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The prevalence of intestinal parasitic infections in the urban slums of a city in Western India

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Summary
Background: There is scant information available on the prevalence of parasitic infections in Gujarat, a state in Western India. The present community-based study was undertaken in the urban slums of a city in Gujarat to determine the following parameters: (a) the prevalence and type of pathogenic intestinal parasites and (b) the availability of sanitary facilities in the study population.
Materials and methods: This cross-sectional study was conducted in 2008, and the study participants were urban slum dwellers. Considering an expected infection prevalence of 30% among slum dwellers, an allowable error of 10% and an anticipated design effect of two, the sample size for the cluster design was set to 1800 participants from 30 clusters and 360 households (HHs). Stool samples were examined using both direct wet mount and the formalin—ether sedimentation concentration technique, followed by trichrome staining for protozoan cysts.
Results: Toilet facilities were utilized by 56% of the HHs, while 44% of the HHs resorted to open air defecation. The overall prevalence rate of intestinal parasitic infections was 15.19%. Parasitic infections due to protozoa were observed in 70.71% of the study participants. Helminth infections were detected in 25.71% of the participants, and multiple parasitic infections were detected in 3.57%. Diarrhea was the most common complaint (9.56%) in the study population.
Conclusions: This study demonstrates that poor sanitation and inadequate environmental conditions are the main determining factors that predispose the population to intestinal parasites. Mass deworming programs are recommended for school children, as this population is easily accessible.
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Introduction

Parasitic infections caused by protozoa and helminths are major global health problems. The prevalence of parasitic infections varies with the level of sanitation and is generally higher in the tropics and sub-tropics than in more temperate climates [1—3]. In addition, poverty, malnutrition, high population density, the unavailability of potable water, low health status and a lack of personal hygiene provide optimal conditions for the growth and transmission of intestinal parasites. Other barriers to decreasing the rates of parasitic infections include insufficient parasitic disease research, neglect of the problem in developing countries and a lack of follow-up treatments [4].

The most common parasitic infections reported worldwide are those of *Ascaris lumbricoides*, *Ancylostoma duodenale*/*Necator americanus*, *Trichuris trichiura*, *Enterobius vermicularis*, *Entamoeba histolytica* and *Giardia lamblia* [1—6]. It is estimated that the global prevalence of *A. lumbricoides* infection is >1200 million cases and that the prevalence of *T. trichiura* and the hookworms *A. duodenale* and *N. americanus* is between 700 and 800 million cases [7]. The prevalence of *E. histolytica* ranges from 5% to 81%, and the parasite is estimated to affect approximately 480 million people worldwide [2,4]. Furthermore, *G. lamblia* is the most common intestinal parasite in the United States [8], whereas *A. lumbricoides* (47.0%), *T. trichiura* (18.8%) and hookworms (17.2%) are the most frequent causes of intestinal parasitic infections in China [9].

As India is considered a developing country, intestinal parasitic infections are a major health issue. Epidemiologic surveys of these infections are important because they reflect the sanitary conditions of the community and provide basic data for the control of future infections. Various community-based surveys conducted in India have shown a wide range (11.50—97.40%) of prevalence rates [3,6,10—18]. Considering the scarcity of available information on the prevalence of parasitic infections in Gujarat, a state in Western India, we performed the present community-based study in the urban slums of a city located in central Gujarat, India. The goals of the study were to identify the prevalence and type of pathogenic intestinal parasites and to assess the availability of sanitary facilities in the study population to determine the need for control measures.

Materials and methods

Study period

This cross-sectional study was conducted between February and December 2008.

Sample size

A sample size of 1800 was determined for cluster design based on an expected parasite prevalence of 30% among slum dwellers, as shown by various community-based surveys [3,10—12] conducted in India, a 10% margin of error and an anticipated design effect of two.

Sampling methodology

The sampling was performed in two stages. Stage one involved sampling to select 30 clusters, each of which represented a single slum. A list of slums obtained from the Municipal Corporation included 337 slums, constituting 52,987 households (HHs). A cumulative frequency of HHs was prepared, and 30 proportionate clusters were selected using a cluster-sampling method. At stage two, it was decided to study 12 HHs from each cluster. To achieve this, the larger clusters (those having >40 HHs) were divided into four quadrants, and three HHs were randomly selected from each of the four quadrants. The required sample size of 1800 participants from 360 HHs was calculated considering an average of five persons per HH. A pretested structured questionnaire was used to collect information regarding the housing conditions, sanitary facilities, water supply, personal hygiene and diarrhea-related morbidity. Training was imparted to post-graduate medical students and technicians regarding proper sample collection and processing. For the purpose of uniformity, a single public health expert assessed the general status of the subjects.

Collection and analysis of stool samples

During the home visits to the families, the relevant data were recorded in the structured questionnaire. Each member of the household was provided with a clean, broad-mouthed, labeled, screw-capped plastic container (50 ml capacity) containing 10 ml of sodium acetate-acetic acid-formalin (SAF), two applicator sticks and one thick piece of tissue paper (18''X12''). All individuals were requested to provide a morning fecal sample on the tissue paper, avoiding contamination with urine, and were instructed (attendent in the case of children) to collect a stool sample the size of a large marble with the provided applicator sticks, place it directly into the plastic container and close it tightly. To improve compliance, mothers and grandmothers were motivated and educated about the importance of this study, and they were assured that immediate treatment would be provided to all members of the HHs whose samples tested positive. Prior informed consent for stool collection was obtained from the study participants. A single stool sample was collected from each subject on the following day, and in 30% of the cases, samples were collected on the consecutive 2nd or 3rd days; the samples were then brought to the Department of Microbiology at the Medical College for examination. Initially, a macroscopic examination of the stool was performed to find evidence of blood, mucus, parasitic segments or whole parasites. Next, a direct unstained wet smear (saline mount) examination was carried out, and a drop of 1% Lugol's iodine (HiMedia Laboratories Pvt. Ltd., Mumbai, Maharashtra, India) was placed at the edge of the cover slip to convert it into an iodine mount. The direct saline and iodine mounts were systematically examined under the low-power objective (10×) with low light intensity and were then switched over to the high dry objective (40×). All stool samples were then processed by formalin—ether sedimentation concentration [19,20]. The saline and iodine preparations from each concentrated sample were examined similarly under 10× and 40× magnifications. Smears were made from the samples that revealed protozoan cysts using the concentration technique and were stained using the trichrome staining procedure [19,20]. To maintain internal validity of the results, all slides were examined by the same microbiologist. To ensure quality control, all of the laboratory procedures, including the collection and handling of the specimens, were carried out in accordance with the CLSI guidelines [21]. The microscope used for identification was calibrated. Although all slides were examined by a single microbiologist, one in ten slides was randomly reviewed by a colleague. For accurate identification of the parasite species, the WHO documents entitled 'Training manual on diagnosis of intestinal parasites' (WHO/CTD/SIP/98.2 CD-Rom-2004) and 'Slide sets' were referenced.

The study was approved by the local institutional review board. All participants found to be suffering from worm infections were given complete treatment and the necessary hygiene education. The provision of free treatment was an incentive for the subjects whose stool samples were found to be positive. The physicians, who were resident doctors from the Department of Preventive and Social Medicine, provided commercially available medication after assessing the complete medical history of the participants and examining them. The drugs were dispensed after counseling the subjects about the importance of treating the infection, with the anticipation that they would complete the drug regimen. Post-treatment follow up was not within the scope of the study.

Data analysis

The data were entered and analyzed in the Epi-info Version 6.04d package, and the proportion and chi-square tests were calculated where appropriate.

Results

Study population

We studied a population of 1872 city slum dwellers residing within 409 HHs and spread over 30 clusters. There was an equal distribution of males (49.73%) and females (50.27%) in the study population. The family size ranged from two to nine, with an average of five individuals per HH and three square meters allotted per person. The average family income was Rupees (Rs) 1800/month (32.5 US Dollars as of July 20, 2012). The overall literacy rate above five years of age was 73.14% for males and 42.72% for females. The age distribution was 3.04% infants, 19.76% aged 1—4 years, 26.4% aged 5—14 years, 11.2% aged 15—25 years and 39.48% aged more than 25 years.

Sanitary facilities

Of the HHs in the study, 80.27% were living in conditions of abject poverty. Toilet facilities were utilized by 56% of the HHs, while 44% of the HHs resorted to open air defecation. Intestinal parasitic infections are usually related to the HH environment and sanitation and are more common where sanitary conditions are poor [2—6,12,13,17,18], a finding that was corroborated by our study. There was a significantly higher prevalence of parasitism among those not using a toilet and resorting to open air defecation ($P < 0.01$, $X^2 = 7.06$). No further significant relationships were found between intestinal parasitic infections and environmental or behavioral factors.

Table 1 Distribution of the population whose stools were examined for intestinal parasites by age and gender ($n = 880$).

Age group (years)	<1	1—4	5—14	15—25	≥25	Total
No. of stool samples examined						
Male	24 (46.15%)	106 (58.24%)	138 (48.59%)	27 (34.18%)	118 (41.69%)	413 (46.9%)
Female	28 (53.85%)	76 (41.76%)	146 (51.40%)	52 (65.82%)	165 (58.30%)	467 (53.1%)
Total	52 (5.9%)	182 (20.68%)	284 (32.27%)	79 (8.9%)	283 (32.15%)	880 (100%)

Table 2 Distribution of the population showing prevalence of pathogenic intestinal parasites by age and gender from amongst the particular subgroups as shown in Table 1.

Age group (years)	<1	1—4	5—14	15—25	≥25	Total
Stool samples positive						
Male	0	20 (18.87%)	33 (23.91%)	4 (14.81%)	14 (11.86%)	71 (17.19%)
Female	2 (7.14%)	14 (18.42%)	29 (19.86%)	3 (5.76%)	21 (12.72%)	69 (14.77%)
Total	2 (3.85%)	34 (18.68%)	62 (21.83%)	7 (8.86%)	35 (12.37%)	140 (15.90%)

Although the response rate to the questionnaire was 100%, stool samples could only be obtained for examination from 880/1872 individuals, representing a 46% overall response rate and a 47% HH response rate (191/409). Unwillingness to submit a stool sample for examination was largely observed in the male population and was often due to indifference or apathy. In a small percentage of individuals, the hesitancy was due to the nature of the samples and a lack of toilet facilities in the household.

Although adults comprised 50% of the study population, 58.86% of the stool samples were received from children below fifteen years of age. Only 41.14% of the samples were from adults and, of these, 59.95% (217/362) were from females and 40.05% were from males (Table 1). The overall prevalence rate of intestinal parasitic infections was 15.19% (140/880). Furthermore, 53.40% (102/191) of the responsive HHs tested positive for parasitosis; males across all age groups showed a slightly higher prevalence rate of infestation (17.19%) as compared to females (14.77%). Similarly, a slightly higher prevalence of intestinal parasitic infestation (21.83%) was noted in the age group of five to fourteen years, although this was not statistically significant (Table 2).

Protozoan parasites comprised the bulk of the infections (70.71%; 99/140), while helminths were detected in (25.71%; 36/140) and mixed parasitic infections in (3.57%; 5/140). *E. histolytica/Entamoeba dispar* and *G. lamblia* were identified as the protozoan parasites, while *A. lumbricoides*, *Hymenolepis nana*, *Taenia* spp. and *E.*

Table 3 Prevalence of pathogenic intestinal parasites by age and gender.

Age group (years)	<1		1—4		5—14		15—25		≥25		Total		Total prevalence among positive samples ($n = 140$)		Total prevalence among samples examined ($n = 880$)
Gender	M	F	M	F	M	F	M	F	M	F	M	F	*n*	%	%
Entamoeba histolytica/Entamoeba dispar	1	—	4	4	12	13	1	1	12	3	30	21	51	36.4	5.79
Giardia lamblia	—	—	7	10	11	10	1	2	3	4	22	26	48	34.28	5.45
Ascaris lumbricoides	—	—	1	4	4	4	—	1	3	1	8	10	18	12.85	2.04
Hymenolepis nana	—	—	1	1	2	3	1	—	1	1	5	5	10	7.14	1.13
Taenia spp.	—	—	—	—	—	1	—	—	3	2	3	3	6	4.28	0.68
Enterobius vermicularis	—	—	—	—	—	—	—	—	—	1	—	1	1	0.71	0.11
Ankylostoma duodenale	—	—	—	—	—	—	—	—	—	1	—	1	1	0.71	0.11
Multiple	—	1	1	1	2	—	—	—	—	—	3	2	5	3.57	0.56

vermicularis were the most prevalent intestinal helminths. The non-pathogenic protozoan *Entamoeba coli* was detected in 10% of the samples but was omitted from the statistical analysis. The frequencies of the various parasitic infections by age and sex are shown in Table 3. Dual protozoan infections with *E. histolytica*, *E. dispar* and *G. lamblia* were observed in 2.14% of the study participants, while mixed infections with protozoa and helminths, namely *H. nana* and *G. lamblia*, were noted in 1.43%. We did not come across dual helminth infections in any of the samples. *Taenia* infections were most common in the adult population (5/6; 83.33%).

Diarrhea was the major complaint during the final two weeks prior to the study visit; it was observed in 9.56% (84/882) of the population and was significantly more common in the age group of 0 to five years (16.62%, $P < 0.001$, $X^2 = 65.89$). A history of passing worms in the stool was described by 6.6% (58/882) of the study participants. A significantly higher proportion of respondents in the age group of up to fifteen years provided a history of passing worms in the stool ($P < 0.001$, $X^2 = 67.13$), and passing worms was more common in the illiterate or solely primarily educated population ($P < 0.001$, $X^2 = 15.59$). Pallor (clinical anemia) was noted in 6.03% (55/882) of the participants and was significantly more frequent in the population under fifteen years of age ($P < 0.001$, $X^2 = 69.06$).

Discussion

Intestinal parasites constitute a major health problem in many developing countries, predominantly due to poor sanitation and inadequate personal hygiene.

In our study, the overall prevalence rate of intestinal parasitic infections was 15.19%, which was lower than previous reports from other countries. Other developing regions, such as Iran, northern Lebanon, Brazil, Nepal, Malaysia, and Saudi Arabia, have reported prevalence values ranging from 19.3% to 70% (Table 4) [4,5,22—25]. Various studies to elucidate the prevalence rate of intestinal parasitosis in both healthy and symptomatic populations in rural and urban India have reported the prevalence rate to vary from 11.50% to 97.4% (Table 4) [3,6,10—18]. This wide variation among studies could be attributed to the time and period of the study, the age of the study population, variations in diet, habits and occupations, different sampling techniques and research methodologies, geographical differences and the inclusion of non-pathogenic intestinal parasites in the analysis.

In a majority of the studies [3,4,12—18,22,23], including the present study, the parasite infection rates were based on the examination of a single stool specimen per individual. Based on the high prevalence rate of parasitosis and the absence of trophozoites in their studies, Rao et al. [14] and Das et al. [15] concluded that the examination of a single preserved stool specimen in a healthy population, using both direct and formal-ether concentration, was adequate to detect the intestinal parasitic infections in a community. Contrary to this, Kang et al. [6] demonstrated a much higher prevalence rate of intestinal parasites (97.4%) in a smaller group of subjects from whom a greater number of stool samples was collected (a minimum of 12 and a maximum of 15). These authors opined that in clinical practice, 3 stool samples should give a sensitivity of greater than 75%. However, the cost of such comprehensive studies must be weighed against the probable gain in sensitivity and, unlike our community-based survey involving a large population, is likely to be practical only in research situations. Moreover, collecting multiple samples would entail logistical constraints and high drop-out rates.

As in other studies [4,5,10,14,18,23,24], our study did not reveal any statistically significant differences in the parasite prevalence rates between the sexes. However, we noted a slightly higher prevalence of parasitic infestation in the age group of five to fourteen years. Studies conducted worldwide [4,9,22,25] as well as in India [3,6,17,23] have also demonstrated that the highest rates and the heaviest infections typically occur among children aged between five and fourteen years.

The high rate of protozoan infections (*E. histolytica*/*E. dispar* and *G. lamblia*) as compared to helminth infections (*A. lumbricoides*) in this study is in accordance with reports from across the world as well as previous studies in India [4,8,10—12,18,22,24,25]. We observed that *G. lamblia* had a slightly lower prevalence than *E. histolytica*, although it was the predominant parasite in both the dual protozoan and multiple parasite infections. Most reports from the literature label *G. lamblia* as the predominant protozoan parasite in single [4—6,8,10,13,18,22], dual and multiple protozoan infections. The high age-specific prevalence rates of *E. histolytica*/*E. dispar* and *G. lamblia* in our study reflects their fecal—oral mode of transmission, which is common in children. *A. lumbricoides* was the parasite most commonly observed to infect two or more members of a single family, which could be attributed to the fact that the infestation was acquired from the same source, and

Table 4 Comparative prevalence of potentially pathogenic parasites reported world wide.

	Samples		% of samples +ve for parasites								
	n	% +ve	*E. histolytica/E. dispar*	*G. lamblia*	*A. lumbricoides*	*H. nana*	*Taenia* spp.	*E. vermicularis*	*A. duodenale* (Hook worm)	Others	Multiple
Singh et al. [3]	514	42.41	0	7	28	–	4	–	–	5	2.50
Sayyari et al. [4]	45,128	19.3	1.0	10.9	1.50	–	0.20	0.50	0.10	0.30	–
Hamze et al. [5]	17,126	33.35	1.50	5.13	12.40	–	1.10	–	–	12.80	–
Kang et al. [6]	993	45.40 (97.4)	2.80	15.10	0.80	7.60	7.30	1.10	22.80	0	–
Kappus et al. [8]	216,275	20.00	4.20	7.20	0.80	–	–	–	1.50	8.00	–
Xu et al. [9]	1,477,742	–	–	–	47.00	–	–	–	17.20	18.80	–
Ramesh et al. [10]	970	12.50	1.90	7.40	1.00	1.90	–	–	1.30	0	–
Kaur et al. [12]	127	46.50	11.00	11.00	0.80	–	–	–	–	23.70	–
Bansal et al. [13]	550	19.30		6.00	9.30	–	–	–	–	4.00	–
Rao et al. [14]	81	67.90	7.40	7.40	33.30	4.90	0	1.20	13.50	6.10	–
Das et al. [15]	711	47.10	9.00	3.00	3.00	–	–	–	27.10	1.8	–
Nitin et al. [18]	1071	11.50	0.84	2.52	1.30	0.56	0.09	–	0.28	–	–
Chandrashekhar et al. [23]	2091	21.30	1.70	13.20	2.10	1.60	–	–	0.40	1.30	0.70
Present study	880	15.90	5.79	5.45	2.04	1.13	0.68	0.11	0.11	–	0.56

this finding corroborates an earlier report by Bansal et al. [13].

Despite our best efforts at persuasion, we collected stool samples from only 46% of the study population. This low percentage was unavoidable, as it was a community-based study. However, we did request the reasons for refusing to participate, which included hesitancy due to the nature of the samples and lack of toilet facilities in the house. It is possible that we could have observed a higher prevalence if the response rate was higher. In certain cases, two to three visits were required to collect even a single stool sample from a household.

We strongly believe that the data collected from this study will form a baseline for future evaluation of measures at reducing the fecal—oral transmission of intestinal parasites by improving sanitation, health education and therapy against parasites in developing countries.

To conclude, this study demonstrates that intestinal parasite infections are a public health problem in our study population. Poor sanitation and inadequate environmental conditions constituted the main determining factors that predisposed this population to intestinal parasites. Improvements in sanitation, limiting open air defecation, provisions of sanitary latrines for all, and hygiene and health education are the required interventions that will be instrumental in preventing these infections. Furthermore, mass deworming programs for school children are highly recommended, as this population can be easily accessed for treatment.

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Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

Not required.

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