Risk factors for intestinal parasitosis, anaemia, and malnutrition among school children in Ethiopia

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Research on associated risk factors for intestinal parasitic infections and malnutrition in various geographic regions is needed for the development of appropriate control strategies. The aim of this study was to determine the risk factors associated with intestinal parasitic infections, anaemia, and malnutrition in school children, living in urban and rural areas of northern Ethiopia. Six hundred school children, aged 6–15 years, were randomly selected in a cross-sectional survey from 12 primary schools. Sociodemographic and anthropometric data were collected. Faecal samples were examined using direct, concentration, and the Kato–Katz methods. Urine specimens were analysed for *Schistosoma haematobium* ova. Haemoglobin was measured using a HemoCue spectrometer. The overall prevalence of intestinal parasitosis was 72% (95% confidence interval (CI): 66–76%). The prevalence of anaemia, stunting, and thinness were 11% (95% CI: 8–13%), 35% (95% CI: 31–38%), and 34% (95% CI: 30–38%), respectively. Poor personal hygiene habits were generally associated with anaemia and nutritional deficiency (low body mass index). Multivariate logistic regression models related Schistosoma mansoni infection with boys. Boys were also more likely to be malnourished. Hookworm infection was associated with anaemia and unhygienic finger nails.

Access to clean water and latrines, with some hygiene and sanitation communication activities, could improve health of children in Ethiopia. The use of smartphone technology in demographic data collection proved to be successful. The potential advantage offered by this technology for parasitological field surveys merits further investigation.

Keywords: Intestinal parasitosis, Anaemia, Malnutrition, Risk factors, School children

Introduction

Intestinal parasitic infections,[1] anaemia, and malnutrition are highly endemic in resource-limited regions.[2,3] School-aged children are more at risk for disease than any other age group, because they are particularly susceptible to parasitic infections.[1,4] In developing countries, 12% of the global disease burden due to intestinal worms is estimated to occur in children aged 5–14 years.[5]

Human gastrointestinal parasites are linked with an increased risk for childhood malnutrition and growth deficits.[6,7] Parasitic diseases, such as helminthiasis, cause malnutrition[8] through mechanisms that include decreased food intake and nutrient absorption, increased metabolic requirements, and direct nutrient losses.[9] The poor health also results in deficits in cognitive development and educational achievements.[3,10]

Many health programmes in developing countries were not paying enough attention to the improvement of the health of children at school age.[11] Nowadays however, there is huge commitment to controlling intestinal parasitic infections and to improving the health and development of young children.[12] To be effective, interventions aimed at reducing the effects of infection and malnutrition need to be based on a proper assessment of the current situation.

In this study, we investigated the prevalence and the associated risk factors for intestinal parasitosis, anaemia, and malnutrition in school children in urban and rural areas of northern Ethiopia. Like any other deprived area in the country, lack of access

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to improved sanitation facilities and poor hygiene behaviour characterises the study area. Intestinal parasitic infections are amongst the top ten causes of morbidity following acute upper respiratory tract infection, pneumonia, and diarrhoea.[13] No data on the nutritional status among school children is available, but a study done on adolescence girls from the area showed high prevalence of malnutrition.[14]

Methods

Study design and study population

The cross-sectional study was carried out in October 2010 among 12 primary schools in northern Ethiopia. The study area lies in an approximate 1010 km^2 at an altitude of 1900–2300 m above sea level. Like the rest of the region, the area has a semi-arid climate characterized by inadequate and erratic rainfall, mainly falling between June and September. Subsistence farming is common among the inhabitants.

The study schools were selected by purposive sampling as they were part of the Demographic and Health Surveillance (DHS) site established by the College of Health Sciences of Mekelle University. We incorporated all the schools that offered education for grades 1–8 in the DHS districts. Schools in towns with municipal administration were considered as urban, while schools in areas without municipal administration and where the predominant type of economic activity was agricultural were considered as rural.

Six hundred school children (age range: 6–15 years), out of 18 628 currently enrolled, were selected by a systematic random sampling technique using school rosters as a sampling frame. To obtain the exact ages of the children, the reported age of a child was cross-checked using school records, baptism certificates, birth certificates, local calendars, and information from parents. The selected school children were invited to participate in the study after obtaining a written informed consent from parents or guardians.

Data collection

Sociodemographic information

Demographic and socioeconomic data were collected using episurveyor web-based software (http://www.episurveyor.org) in combination with a smart phone application. Structured questionnaires were uploaded on a smart phone (Nokia E71) using the Datadyne Episurveyor software. To reduce input errors, easy-to-use data collection forms were developed and phones were programmed to prevent moving forward without answering the current question. Two separate questionnaires (child and household) were administered by the investigators in a local language to generate information on personal bio-data and other sociodemographic and socioeconomic information. Almost all sociodemographic data were collected by asking questions to the parents or guardians. Some variables, like hand hygiene and cleanliness of hand fingernails, were studied by observation. Physical cleanliness of hands was assessed by checking the palm, fingertips, finger pads, and back of the hand of both hands, and hands were coded as unclean if any visible dirt was seen and clean if there was no visible dirt. Finger nail hygiene of both hands was observed and clean and trimmed fingers were coded as clean and untrimmed nails with accumulated dirt were coded as unclean. To ensure uniform understanding among all data collectors, in-house training was conducted using role play and thereafter pre-testing was conducted in the field prior to actual data collection. Daily close supervision (spot checks, re-interviewing, and thorough scrutiny of filled-in questionnaires) was made by the field supervisors deployed with the data collectors.

Parasitological examination

From each subject, about 10 g (thumb size) fresh stool and 10 ml of fresh midday urine specimens were collected on the spot in clean and labelled containers. Stool specimens were analysed by well-trained laboratory technologists using direct saline wet mount, formalin ethyl acetate concentration technique,[15] and the Kato–Katz technique (thick smear 41.7 mg).[16] Duplicate Kato slides were prepared for each stool specimen by an experienced laboratory technologist and the Kato and wet mount preparations were analysed within 1 hour of preparation to detect hookworm eggs and protozoan trophozoites (*Entamoeba histolytica*/*Entamoeba dispar* and *Giardia lamblia*), respectively. The remaining stool specimens were transported in screw-capped cups in 10% formalin to the laboratory and were examined using the concentration method within 2–8 hours after collection. Kato preparations were re-examined after 72 hours for the presence of helminth ova. The total number of eggs detected on each slide was counted and the number of eggs per gram of faeces (epg) was calculated to determine egg burden using a conversion factor of 24, provided with the kit. A child was classified as infected if an infection was detected by any of the methods used.

Urine specimens that screened positive for micro-haematuria with reagent test strips and those with gross haematuria were subjected to microscopic diagnosis of *S. haematobium* ova using sedimentation method.[17] Ten per cent sub-samples of stool smears were re-examined for quality control purposes.

Haemoglobin survey

Haemoglobin concentration was determined in finger prick blood using a HemoCue analyser in the field (HemoCue Hb 201+, Sweden).[18] A short training on

the machine operation was given to the technicians collecting and analysing blood samples before the actual data collection period. The machines were checked on a daily basis using the reference micro-cuvettes as indicated by the manufacturer. Haemoglobin readings were adjusted for altitude and anaemia was defined for respective age and gender groups based on the World Health Organization cut-off value.[19]

Anthropometry

Anthropometric data were collected by recording age, weight, and height of the study participants. A portable weight scale and locally made stadiometer with a sliding headpiece were used to measure weight (to the nearest 0.1 kg) and height (to the nearest 0.1 cm), respectively. Each child was weighed with minimum clothing and barefooted. The weighing scale was calibrated using standard calibration weights of 2 kg iron bars. Measurements of weight and height were taken twice and the average was recorded.

Anthropometric measurements were converted into height-for-age and body mass index (BMI)-for-age Z scores using WHO AnthroPlus (version 1.0.4). Children below $-2Z$ scores for height-for-age and BMI-for-age were classified as stunted and thin, respectively.

Statistical analysis

Data were entered in an Excel spread sheet and were anonymised at Mekelle University with additional data cleaning at Alcala University, Spain. Statistical analysis was done using Statistical Package for Social Sciences (SPSS) version 16 (Chicago, USA). Descriptive statistics was used to analyse the prevalence of the outcome variables. chi-square, student's t test, and logistic regression tests were used to investigate associations among potential variables or risk factors by odds ratio (OR) and 95% confidence interval, and the statistical significance was set at $P < 0.05$.

Ethical Considerations

Ethical clearance was obtained from the institutional Ethical Review Boards of the College of Health Sciences, Mekelle University, Ethiopia and Alcala University, Spain. Written permission to conduct the study was sought from the Regional Health Bureau and local Health and Education offices. Written consent was obtained from parents or guardians of the children. Children who were diagnosed positive for intestinal parasitic infections were treated with standard regimen.[20]

Results

From the 600 school children selected for the study, 583 (97.2%) and 525 (87.5%) children were able to provide stool and blood specimens, respectively. Anthropometric measurements were made on 587 (97.8%) children. About 48% ($n = 288$) of the study participants were boys and the mean (SD) age was 11.3 (2.5) years. Table 1 describes the prevalence of parasitic infections (72%, 95% CI: 66–76%), anaemia

Table 1 Urban versus rural prevalence of intestinal parasitosis, anaemia, and malnutrition among school children, northern Ethiopia

Dependent variables	Urban No. (%) (n = 149)	Rural No. (%) (n = 451)	Total No. (%) (n = 600)	P-value
Intestinal parasitic infections *				
Protozoa				
Entamoeba histolytica/dispar	44 (31)	183 (41)	227 (39)	0.021
Giardia lamblia	14 (10)	45 (10)	59 (10)	0.880
Nematodes				
Hookworm	0 (0)	31 (7)	31 (5)	0.001
Ascaris lumbricoides	18 (12)	10 (2)	28 (5)	<0.0001
Entrobius vermicularis	13 (9)	73 (16)	86 (15)	0.028
Strongyloides stercoralis	0 (0)	5 (1)	5 (0.9)	0.200
Trichuris trichiura	1 (0.7)	0 (0)	1 (0.2)	0.079
Trematodes				
Schistosoma mansoni	21 (15)	59 (13)	80 (14)	0.700
Cestodes				
Hymenolepis nana	30 (21)	95 (22)	125 (21)	0.877
Taenia sp.	3 (2%)	1 (0.2)	4 (0.7)	0.019
Total parasitosis	100 (70)	321 (73)	421 (72)	0.483
Anaemia†	11 (8)	46 (12)	57 (11)	0.228
Stunting ‡	46 (32)	157 (35)	203 (35)	0.529
Thinness ‡	47 (33)	153 (34)	200 (34)	0.714
Stunting and thinness‡	30 (21)	88 (23)	118 (20)	0.801

* Stool specimens were collected from 143 (urban), 440 (rural) and 583 (total) children.
† Blood specimens were collected from 136 (urban), 389 (rural) and 525 (total) children.
‡ Anthropometric measurements were taken from 142 (urban), 445 (rural) and 587 (total) children.

(11%, 95% CI: 8–13%), stunting (35%, 95% CI: 31–38%), and thinness (34%, 95% CI: 30–38%). We also present the differences between urban and rural areas. *E. histolytica/dispar* proved to be the most commonly detected parasite (overall prevalence of 39%) and was significantly higher in children from rural areas. Hookworm showed a distinct distribution found only in few sites in rural areas.

Anaemia prevalence in the study group was of a mild public health importance and, although not statistically significant, was slightly higher (12% vs 8%) in rural areas. Malnutrition prevalence was similar among the urban and rural schools and about 20% of the children were both stunted and thin. Children infected with up to six parasite species were identified. Prevalence of multiple parasite infection was about 27% (156/583) and *E. histolytica/dispar*, *Hymenolepis nana,* and *S. mansoni* were the most common parasite combinations detected in multiple parasitic infections. No *S. haematobium* eggs were detected.

Egg concentrations of helminthic infections were of light intensity.[21] The arithmetic mean egg counts for the most common soil-transmitted helminths and schistosomiasis were: 75 eggs per gram of stool (epg) for hookworm (range: 24–330 epg), 52 epg for *Ascaris lumbricoides* (range: 24–132 epg), and 75 epg for *S. mansoni* infection (range: 24–720 epg).

Mean (SD) haemoglobin reading in our survey was 132 (1.2) g/l. No cases of severe anaemia (haemoglobin <70 g/l) were detected. Mean (SD) haemoglobin concentration among anaemic subjects was 113 (1.3) g/l. Furthermore, there was no significant association ($P > 0.05$) between individual hygiene and sanitation practice and haemoglobin readings among the anaemic children (data not shown in table). Anaemia was not associated with either stunting ($P = 0.209$) or thinness ($P = 0.640$) (data not shown in table). Similarly there were no significant associations between stunting ($P = 0.404$) and low BMI ($P = 0.864$), and intestinal parasitic infections (data not shown in the table).

Exploratory univariate and multivariate logistic regression (adjusted for age and sex) analysis results for intestinal parasitic infections are shown in Table 2. Overall we found no relevant pattern of associations between intestinal parasitosis and drinking water source, personal hygiene, and sanitation practices. We found positive associations between *E. histolytica/dispar* and drinking water from hand pump sources. In addition, children who defecate around the bushes and homestead and those with unhygienic finger nails were more likely to be infected with hookworm. Infection with *S. mansoni* was significantly higher in boys.

Our findings revealed stronger positive associations of poor personal hygiene habits with anaemia and malnutrition (Table 3). *E. histolytica*, hookworm, and *S. mansoni* were incorporated in the analysis because of their high prevalence and nutritional significance, respectively.

Children who did not use a latrine and had unclean hands and finger nails were more often anaemic and malnourished. Boys were more likely to be anaemic and malnourished than girls. Infection with hook worm, *E. histolytica/dispar,* and having unclean hands were significantly associated with anaemia. Dirty hands were also associated with thinness. Not much difference was observed between the crude and adjusted odds ratios (Tables 2 and 3), indicating that the observed associations were not affected by age and gender of the child.

Discussion

Our findings revealed widespread prevalence of intestinal parasitosis and malnutrition among school children in Ethiopia. However, the prevalence of anaemia was 11%. Although there were slight differences between urban and rural schools, the overall magnitude of the problem was the same. Children with unclean hands were more likely to be anaemic and thin. Furthermore, open air defecation around the backyard contributes to the poor nutritional status of these children, which suggests the need to address environmental sanitation. However, intestinal parasitic infections and individual hygiene and sanitation practices were not very clearly related, although there were significant associations between not using a latrine, unclean fingernails, and presence of hookworm.

The overall prevalence of intestinal parasitic infection in our data was higher than the 2008 national prevalence report for the country,[22] and studies done elsewhere.[23–25] The prevalence of soil-transmitted helminthiasis (10%) was in line with the 2008 World Health Organization report (<20%) for the country,[26] while the prevalence of schistosomiasis was higher in our survey (13.4%) than the reported prevalence of <10%. This might indicate a need for epidemiological updates on *S. mansoni* as prevalence within endemic communities might differ due to changes in local environment and other exposure-related factors.[27]

Anaemia prevalence in the study group was consistent with a recent prevalence report for the country,[22] and for Africa, but was much lower than the global prevalence.[2] The significantly higher involvement of boys than girls in animal keeping activities, hence keeping them away from the home environment, and frequent bathing and swimming in streams, thus higher rate of exposure to *S. mansoni* infection, might be the reason for the higher anaemia prevalence. In our data, the prevalence of stunting

Table 2 Associations of intestinal parasitic infections among school children, Ethiopia

		E. histolytica/dispar		Hookworm		*S. mansoni*		*E. vermicularis*		*H. nana*	
		COR (CI)		COR (CI)		COR (CI)		COR (CI)		COR (CI)	
	n	AOR (CI)§	%	AOR (CI)§	%	AOR (CI)§	%	AOR (CI)§	%	AOR (CI) §	%
Age											
6–9	169	1	34	1	4	1	9	1	16	1	31
10–15	431	1.50 (1.02, 2.21)*	43	2.01 (0.76, 5.33)	6	1.74 (0.96, 3.15)	17	0.90 (0.54, 1.49)	14	0.47 (0.31, 0.71)*	15
		1.03 (0.53, 1.98)		2.86 (0.68, 12.07)		0.99 (0.37, 2.65)		1.30 (0.55, 3.10)		0.73 (0.34, 1.56)	
Sex											
Male	288	1	37	1	5	1	18	1	14	1	23
Female	312	1.16 (0.83, 1.61)	41	1.30 (0.62, 2.70)	6	0.48 (0.29, 0.78)*	10	1.14 (0.72, 1.80)	16	0.85 (0.57, 1.26)	20
		1.15 (0.82, 1.61)		1.26 (0.60, 2.65)		0.47 (0.29, 0.76)*		1.15 (0.72, 1.83)		0.86 (0.57, 1.28)	
Family size											
<=7	372	1	42	1	8	1	15	1	17	1	19
>7	228	1.28 (0.74, 2.24)	48	0.57 (0.17, 1.84)	5	0.93 (0.42, 2.06)	14	1.32 (0.65, 2.67)	21	1.39 (0.71, 2.71)	25
		1.29 (0.73, 2.30)		0.48 (0.14, 1.67)		0.87 (0.38, 2.01)		1.44 (0.69, 3.02)		1.50 (0.74, 3.03)	
Latrine use											
Yes	264	1	34	1	3	1	10	1	14	1	21
No	336	1.29 (0.85, 1.96)	39	3.53 (1.31, 9.57)*	9	1.68 (0.92, 3.07)	16	0.89 (0.51, 1.57)	13	1.02 (0.63, 1.64)	21
		1.37 (0.89, 2.10)		3.24 (1.18, 8.97)*		1.60 (0.86, 2.98)		0.92 (0.52, 1.64)		0.95 (0.57, 1.57)	
Hand hygiene											
Clean	174	1	35	1	7	1	12	1	13	1	21
Unclean	426	1.25 (0.80, 1.93)	40	0.56 (0.21, 1.53)	4	1.38 (0.76, 2.53)	16	1.07 (0.58, 1.98)	14	1.13 (0.67, 1.88)	23
		1.62 (1.00, 2.62)*		0.56 (0.20, 1.61)		1.27 (0.67, 2.42)		1.16 (0.61, 2.20)		0.91 (0.52, 1.59)	
Finger nail hygiene											
Clean	186	1	31	1	2	1	13	1	9	1	24
Unclean	414	1.47 (0.94, 2.29)	39	3.67 (1.08, 12.50)*	8	1.08 (0.58, 2.02)	14	1.77 (0.90, 3.48)	16	0.77 (0.47, 1.27)	20
		1.67 (1.04, 2.67)*		3.84 (1.10, 13.41)*		1.03 (0.54, 1.97)		1.80 (0.91, 3.56)		0.73 (0.43, 1.24)	
Household water source											
Pipe	156	1	33	—	–	1	18	1	13	1	16
Hand pump	300	2.48 (1.26, 4.88)*	55	—	–	0.73 (0.30, 1.74)	14	1.56 (0.62, 3.95)	19	1.23 (0.52, 2.91)	19
		2.37 (1.14, 4.91)*		—	–	0.64 (0.25, 1.63)		1.75 (0.67, 4.60)		1.69 (0.68, 4.21)	
Wells and streams	144	1.12 (0.50, 2.51)	35	—	–	0.49 (0.16, 1.54)	10	2.35 (0.85, 6.46)	26	2.13 (0.84, 5.42)	29
		1.01 (0.42, 2.39)		—	–	0.44 (0.13, 1.43)		2.70 (0.93, 7.88)		3.07 (1.10, 8.52)*	

§ Adjusted for age and sex.
* Statistically significant at 0.05.
E. histolytica/dispar = Entamoeba histolytica and/or Entamoeba dispar; S. mansoni = Schistosoma manson; E. vermicularis = Entrobius vermicularisi; H. nana = Hymenolepis nana.
COR = crude odds ratio as computed by logistic regression model; AOR = adjusted odds ratio as computed by logistic regression model.

Table 3 Associations of anaemia and malnutrition among school children, Ethiopia

		Dependent variables								
		Anaemia			Stunting			Low BMI-for-age		
Independent variables	*n*	COR (95% CI)	%	AOR (95% CI) §	COR (95% CI)	%	AOR (95% CI) §	COR (95% CI)	%	AOR (95% CI) §
Age										
6–9	169	1	13		1	29		1	25	
10–15	431	1.37 (0.70, 2.67)	10	4.20 (1.46, 12.04)*	1.65 (1.11, 2.46)*	38	1.64 (0.84, 3.19)	2.06 (1.36, 3.12)*	40	1.27 (0.64, 2.52)
Sex										
Male	288	1	15		1	38		1	35	
Female	312	0.46 (0.26, 0.82)*	7	0.46 (0.26, 0.81)*	0.74 (0.53, 1.05)	31	0.73 (0.52, 1.02)	0.90 (0.64, 1.27)	33	0.89 (0.63, 1.25)
Family size										
≤7	372	1	9		1	29		1	37	
>7	228	1.80 (0.74, 4.40)	15	1.86 (0.74, 4.66)	2.06 (1.16, 3.67)*	46	2.04 (1.14, 3.65)*	1.12 (0.63, 1.97)	40	1.06 (0.59, 1.89)
Latrine use										
Yes	264	1	8		1	30		1	30	
No	336	1.47 (0.72, 3.00)	11	1.25 (0.60, 2.59)	1.46 (0.96, 2.21)	39	1.42 (0.93, 2.16)	1.61 (1.07, 2.44)*	41	1.65 (1.08, 2.52)*
Hand hygiene										
Clean	174	1	6		1	33		1	33	
Unclean	426	4.05 (2.00, 8.22)*	20	3.20 (1.54, 6.65)*	1.40 (0.90, 2.18)	41	1.35 (0.85, 2.1)	1.59 (1.03, 2.47)*	44	1.76 (1.11, 2.80)*
Finger nail hygiene										
Clean	186	1	7		1	33		1	39	
Unclean	414	1.71 (0.76, 3.88)	11	1.51 (0.66, 3.47)	1.12 (0.72, 1.75)	36	1.12 (0.71, 1.75)	0.87 (0.56, 1.34)	35	0.90 (0.58, 1.39)
Household water source										
Pipe	156	1	9		1	31		1	42	
Hand pump	300	1.62 (0.55, 4.77)	14	1.93 (0.62, 6.00)	1.26 (0.63, 2.53)	36	1.29 (0.63, 2.66)	0.65 (0.33, 1.27)	32	0.47 (0.23, 0.98)*
Wells and streams	144	0.69 (0.16, 3.04)	7	0.83 (0.18, 3.86)	1.33 (0.59, 2.97)	37	1.39 (0.60, 3.22)	1.24 (0.57, 2.67)	47	0.87 (0.38, 1.98)
E. histolytica/dispar										
No	356	1	9		1	34		1	34	
Yes	227	1.78 (1.02, 3.12)*	14	1.95 (1.11, 3.44)*	1.12 (0.79, 1.59)	36	1.11 (0.78, 1.57)	0.97 (0.68, 1.38)	34	0.90 (0.63, 1.29)
Hookworm Infection†										
No	148	1	10		1	34		1	35	
Yes	31	3.77 (1.26, 11.32)*	28	4.60 (1.44, 14.65)*	2.23 (0.96, 5.19)	47	2.24 (0.96, 5.23)	0.62 (0.23, 1.65)	23	0.60 (0.22, 1.65)
S. mansoni Infection†										
No	296	1	10		1	34		1	35	
Yes	80	2.77 (0.92, 8.34)	14	2.60 (0.84,8.11)	1.16 (0.64, 2.11)	35	079 (0.43, 1.46)	1.07 (0.59, 1.95)	34	0.85 (0.46, 1.58)

§ Adjusted for age and sex.
* Statistically significant at 95% confidence interval (CI).
† Statistical analysis done only for areas where the parasite was detected.
COR = crude odds ratio as computed by logistic regression model; AOR = adjusted odds ratio as computed by logistic regression model.
E. histolytica/dispar = *Entamoeba histolytica/Entamoeba dispar*; *S. mansoni* = *Schistosoma mansoni*.

(low height-for-age) and thinness (BMI-for-age) were higher than other reports for the country,[22,28] but were within the range reported for Africa.[3]

The inconsistent pattern of associations observed between poor hygiene and sanitation practices and intestinal parasitic infections could be partially explained by the differences in transmission and epidemiological features between the different intestinal parasite species and hence leads to various confounding factors, since infections are related to a range of host and environmental aspects.[29] Another possible reason might be lack of statistical power in our data due to the observed low prevalence rates of some parasitic infections.

Associations between poor hygiene and sanitation practices and malnutrition are well documented,[30,31] although comparisons are difficult because of differences in study populations. However, a study on rural adolescent girls from the same region found associations between open-air defecation (lack of latrine) and thinness.[14]

In sharp contrast to some studies,[32–34] but in agreement with other studies,[35–37] we found no significant association between intestinal parasitic infections and malnutrition. The lack of association may be explained by the overall low worm loads[35] or could be due to a real absence of measurable differences. In this study, no differentiation was done between the invasive *E. histolytica* and the commensal *E. dispar* parasites, and is likely that most of the infection were due to *E. dispar*, and so were harmless and could not have been associated with any disease. Study from Ethiopia reported high prevalence of the commensal *E. dispar* infection.[38]

Application of smart phone technology for demographic data collection improved data collection time and quality by avoiding paper records and the need for manual data entry. It enabled us to develop easy-to-use data collection forms, which could be used on the mobile phones even when there was no mobile network connectivity. When the mobile network was available, the forms stored on the phones were uploaded to the server. The cost of the phones and maintaining battery power in remote areas usually make smooth data collection difficult. In this particular survey, limited electricity access was mitigated by using solar chargers and extra mobile batteries. The potential use and advantage offered by this technology for parasitological field surveys in resource-limited settings merit further investigation.

The following limitations should be considered when interpreting the results of the present study. We had enough statistical power to investigate associations for the most prevalent parasites, but we lacked adequate power to draw meaningful conclusions for the less prevalent parasites. We were also reluctant to do extensive multivariate analysis. This would have required a thorough consideration of all possible confounding factors for each variable of interest, and it would result in an enormous amount of statistical test thereby increasing the risk of committing several Type-1 errors. This association part of this study should, therefore, be regarded as exploratory, giving direction for in-depth investigations of patterns of associations between risk factors and parasites. Another limitation was the cross-sectional nature of the study, making any inference on casual relationship among variables impossible.

Our results emphasize the need of increased personal hygiene practice; such as increased access to clean water for hand washing, access to latrines to restrict contamination, and hygiene-related education, which would improve the health of the age group. Randomized trials should be carried out to address the causal relationship between personal hygiene, parasitic infection, and malnutrition.

Conflict of interest statement

We declare that we have no conflict of interest.

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