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An update of intestinal helminth infections among urban slum communities in Bangladesh

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ABSTRACT

Aim: To assess the prevalence of intestinal helminth infections and associated risk factors among people living in urban slums in Bangladesh.
Methods: A cross-sectional study was conducted across three clusters: Dhaka, Sylhet and Chattogram. In total, 360 individuals divided into two groups (school-aged children and adults) provided stool samples and completed a semi-structured questionnaire. Parasitological assessment was performed using the formol-ether concentration technique.
Results: Overall, 31.7% (114/360) of participants had helminthiasis, with 13.3% (48/360) having mixed infections. Among the infected participants, school-aged children had a higher rate of infection (41.7%, 75/180) compared with adults (21.7%, 39/180). *Ascaris lumbricoides* was the predominant parasite, followed by hookworms, *Trichuris trichiura, Hymenolepis nana, Enterobius vermicularis* and *Rhabditis* sp. Parasitic infections were significantly associated with type of latrine used, direct exposure to soil, open defaecation, and presence of free-roaming animals.
Conclusion: Despite continuous efforts to control helminthiasis, a substantial proportion of the study participants were infected with intestinal helminths. Ignorance of the roles of the environment and animals was influential, and had a negative impact on existing control interventions. An integrated public health and veterinary public health approach is required for sustainable control of intestinal helminthiasis.

Introduction

The disease burden associated with intestinal helminth infections is vast, affecting an estimated 1.5 billion people across the globe (London Applied & Spatial Epidemiology Research Group, 2018). Helminth infections affect the health and wealth of nations and individuals alike; have a negative impact on health, nutrition and productivity; and exacerbate poverty (Savioli et al., 2004; Stepek et al., 2006). The majority of infections occur in warm, humid equatorial regions, and are most prevalent in developing and lower-income countries where poverty, inadequate sanitation, lack of awareness and minimal health care prevail (Pullan et al., 2014; Jourdan et al., 2017). It is well established that environmental conditions and behaviours of people play an important role in the transmission of helminths (Brooker et al., 2006). The majority of infections remain asymptomatic, only becoming evident when the infection is particularly severe (Idris et al., 2019). This may be one reason why helminth infections have been neglected in terms of public recognition and research funding. Helminths cause morbidity through various mechanisms, including anaemia, vitamin A deficiency and loss of appetite, resulting in restricted growth, impairment of cognitive development and reduced ability to learn (Bharti et al., 2018).

Parasitic infections are associated with community sanitation and public health infrastructures; individuals living in poor socio-economic conditions are more likely to have parasitic infections (Ngui et al., 2015; Gizaw et al., 2019). Although economic growth in Bangladesh is projected to increase according to a World Bank report in 2019, many people still live below the poverty line. Helminth control programmes have been implemented in Bangladesh for over a decade; a biannual mass

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deworming programme with single-dose mebendazole targeting school-aged children has been in place since 2008 (Benjamin-Chung et al., 2015). The emphasis on school-aged children is justified as high levels of infection are observed in this age group, and schools offer a convenient platform to reach the target group (Brooker et al., 2003, 2006). However, despite the declining trend of infection in the last few years and substantial progress in reducing morbidity associated with parasitic diseases, several studies have reported high prevalence in Bangladesh (Mukutmoni and Khanum, 2018; Hossain et al., 2019; Fatema et al., 2020). This is evidence that preventative chemotherapy is a stop-gap solution and not a permanent solution to control parasitic infections. Reinfection rates are often high due to the presence of persistent reservoirs in the communities. Even a moderate presence of asymptomatic carriers may permit the parasites to keep up transmission limit, rendering the tremendous efforts directed towards deworming will fail to achieve long-term control goals and ultimately become unsustainable (Utzinger et al., 2010; Nath et al., 2019). Furthermore, the roles of animals, and the surrounding environment, are often underestimated in current control strategies.

Risk mapping to understand the factors that influence transmission in a particular area can assist governments and policy makers in delivering and monitoring disease control programmes. It is also vital to know the level of community awareness and related practices before launching any control programme. There are still several localities, including the current study areas, where prevalence and risk assessment have yet to be determined. Targeted control initiatives fail to reduce transmission and infection rates due to a lack of much-needed information. Inadequate research, ignorance of the problem and a lack of follow-up are some of the other potential bottlenecks. Given the scarcity of data on the distribution of parasitic diseases, this study aimed to determine the prevalence of intestinal parasitic infections, associated factors and community perception in selected slums of Bangladesh. Slums are considered poor in terms of sanitation and personal hygiene, and have been identified as potential reservoirs for the spread of communicable diseases (Adiga et al., 2018). Additionally, poverty, malnutrition, high population density and poor health status provide optimal circumstances for disease transmission. The findings from this study may be of interest to public health authorities in defining and refining targets of current control initiatives.

Methods

Study design and sample size

A cross-sectional survey with convenience sampling was undertaken from July 2020 to February 2021. The study was conducted in urban slums of three selected areas of Bangladesh: Sylhet (Bondor, Varthokhola), Dhaka (Mohammadpur, Kamalapur) and Chattogram (Madarbari, Bakalia). The participants were divided into two age groups: school-aged children (5–15 years) and adults (16–59 years). The sample size calculation was performed using a single proportion formula: $N=(Z)^2P(1\text{-}P)/d^2$ where P is the prevalence of helminths from a previous study (35%), Z is the level of confidence (1.96), and d is 5% marginal error (Pourhoseingholi et al., 2013); this gave a minimum sample size of 349 individuals. By adjusting for attrition rate, the minimum number of participants required in this study was estimated at 360 (120 respondents from each study area).

Collection of samples and questionnaire survey

Data were collected using a pre-tested questionnaire and checklists with the help of trained field assistants familiar with the study areas. Prior to the study, meetings were conducted in the study areas following a short briefing about the purpose and methods of the study. Prior to data collection, the aims and benefits of participation were explained clearly to the participants. Participation was voluntary, and participants were informed that they were able to withdraw from the study at any time during the data collection process. The interviewers explained the study protocol to participants on the day of sample collection, and provided each participant with the informed consent form and a pre-labelled container for stool sample collection. Respondents who had other medical complications were excluded from the study. The following day, the filled stool container was collected from each participant. Each participant was provided with a unique identification code to avoid repetitive sampling. Due to the lack of deep freezers and laboratory facilities in the study areas, all samples were fixed with 10% formalin before being transported to Chungbuk National University, Korea. A semi-structured questionnaire was used to obtain information on demographics, household sanitation facilities, and knowledge of participants regarding parasitic diseases and their prevention. The questionnaire was prepared in English, translated into Bangla, and checked for accuracy. Direct observations on sanitation facilities were carried out in the community according to the World Health Organization/United Nations Children's Fund Joint Monitoring Program classification guidelines (World Health Organization, 2015).

Parasitological assessment

The specimens were checked for identification number and divided into two aliquots. Parasitological assessment was performed using a modified formalin ether sedimentation method (Nath et al., 2021). In brief, one aliquot was used for the formol-ether concentration technique, and the other aliquot was kept for cross-checking. The procedure began with homogenization, and mixed 1–2 g of stool sample in 5 mL of normal saline. The mixture was left for 5 min to settle and then poured into a 15-mL tube through a double layer of gauze to remove large particles. The resulting mixture was then transferred to a test tube and centrifuged at 1500 rpm for 5 min. Next, the supernatant was poured off gently without disturbing the sediment, mixed with 10% formalin and absolute ether (formalin:ether 7:3), and centrifuged at 1500 rpm for another 5 min. Finally, the supernatant was discarded, and the whole sediment was examined for parasites. Standardized procedures as presented in the World Health Organization's 'Training manual on diagnosis of intestinal parasites' (World Health Organization, 2004) were used for identification of helminth species.

Data management and analysis

Collected data were checked to ensure accuracy and completeness, and were analysed using STATA Version 17.0 (Stata Corporation, College Station, TX, USA). Descriptive statistical analyses were performed to obtain a clear understanding of the population and describe the studied characteristics of the population. Prevalence ratios were computed to relate the probability of infection with intestinal helminths according to Thompson et al. (1998). The strength of the association between infection and variables was analysed by logistic regression analysis. In all statistical tests, $P<0.05$ was considered to indicate significance.

Results

In total, 360 study participants, comprising 210 (58.3%) males and 150 (41.7%) females, aged between 5 and 59 years, were enrolled in the study. Equal proportions of school-aged children and adult participants were included from each study area. Among the school-aged children, 23.1% did not attend school and were engaged in non-specific jobs to support family income. Homeless children were also included in this study. The predominant religion was Islam (78.4%), and the monthly family income of the majority of participants (80.3%) was <US$100 (8000 BDT). Detailed information about the characteristics of these participants is shown in Table 1.

Of 360 community residents who participated in the study, 114 were infected with at least one intestinal parasite; as such, the over-

Table 1
Sociodemographic characteristics of study participants (n=360)

Characteristics			Dhaka(n=120)		Chattogram (n=120)		Sylhet(n=120)		Overall(n=360)	
			n	%	n	%	n	%	n	%
Sex	Male		72	60.0	63	52.5	75	62.5	210	58.3
	Female		48	40.0	57	47.5	45	37.5	150	41.7
Age group	Children (5–15 years)		60	50.0	60	50.0	60	50.0	180	50.0
	Adult (16–59 years)		60	50.0	60	50.0	60	50.0	180	50.0
Religion	Islam		101	84.2	87	72.5	94	78.3	282	78.4
	Hindu		19	15.8	25	20.8	26	21.7	70	19.4
	Other		-	-	8	6.7	-	-	8	2.2
Education	SAC	School going	27	22.5	32	26.7	39	32.5	97	26.9
		Non-school going	34	28.3	28	23.3	21	17.5	83	23.1
	Adult	Illiterate	9	7.5	6	5.0	6	5.0	22	6.11
		Primary	25	20.8	25	20.8	29	24.2	82	22.8
		Secondary	21	17.5	18	15.0	22	18.3	61	16.9
		College education	5	4.2	11	9.2	3	2.5	15	4.2
Occupation	School-aged/non-specific		60	50.0	60	50.0	60	50.0	180	50.0
	Job/business		22	18.3	15	12.5	10	8.3	47	13.1
	Housewife		12	10.0	26	21.7	23	19.2	61	16.9
	Farmers		17	14.2	11	9.2	21	17.5	49	13.6
	Day labour/non-fixed		9	7.5	8	6.7	6	5.0	23	6.4
Monthly income	<US$100		91	75.8	102	85.0	96	80.0	289	80.3
	>US$100		29	24.2	18	15.0	24	20.0	71	19.7
Family size			5.65±2.2		6.18±1.8		5.91±1.7		5.67±1.9	

SAC, school-aged children.

Table 2
Prevalence and multiplicity of intestinal parasitic infection

Parasite		Study site						Overall (n=360)		P-value
		Dhaka(n=120)		Chattogram(n=120)		Sylhet(n=120)				
		n	%	n	%	n	%	n	%	
	Any species	29	24.2	46	38.3	39	32.5	114	31.7	
Species	*Ascaris lumbricoides*	8	6.7	25	20.8	19	15.8	52	14.4	<0.05
	Hookworms	14	11.7	16	13.3	21	17.5	51	14.2	<0.05
	Trichuris trichiura	3	2.5	4	3.3	1	0.8	8	2.2	
	Hymenolepis nana	2	1.7	-	-	-	-	2	0.6	
	Enterobius vermicularis	1	0.8	1	0.8	-	-	2	0.6	
	Rhabditis sp.	-	-	-	-	1	0.8	1	0.3*	
Infection type	Single infection	27	22.5	41	34.2	31	25.8	99	27.5	<0.05
	Mixed infection	2	1.7	5	4.2	8	6.7	15	4.2	

$P<0.05$ indicates significance.

all prevalence was 31.7% [95% confidence interval (CI) 26.1–35.7]. Prevalence varied by study area: Dhaka 8.1% (29/360), Chattogram 12.8% (46/360) and Sylhet 10.8% (39/360). Most infected participants (86.8% 99/114) had a single infection, while co-infection with two or more helminth species was detected in 13.2% (15/114) of participants. School-aged children had a higher rate of infection (41.7%, 75/180) compared with adults (21.7%, 39/180). Six species of helminth were observed: *Ascaris lumbricoides*, hookworms, *Trichuris trichiura, Hymenolepis nana, Enterobius vermicularis* and *Rhabditis* sp. (Table 2, Figure 1). *A. lumbricoides* was the predominant species [52/360 (14.4%)], followed by hookworms [51/360 (14.2%)].

Associations between parasitic infections and risk factors were examined (Table 3). Using the logistic regression model, several factors that contributed to intestinal parasitic infection were identified: frequent contact with soil [adjusted odds ratio (AOR) 4.64, 95% CI 2.08–9.61], type of latrine used (AOR 3.97, 95% CI 1.01–7.25), lack of use of spray disinfectant in and around the household (AOR 4.91, 95% CI 2.61–9.67), presence of free-roaming animals (AOR 6.04, 95% CI 4.16–11.27), and open defaecation (AOR 5.42, 95% CI 2.41–9.02). Family size and animal ownership were only found to be significant on univariate analysis.

Assessing and analysing contextual factors are prerequisites for successful control interventions. Table 4 shows the knowledge of participants regarding control of intestinal helminths. In total, 292 (81.1%) respondents had heard of the intestinal parasite control programme. In terms of disease severity, 59.2% of respondents were aware that intestinal parasitic infection is a serious disease, but 23.3% of respondents were unclear about the severity of the disease. The majority of participants (79.2%) reported that they knew about anthelmintics, and 69.7% stated that intestinal parasitic infection could be prevented by consuming anthelmintics. Regarding the source of infection, 89.2% of respondents mentioned faeces as the source of infection. However, 58.1% of participants did not think animals were a source of parasitic infection. Additionally, only 54.2% of respondents thought that soil was a source of intestinal parasitic infection.

Discussion

Helminthiasis is a classic disease of poverty; the relationship between parasites and humans has been influenced by global changes in the sociocultural spectrum, hygienic conditions, economic status, and occupation related to soil or animals (Ngui et al., 2015; Jourdan et al., 2017). Most intestinal parasites have simple routes of transmission; high proliferation capacity and ability to resist extreme environmental conditions could facilitate high transmission (Brooker et al., 2006). Epidemiological data on helminth infections reflect the community's sanitary conditions, and are critical for identifying the source of infection and adopting control efforts. In this study, 31.7% of examined individuals were con-

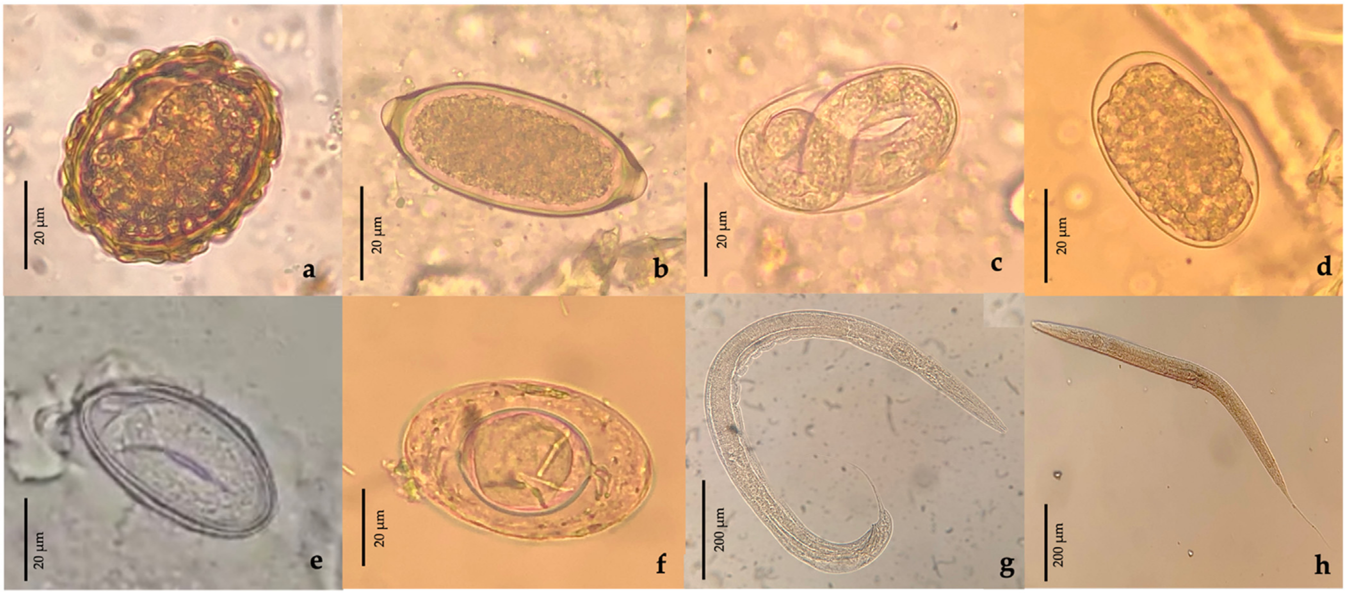

Figure 1. Observed eggs and larvae. (a) *Ascaris lumbricoides* egg. (b) *Trichuris trichiura* egg, (c, d) Hookworm eggs. (e) *Enterobius vermicularis* egg. (f) *Hymenolepis nana* egg. (g) *Rhabditis* sp. (male). (h) *Rhabditis* sp. (female).

firmed to have intestinal parasitosis, which was higher than the average prevalence in Bangladesh (15.7%) (FHI-360, 2017). This may be due to geographical differences and the socio-economic and sanitary status of the study population. It is also likely that the environment is highly contaminated; a high concentration of geohelminths was reported in the study setting (Nath et al., 2021). Among the positive individuals, 65.8% were school-aged children, although they had been subjected to one or more rounds of anthelmintic drug administration in the frame of national mass drug administration (MDA) campaigns. The contextual factors may explain why the prevalence of parasitic infections in slum areas is still high, coupled with the risk of rapid reinfection after deworming. Slum dwellers are particularly vulnerable to helminth infections due to their unsanitary living conditions. Healthcare coverage to combat infectious diseases is severely restricted in such places. As a result, parasitic infection in the intestine has been continued. Furthermore, slums are not homogenous in urban areas, and the risk factors are unlikely to be distributed uniformly across the entire community (Das and Bhusan, 2017). People from slums disseminate continuously across the country, impacting the spread of parasites outside slums. Individuals of lower socio-economic status may be at high risk of parasitic infection due to lower quality health care and attention (Anantaphruti et al., 2008). In this study, a substantial proportion of adults were found to have a parasitic infection. A major drawback of the current control programme is the neglect of adult populations, although it is known that transmission among elderly people may lead to reinfection of treated children (Utzinger et al., 2010). The present results show that helminths, especially hookworms, are concentrated in adult populations, so school-based MDA-based programmes will miss this important reservoir, challenging programme success. In addition, insufficient knowledge on parasite transmission, risky behaviour (e.g. walking barefoot, open defaecation, disposal of children's faeces in open areas), and soil contamination by improperly managed animals and animal manure may contribute substantially to overall transmission (Ziegelbauer et al., 2012). It has been reported that even after several years of mass chemotherapy, prevalence can bounce back after the cessation of preventive chemotherapy if the initial force of transmission is strong and other long-term control measures are not implemented concomitantly (Alum et al., 2010). Based on the findings of this study, multiple implementation strategies including periodic parasitological assessment and regular monitoring control interventions must be considered.

This study found that *A. lumbricoides* and hookworms were the most common helminths in the study areas. It was been suggested that *A. lumbricoides* causes the highest burden of parasitic infection in the world (Bethony et al., 2006). This may be due to the production of a huge number of eggs by adult females, and the resistance of eggs under extreme environmental conditions due to their outer corticated coat that favours survival for several days to years (Hall and Holland, 2000). The prevalence of hookworms in the current study may be attributed to the unsanitary environment, open defaecation, improper disposal of children's faeces, and untreated asymptomatic individuals who continue to shed eggs for a prolonged time (Utzinger et al., 2010). As hookworm infection is mainly concentrated in adult populations, but adults are not included in MDA-based control programmes, the success of these programmes is challenged. Unfortunately, this study did not detect *Strongyloides* spp. because it was not possible to examine stool samples immediately, and there are no deep-freezing facilities in the study areas. This study found the first human case of *Rhabditis* sp. infection in Bangladesh. This was identified based on morphometric features, and was confirmed by mitochondrial DNA amplifying cox1 (cytochrome *c* oxidase) gene. The features used in confirming *Rhabditis* sp. were the prominent elongated tail, and the stage of the parasite (larvae, adult males and adult females) passed in stool. Phylogenetic analysis illustrated that *S. stercoralis* and *Rhabditis* sp. isolates were placed in two distinguishable separate clades. *Rhabditis* spp. are facultative, opportunistic nematodes, and have been reported to infect humans (Ahn et al., 1985; Meamar et al., 2007). The finding was surprising, and emphasized the need for careful inspection in order to diagnose *Rhabditis* sp. infection, especially in endemic areas where humans frequently come into contact with soil and animals.

This study identified intestinal parasitosis as an underestimated health problem in slum areas. It should be noted that the study sample consisted of healthy individuals without gastrointestinal complaints. The majority of residents in the study areas were unaware of the effects of parasitism, and these knowledge gaps appeared to be distributed equally across the three study areas. There is a need for continuous advocacy and dissemination of information to the communities to enhance awareness. Infections were found to be associated with factors such as health-seeking behaviours, exposure to contaminated soil, and cohabitation with animals. Parasitic infections were found to be 5.42-fold higher in communities with open defaecation behaviours. In many areas, children, especially those aged <5 years, defaecate indiscrimi-

Table 3
Potential risk factors associated with intestinal parasitic infections (risk factors vs infection)

Total infected (*n*=114)						
Variable	Parasitic infection (%) Yes	No	COR with 95% CI	*P*-value	AOR with 95%	*P*-value
Age						
Adult (16–59 years)	39 (21.7)	141 (78.3)	1	0.832		
Children (5–15 years)	75 (41.7)	105 (58.3)	1.72 (0.88–2.93)		1.67 (0.72–2.85)	
Sex						
Male	54 (25.7)	156 (74.3)	1	0.663		
Female	60 (40.0)	90 (60.0)	1.08 (0.72,1.48)		1.05 (0.66,1.39)	
Family size[a]						
≤5	33 (19.1)	140 (80.9)	1	0.019		
>5	81 (43.3)	106 (56.7)	1.55 (1.24–3.82)		1.47 (1.09–3.76)	
Family index						
>US$100	42 (24.7)	128 (75.3)	1	0.982		
<US$100	72 (37.9)	118 (62.1)	1.41 (1.17–2.99)		1.33 (1.05–2.91)	
Water source for cooking						
Tube well/treated	35 (17.3)	167 (82.7)	1	0.281		
Ponds/untreated	77 (48.7))	81 (51.3)	2.18 (0.81–8.75)		2.04 (0.73–8.46)	
Playing/working with soil without footwear (direct exposure to soil)						
No	21 (14.8)	121 (85.2)	1	0.005		<0.05
Yes	93 (42.7)	125 (57.3)	4.81 (2.22–9.74)		4.64 (2.08–9.61)	
Type of house floor						
Concrete/cement	38 (24.1)	120 (75.9)	1	0.388		
Soil	76 (37.6)	126 (62.4)	1.95 (1.12–3.62)		1.87 (0.89–3.56)	
Type of latrine						
Concrete/cement	31 (12.1)	225 (87.9)	1	0.015		<0.05
Soil/mud (Kacha)	83 (79.8)	21 (20.2)	2.36 (1.29–7.78)		3.97 (1.01–7.25)	
Use of spray disinfectant in and around household and latrines (disinfection practices)						
Yes	13 (22.4)	45 (77.6)	1	0.001		<0.05
No	101 (33.4)	201 (66.6)	5.03 (2.86–9.91)		4.91 (2.61–9.67)	
Presence of free-ranging animals in community						
No	5 (7.1)	66 (92.9)	1	0.002		<0.05
Yes	109 (37.7)	180 (62.3)	6.18 (4.54–11.49)		6.04 (4.16–11.27)	
Open or indiscriminate defaecation in community						
No	15 (17.9)	69 (82.1)	1	0.005		<0.05
Yes	99 (35.9)	177 (64.1)	5.48 (2.58–9.21)		5.42 (2.41–9.02)	
Animal ownership[a]						
No	19 (22.4)	66 (77.6)	1	0.019		
Yes	95 (34.5)	180 (65.5)	3.83 (1.67–5.99)		3.75 (1.72–6.97)	
Handing animal manure (household work/cooking fuel/fertilizer)						
No	37 (36.3)	65 (63.7)	1	0.661		
Yes	77 (29.8)	181 (70.1)	1.81 (0.62–5.80)		1.67 (0.79–5.92)	
Taking anthelmintic (in preceding year)						
Yes	43 (22.4)	149 (77.6)	1	0.583		
No	71 (42.3)	97 (57.7)	1.98 (1.11–4.53)		1.45 (1.03–4.32)	

COR, crude odds ratio; AOR, adjusted odds ratio; CI, confidence interval.
[a] Significant on univariate analysis alone.*P*<0.05 indicates significance.

nately around their homes, and in some cases, adults defaecate indiscriminately near water bodies; this behaviour may contribute to the persistence of parasite transmission in the environment (Abossie and Seid, 2014; Gizaw et al., 2019). The present study also found a relationship between animals and human parasitic infections. Many routes to animal and animal faeces exposure occur in and around the household environment. Livestock represent an integral part of the livelihood of these communities; inherently, several livestock farms were located above water bodies, and the water was used for bathing and household activities. Insufficient separation of animal faeces and animal products from domestic environments, which is common in the study areas, can also transmit zoonotic pathogens (Penakalapati et al., 2017). Stray animals, particularly dogs and cats, roam freely and defaecate around the area, putting humans at risk for various zoonotic parasites. People living in communities with free-roaming animals were 6.04 times more likely to have parasitic infections. In this study, widespread faeces contamination has been observed in backyards, and children may be at particular risk due to geophagia. The environment, especially soil, can also be contaminated due to lack of adequate waste disposal facilities. The lack of disinfection practices also contributed to the presence of intestinal parasites. Community-engaged strategic and integrated approaches are required for the prevention of transmission. Proper veterinary care and regular deworming of animals may reduce the probability of transmission of parasites.

Evaluating community knowledge on intestinal parasitic infections aids in recognizing, planning and carrying out effective control interventions. The majority of respondents were aware that faeces can be a source of parasitic infection, but most were unaware of the roles of animals and soil in the transmission of intestinal parasites. This lack of knowledge can contribute to poor practices. The present study found that a high number of school-aged children took anthelmintics periodically, but the proportion of adult respondents who took anthelmintics was lower. Ignorance of the need to take anthelmintic drugs is a barrier for the sustainable control of helminth transmission. In order to achieve successful and sustainable control programme strategies, there is a need to enhance the awareness and involvement of the community through health education campaigns.

This study had several limitations. Due to the coronavirus disease 2019 pandemic and lockdown, it was not possible to obtain data from the wider community; as such, the results may not be truly representa-

Table 4
Knowledge of respondents about control of intestinal parasites

Variables	Response	SAC (n=180)		Adult (n=180)		Total (n=360)	
		n	%	n	%	n	%
Have you heard of the intestinal parasite control programme?	Yes	153	85.0	139	77.2	292	81.1
	No	27	15.0	41	22.8	68	18.9
Is intestinal parasitic infection a serious disease?	Yes	116	64.4	97	53.9	213	59.2
	No	31	17.2	32	17.8	63	17.5
	Do not know	33	18.4	51	28.3	84	23.3
Have you heard of anthelmintics?	Yes	149	82.8	136	75.6	285	79.2
	No	14	7.8	25	13.8	39	10.8
	Do not know	17	9.4	19	10.6	36	10.0
Is taking anthelmintics important to prevent intestinal parasitic infection?	Yes	147	81.7	104	57.8	251	69.7
	No	8	4.4	31	17.2	39	10.8
	Do not know	25	13.9	45	25.0	70	19.5
Is faeces a source of intestinal parasitic infection?	Yes	158	87.8	163	90.6	321	89.2
	No	3	1.7	12	6.7	15	4.2
	Do not know	19	10.5	5	2.8	24	6.7
Are animals a source of intestinal parasitic infection?	Yes	54	30.0	64	35.6	118	32.8
	No	112	62.2	97	53.8	209	58.1
	Do not know	14	7.8	19	10.6	33	9.2
Is soil a source of intestinal parasitic infection?	Yes	93	51.7	102	56.6	195	54.2
	No	51	28.3	48	26.7	99	27.5
	Do not know	36	20.0	30	16.7	66	18.3

SAC, school-aged children.

tive of all endemic areas in Bangladesh. The results presented here are based on a parasitological survey using coprological methods on a single stool sample; the use of Harada–Mori or agar plate culture methods and molecular methods may have revealed additional infections. In addition, this study did not assess the intensity of infection. This limitation will be addressed by future analyses of multiple consecutive stool samples and use of molecular methods. Another limitation of this study was the sociodemographic classification; some data were determined by verbal reporting of participants without definitive proof. Some classifications were made based on observations made by the interviewers. As the respondents could not answer some questions correctly, some variables were omitted, so there may have been subjective variation in gathering data.

In conclusion, this study demonstrated a substantial prevalence of intestinal helminth infection in urban slum settings, indicating persistent community transmission of intestinal helminths in Bangladesh. Efforts to control intestinal parasites with national deworming programmes targeting school-aged children may not be sufficient to achieve long-term control; measures to reduce transmission by improving sanitation, and health education should be considered. Furthermore, the negative consequences of helminth infections should be clearly recognized by community members, and incorporated into their daily activities. Intestinal parasitosis was found to be associated with several risk factors, including exposure to soil, lack of disinfection activities, open defaecation and animal cohabitation. When planning and executing control strategies, the roles of adults, animal reservoirs and soil contamination in maintaining the helminth transmission cycle must be considered carefully. Lack of concern, along with ignorance regarding the untoward effects of helminths, may increase the risk of reinfection. Therefore, the need for regular screening for intestinal parasites, and multi-sectoral plans and integrated programmes to target future control interventions is required. The authors strongly believe that these findings will be helpful in articulating future guidelines on control and elimination programmes for helminthiasis.

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Conflict of interest statement

None declared.

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Ethical approval

The study protocol was reviewed and approved by the Parasite Research Centre and Parasite Resource Bank, Chungbuk National University, South Korea and the Department of Parasitology, Sylhet Agricultural University, Bangladesh. There were no anticipated risks or discomforts. All respondents completed an informed consent form before the interview. In the case of school-aged children, consent was given by their parents or local guardians. The local language (Bengali) was used during all levels of data collection.

Availability of data and materials

Datasets are available from the corresponding author on reasonable request.

Author contributions

All authors reviewed and provided feedback for this manuscript. The final version of this manuscript was vetted and approved by all authors.

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