR, Elkins DB, Anderson RM (1989) The influence of individual, social group and household factors on the distribution of *Ascaris lumbricoides* within a community and implications for control strategies. *Parasitology* 98(1):125–134
- Hlaing T, Toe T, Saw T, Kyin ML, Lwin M (1991) A controlled chemotherapeutic intervention trial on the relationship between *Ascaris lumbricoides* infection and malnutrition in children. *Trans R Soc Trop Med Hyg* 85:523–528
- Holland CV, Taren DL, Crompton DW, Nesheim MC, Sanjur D, Barbeau I et al (1988) Intestinal helminthiasis in relation to the socioeconomic environment of Panamanian children. *Soc Sci Med* 26:209–213
- Holland CV, Asaolu SO, Crompton DW, Stoddart RC, Macdonald R, Torimiro SE (1989) The epidemiology of *Ascaris lumbricoides* and other soil-transmitted helminths in primary school children from Ile-Ife, Nigeria. *Parasitology* 99(Part 2):275–285
- Kightlinger LK, Seed JR, Kightlinger MB (1998) *Ascaris lumbricoides* intensity in relation to environmental, socioeconomic, and behavioural determinants of exposure to infection in children from southeast Madagascar. *J Parasitol* 84(3):480–484
- Knopp S, Mohammed KA, Stothard JR, Khamis IS, Rollinson D, Marti H et al (2010) Patterns and risk factors of helminthiasis and anemia in a rural and a peri-urban community in Zanzibar, in the context of helminth control programs. *PLoS Negl Trop Dis* 4(5):e681. doi:10.1371/journal.pntd.0000681
- Lwanga SK, Lemeshow S (1991) Sample size determination in health studies: a practical manual. WHO, Geneva. [http://whqlibdoc.who.int/publications/9241544058_\(p1-p22\).pdf](http://whqlibdoc.who.int/publications/9241544058_(p1-p22).pdf). Accessed 12 May 2006
- Mahomed AA, MacKenzie RN, Carson LS, Jibril JA (2003) *Enterobius vermicularis* and perianal sepsis in children. *Pediatr Surg Int* 19:740–741
- Martin LK, Beaver PC (1968) Evaluation of Kato thick-smear technique for quantitative diagnosis of helminth infections. *Am J Trop Med Hyg* 17:382–391
- Narain K, Rajguru SK, Mahanta J (2000) Prevalence of *Trichuris trichiura* in relation to socio-economic and behavioural

- determinants of exposure to infection in rural Assam. *Indian J Med Res* 112:140–146
- Olsen A, Samuelsen H, Onyango-Ouma W (2001) A study of risk factors for intestinal helminth infections using epidemiological and anthropological approaches. *J Biosoc Sci* 33:569–584
- Saathoff E, Olsen A, Kvalsvig JD, Geissler PW (2002) Geophagy and its association with geohelminth infection in rural schoolchildren from northern KwaZulu-Natal, South Africa. *Trans R Soc Trop Med Hyg* 96(5):485–490
- Stephenson LS, Latham MC, Ottesen EA (2000) Malnutrition and parasitic helminth infections. *Parasitology* 121:S23–S28
- Traub RJ, Robertson ID, Irwin P, Mencke N, Thompson RC (2004) The prevalence, intensities and risk factors associated with geohelminth infection in tea-growing communities of Assam, India. *Trop Med Int Health* 9(6):688–701
- World Health Organization (1987) Prevention and control of intestinal parasitic infections. Report of a WHO Expert Committee. WHO Technical Report Series. 749. WHO, Geneva
- World Health Organization (1993) Cellophane faecal thick smear examination technique (Kato) for diagnosis of intestinal schistosomiasis and gastrointestinal helminth infections. *PDP* 83:3
- World Health Organization (1996) Report of the WHO Informal Consultation on the Use of Chemotherapy for the Control of Morbidity Due to Soil-Transmitted Nematodes in Humans (WHO/CTD/SIP/96.2). WHO, Geneva
- World Health Organization (2002) Prevention and Control of Schistosomiasis and Soil-Transmitted Helminthiasis. Report of a WHO Expert Committee. WHO technical report series No 912. WHO, Geneva. http://whqlibdoc.who.int/trs/WHO_TRS_912.pdf. Accessed 25 June 2007
- World Health Organization (2009) WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. WHO, Geneva. <http://www.who.int/growthref/tools/en/>. Accessed 12 Feb 2010
- Yajima A, Jouquet P, Trung DD, Cam TDT, Cong DT, Orange D et al (2009) High latrine coverage is not reducing the prevalence of soil-transmitted helminthiasis in Hoa Binh province, Vietnam. *Trans R Soc Trop Med Hyg* 103(3):237–241