

Prevalence and Risk Factors of Intestinal Parasitic Infection in Under-Five Children With Malnutrition: A Hospital Based Cross-Sectional Study

Sangeeta Deka¹, Deepjyoti Kalita², Naba Kumar Hazarika³

¹Department of Microbiology, Fakhruddin Ali Ahmed Medical College and Hospital (FAAMCH), Barpeta, Assam, ²Department of Microbiology, All India Institute of Medical Sciences, Rishikesh, Virbhadraroad, Rishikesh, Uttarakhand, ³Department of Microbiology, Gauhati Medical College and Hospital (GMCH), Guwahati, Assam, India

ABSTRACT

Background: Intestinal parasitic infections (IPIs) and malnutrition in under-five children contribute substantially to developing countries' childhood morbidity and mortality. This study assessed the prevalence and profile of IPI in under-five children and compared them with nutritional status and other socioeconomic factors. **Methods:** Anthropometric indices were used for checking the nutritional status of under-five children. Malnutrition was graded into four grades (I-IV) based on the Indian Academy of Pediatrics advocated Weight-for-Age criteria. Children whose Height-for-Age and Weight-for-Height were <-2 , standard deviations were regarded as stunted and wasted, respectively. Stool samples were examined by direct wet mount (normal saline and iodine) and formol-ethyl acetate concentration technique to detect parasitic cyst and ova. Stool smears were made directly from the specimen and after concentration and stained by kinyoun's stain. Subsequently, the association of undernutrition was assessed with intestinal IPI using the Chi-square test. **Results:** The overall prevalence of Grade I, II, III, and IV malnutrition was 52%, 31.7%, 12.2%, and 4.1% while stunting and wasting IPIs were present in 60.2% and 36.6%, respectively. IPIs were present in 47.2%, and 11.4% showed polyparasitism. Soil-transmitted helminths were found to be the commonest (*Ascaris lumbricoides*: 21.1%; *Trichuris trichiura*: 13.0%; and hookworms: 8.1%) followed by the intestinal protozoa (*Enterobius vermicularis*: 7.3, *Giardia lamblia*: 6.5, and *Cryptosporidium* spp.: 2.4%). Increasing age upto 5 years, improper excreta disposal, low level of maternal education, and a higher number of children in the family were predictors of IPIs. The prevalence of IPI was significantly associated with Grade II and III undernutrition, stunting, and wasting. Individually, *Ascaris* and hookworms contributed significantly to stunting and *cryptosporidium* spp. to wasting. **Conclusion:** Prevalence of IPI in malnourished under-five children is high. Joint nutritional interventional strategies, early diagnosis/treatment of under-five children, and increased awareness among masses are imperative to break the vicious cycle of malnutrition and parasitic diseases.

Keywords: Intestinal parasitic infections, malnutrition, Northeast India, soil-transmitted helminths, stunting, wasting

Introduction

Intestinal parasitic infections (IPIs) and malnutrition in under-five children are of significant public health concern in low- and middle-income countries (LMICs) and contribute significantly to childhood morbidity and disability.^[1,2] IPI with the soil-transmitted helminths (STHs) (*Ascaris lumbricoides*, *Trichuris trichiura*, *Ankylostoma duodenale*, and *Necator americanus*) are the most

Address for correspondence: Dr. Deepjyoti Kalita, Department of Microbiology, All India Institute of Medical Sciences, Rishikesh, Virbhadraroad, Rishikesh - 249 203, Uttarakhand, India. E-mail: dkalita@gmail.com

Received: 01-09-2021

Revised: 17-12-2021

Accepted: 27-12-2021

Published: 30-06-2022

Access this article online

Quick Response Code:



Website:
www.jfmpc.com

DOI:
10.4103/jfmpc.jfmpc_1742_21

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Deka S, Kalita D, Hazarika NK. Prevalence and risk factors of intestinal parasitic infection in under-five children with malnutrition: A hospital based cross-sectional study. J Family Med Prim Care 2022;11:2794-801.

common parasitic infections in developing countries.^[3] They pose a considerable global burden affecting approximately more than 1.5 billion people worldwide.^[1,4] These, along with other parasitic agents (e.g., protozoa), pose threats due to changes in ecology, human demographics, and human behavior.^[5]

On the one hand, malnourished children are vulnerable to IPI suffering. In contrast, IPI-related chronic infections can contribute considerably to the evolution of undernutrition in the pediatric population, thus creating a potentially lethal cycle/vicious cycle of worsening illness and deteriorating nutritional status.^[2,6] This combination is a significant reason for high under-five mortality in developing and populous nations like India. Undernutrition claims nearly half of all deaths in under-five children.^[2] Globally, 45.4 million under-five children were wasted and 149.2 million were stunted in 2020. South-east Asia is the worst afflicted region, with >30% of the children still affected by stunting and >15% by wasting in 2020.^[2,7,8] Prevalence of undernutrition among under-five children (National family health survey 4, i.e., NFHS 4) in India shows that 35.7% under-five children were underweight, 38.4% were stunted, and 21% were wasted.^[2,7,8] Such a high prevalence of undernutrition is a matter of significant concern from the point of primary care in our country (especially in rural areas). As mentioned earlier, the risk of IPI and the resultant possibility of forming a vicious cycle (undernutrition and IPI) make this situation very complex from the family medicine practice perspective.^[9-12] It is worth mentioning India, Bangladesh, and Pakistan together comprise half the world's underweight children.^[9]

Studies have proved that effective management of IPI can improve/cure malnutrition more speedily than management with nutritional support measures only. Accordingly, knowledge of the prevalence and pattern of IPI in a particular area can be advantageous in formulating control policies to fight undernutrition. This is essential in the management of such cases at the primary care level (family medicine practice). However, wide geographical variance and identification of new, previously lesser-known parasites that are challenging to treat with known available antiparasitic/anthelmintic agents have complicated the situation.^[5,13] As a result of microbial adaptation and change, climate change, human encroachment into wildlife habitats, and the emergence of new immune-related disorders, parasites such as *Cryptosporidium*, *Cyclospora*, *Giardia*, *Anisakis*, *Microsporidia*, *Strongyloides*, etc., may be poised for an increase in importance.^[5,13]

We have noticed a gap (in terms of published literature) in the knowledge regarding the prevalence of IPI in lower Assam, which encompasses riverine areas and tropical rainforests with high annual rainfall—all of these led to a fertile ground for helminths and protozoa.

Given these facts, this study was undertaken to gain an insight into the prevalence and profile of IPI in under-five children with

malnutrition and to check its association with sociodemographic factors and different grades of undernutrition.

Materials and Methods

Study setting and population

This cross-sectional study was carried out in our tertiary care teaching hospital in the largest city of North-eastern India. Necessary Institutional Ethics Committee permission was obtained (MC/1372009/pt-III/323). Children between the age of 6 months and 5 years, having malnutrition and visiting (pediatric out-patient/inpatient) for a routine check-up, or illnesses like chronic diarrhea, respiratory tract infections, fever, etc., or those with symptoms of malnutrition (growth retardation, failure to thrive, lethargy, generalized weakness, xerophthalmia, etc.) were included in the study. The parents of study subjects were explained the purpose of the study, and informed consent was taken from them. A detailed history including food habits, sanitation, socioeconomic status, and maternal education level was recorded on a predesigned proforma. Since malnutrition is the commonest with the highest morbidity and mortality in the under-five children group and WHO defines the magnitude of undernutrition in terms of stunting, wasting, and underweight in this age, only under-five children were included in the study.

Assessment of malnutrition

Standard anthropometric measurements evaluated all the children to assess their nutritional status. A child's weight was recorded accurately on an electronic weighing scale with a sensitivity up to 0.01 Kg. The accuracy of the weighing scale was checked regularly, and zero error was noted and corrected before individual weight measurement. The recumbent length was measured in an infantometer for babies less than 2 years. For children more than 2 years, standing height was measured against the wall with the help of a measuring tape correct to the nearest 1 mm. The mid-arm circumference was measured by placing a measuring tape firmly (without compressing the tissues) around the left upper arm at a point midway between the tip of the olecranon process and the tip of the acromion.

The nutritional status of the students was further assessed by standard deviation score (z-score) and percentile to find out the presence of undernutrition and its extent, the 50th percentile of the growth charts of the National Status for Health Statistics (NCHS), was used as normal standard. The three parameters taken were Weight for Age (WFA), Height for Age (HFA), and Weight-for-Height (WFH). For grading malnutrition, the method advocated by the Indian Academy of Pediatrics was taken into account, taking the parameter WFA. Children having WFA >80% of the standard were regarded as normal and excluded from the study, whereas WFA of 71% to 80%, 61% to 70%, 51% to 60%, and ≤50% were considered Grade I, II, III, and IV protein-energy malnutrition (PEM),

respectively. Using a Z-score of < -2.00 as cut-off, the children falling below this in the HFA parameter as stunted and WFH parameter as wasted (WHO classification).

Laboratory procedures

The parents/guardians were advised to collect the child's fresh stool sample in a wide-mouthed, clean pre-labeled container with a tight lid. The specimen was processed within half an hour of collection. The color, consistency, odor, and pH of the stool were noted. Naked eye examination of stool was done to check for the presence of parasitic elements.

Later, the stool samples were subjected to microscopic examination: (i) Wet mount preparations with normal saline and (ii) iodine preparation, and observed under low-power (10 \times) and high-power (40 \times) objective of a microscope. The stool specimens' direct smear was made and examined after Kinyoun's stain (modified acid-fast stain) procedure.

If no ova and cyst of the parasite were detected in direct microscopy, the stool specimens were concentrated using the Formol-Ethyl Acetate concentration method sedimentation technique. Normal saline and iodine wet mounts and direct smears stained with Kinyoun's stain were prepared from the sediments and examined.

Statistical analysis

Data were entered into Microsoft Excel, double-checked, and merged into a single database for statistical analysis with SPSS (v17.0). Graphs and tables were created using the Microsoft Excel function. A Chi-square test was used to check the association of IPIs with various nutritional statuses of under-five children.

Results and Observations

A total of 123 children with undernutrition were studied for the prevalence and profile of intestinal parasites in them. Characteristics of the study respondents are summarized in Table 1. The age of the children ranged from 6 months to 5 years, with the mean age being 3.3 years. The majority of the malnourished children were in the age bracket 3 to 5 years (55.3%), while fewer cases could be recruited from lower age groups. Males outnumbered females in the ratio of 1.1:1. The majority of the subjects belonged to the low-income group (78.0%), while 16.3% and 5.7% belonged to the middle- and high-income group. Almost one-fourth (26%) of the subjects availed drinking water from municipality supply, whereas 21.1% and 35.8% got it from tubewell and concrete/kutchha well. Half of the study population had access to the sanitary latrine at home, while the other half practiced open-air defecation and other unsanitary defecation practices. About 46.3% used to filter drinking water compared with 53.7% who did not. The majority of the mothers of the study subjects had two or three children (32.5% and 33.3%, respectively). It

Table 1: Sociodemographic and environmental variables of the analyzed population of under-five children

Characteristics	n	%
Age groups		
<1	10	8.1
1 y-2 y	21	17.1
2 y-3 y	24	19.5
3 y-4 y	36	29.3
4 y-5 y	32	26
Gender		
Male	64	52
Female	51	48
Socioeconomic status		
Low	96	78.0
Middle	20	16.3
High	7	5.7
Source of drinking water		
Municipal supply	32	26.0
Tubewell	26	21.1
Well (concrete/kutchha)	44	35.8
Others	21	17.1
Excreta disposal		
Sanitary	62	50.4
Insanitary	61	49.6
Filtration of drinking water		
Done	57	46.3
Not done	66	53.7
Maternal education		
Matriculate or more	24	19.5
Up to high school	57	46.3
Illiterate	42	34.2
Maternal parity		
One	26	21.1
Two	40	32.5
Three	41	33.3
Four or more	16	13.1
Grades of PEM		
I	64	52
II	39	31.7
III	15	12.2
IV	5	4.1
Stunting		
Present	74	60.2
Absent	49	39.8
Wasting		
Present	45	36.6
Absent	78	63.4

was observed that a vast majority of the mothers were either illiterate or studied only up to school (34.2% and 46.3%, respectively).

Most of the children suffered from Grade I PEM (52%), followed by Grade II (31.7%), Grade III (12.2%), and Grade IV (4.1%) [Table 1, Figure 1a]. About 60.2% of the children were stunted and 36.6% were wasted. Both stunting and wasting increased with age reaching maximum cases in the 3 to 4 years age bracket [Figure 1b and Figure 1c].

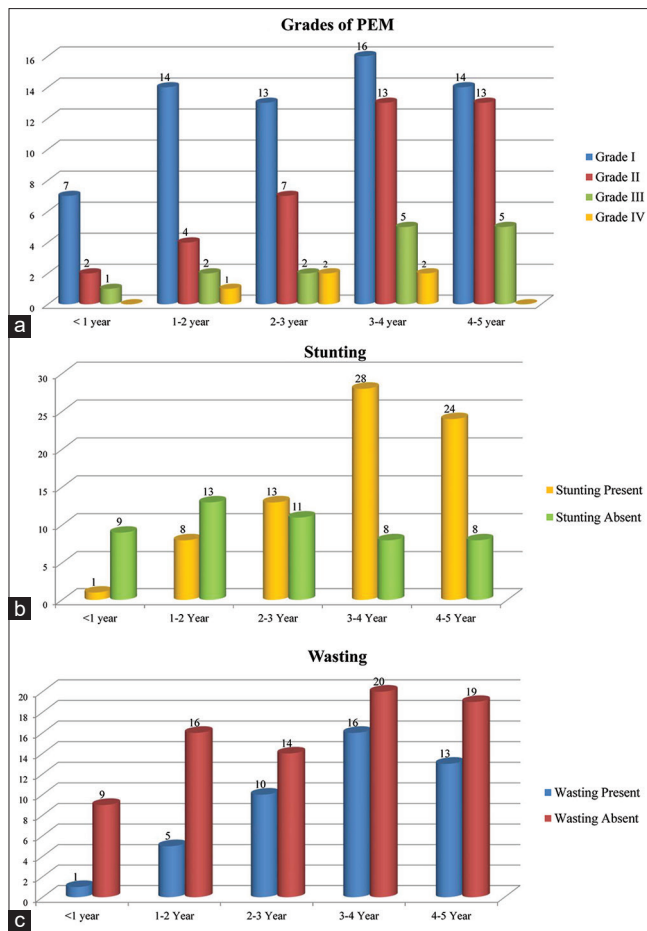


Figure 1: Age-wise distribution of [a] grades of protein energy malnutrition, [b] stunting, and [c] wasting in under-five children

Profile and prevalence of intestinal parasitoses:

Table 2 enumerates the prevalence of different types of parasites in the study subjects. Overall, 47.2% of the children with PEM had IPI [95% Confidence Interval (CI): 38.1–56.3] 35.8% [95% CI: 27.3–44.9] had single parasitic infection whereas 11.4% [95% CI: 6.4–18.4] were infected with multiple parasites. Individually, *Ascaris lumbricoides* was found to be the most common parasite (n = 26, 21.1%), followed by *Trichuris trichiura* (n = 16, 13.0%), Hookworms (n = 10, 8.1%), *Entamoeba histolytica* (n = 9, 7.3%), *Giardia lamblia* (n = 8, 6.5%), and *Cryptosporidium spp.* (n = 3, 2.4%). One case of *F. buski* and *H. nana* each was also isolated. Figure 2 depicts the percentage prevalence of different parasites.

Association of IPI with nutritional status and other factors:

Table 3 shows the correlation of intestinal parasites with sociodemographic and environmental factors. The prevalence of intestinal parasites increased gradually with increasing age in under-five malnourished children (*P*-value: 0.001) with maximum prevalence in the 4 to 5 years (75%). IPI was marginally more in females, but this difference was not statistically significant [*P*-value: 0.475]. Children who practiced open-air

defecation and other unsanitary habits of excreta disposal were at higher risk of acquiring intestinal parasites (*P*-value: 0.024). Lower maternal educational status and higher maternal parity (number of children in the family) were found to be determinants for IPI (*P*-value: 0.030 and <0.001, respectively).

The findings of Chi-square test analysis of intestinal parasites and nutritional status of under-five children are presented in Table 4. As PEM grades increased from I to III, a significantly higher chance of harboring intestinal parasites (*P*-value: 0.029) was observed. Maximum IPI prevalence was seen in grade III malnutrition followed by Grade IV and Grade II PEM. IPI was also significantly associated with stunted and wasted children (*P*-value: 0.031 and 0.016, respectively). Individually, *Ascaris lumbricoides* and hookworm infections were strongly associated with stunting, while cryptosporidiosis was significantly associated with wasting [Table 5].

Discussion

The prevalence of IPI in malnourished children has been found to vary depending on the geographic location, sampling population, study design, and sensitivity of the laboratory methods used. There are multiple published studies on malnutrition and IPI in the pediatric age group. However, to the best of our knowledge, this is the first study from northeast India to assess the nutritional status of under-five children and correlate intestinal parasitoses in them. We observed that 47.2% of malnourished under-five children had IPI. This was relatively high compared with findings of other studies viz Awasthi *et al.*^[14] with 17.5% from Lucknow, India; Ihejirika *et al.*^[15] with 16.6% from Nigeria, Amare *et al.*^[16] (22.7%) from northwest Ethiopia, etc., But, a higher rate, comparable to our finding, was reported by many studies conducted elsewhere.^[17–21] Detection of malnourishment in nearly half of the population (under-five age group) was a significant finding from the general practice (family medicine) perspective.

In our study, STHs were the predominant parasites in malnourished under-five children in concordance with many other studies.^[1,14,16,22] *Ascaris*, *Trichuris*, and Hookworms either singly or in combination with other parasites, affected one-third of the study population (33.3%), while Protozoan parasites (*Entamoeba*, *Giardia*, and *Cryptosporidia*) were found only in 14.6%, a fact with potential impact in primary care practice for the management of such cases. Few other studies did elsewhere reported predominance of protozoa in malnourished children.^[15,19,21,23–25]

The sampling population of this study comprised of underweight children (<–2 SD from median WFA of NCHS chart), with more than 83% having Grade I or II PEM. This predominance of milder grades of malnutrition is typical in India—a fact already established by many previous works. Thus, most likely, in LMICs, bulks of the undernourished children go undetected as most do not show any specific features of malnutrition. Grade III and IV represent only the tip of the iceberg. We further observed that

Table 2: Prevalence and profile of intestinal parasites observed in under-five children

Intestinal Parasite/parasites	n	%	Prevalence
<i>Ascaris lumbricoides</i>	14	11.4	Monoparasitism=44, (35.8%)
<i>Trichuris trichiura</i>	8	6.5	
Hookworms	7	5.7	
<i>Giardia lamblia</i>	6	4.9	
<i>Entamoeba histolytica</i>	4	3.3	
<i>Cryptosporidium spp.</i>	3	2.4	
<i>Fasciolopsis buski</i>	1	0.8	
<i>Hymenolepis nana</i>	1	0.8	Polyparasitism=14 (11.4%)
<i>Ascaris lumbricoides</i> + <i>Trichuris trichiura</i>	6	4.9	
<i>Ascaris lumbricoides</i> + Hookworms	1	0.8	
<i>Ascaris lumbricoides</i> + <i>Entamoeba histolytica</i>	3	2.4	
<i>Giardia lamblia</i> + <i>Entamoeba histolytica</i>	2	1.6	
<i>Ascaris lumbricoides</i> + <i>Trichuris trichiura</i> + Hookworms	2	1.6	
Total	58	47.2%	

Table 3: Association of intestinal parasitic infection with socio-demographic and environmental factors as assessed by Chi-square test

Independent variable	Intestinal parasite		P*
	Present n (%)	Absent n (%)	
Age			
<year	2 (20)	8 (80)	0.001
1-2 year	8 (38.1)	13 (61.9)	
2-3 year	6 (25)	18 (75)	
3-4 year	18 (50)	18 (50)	
4-5 year	24 (75)	8 (25)	
Gender			
Male	30 (46.9)	34 (53.1)	0.475
Female	28 (47.5)	31 (52.5)	
Socioeconomic status			
Low	48 (50)	48 (50)	0.428
Middle	8 (40)	12 (60)	
High	2 (28.5)	5 (71.5)	
Source of drinking water			
Municipal supply	14 (45.2)	17 (54.8)	0.660
Tubewell	14 (53.8)	12 (46.2)	
Well (concrete/kutchra)	23 (52.3)	21 (47.7)	
Others	8 (47.2)	13 (52.8)	
Excreta disposal			
Sanitary	35 (57.4)	26 (42.6)	0.024
Insanitary	23 (37.1)	39 (62.9)	
Filtration of drinking water			
Done	28 (49.1)	29 (50.9)	0.345
Not done	30 (45.5)	36 (54.5)	
Maternal education			
Matriculate or more	7 (29.2)	17 (70.8)	0.030
Up to high school	25 (43.9)	32 (56.1)	
Illiterate	26 (61.9)	16 (38.1)	
Maternal parity			
One	5 (19.2)	21 (80.8)	<0.001
Two	11 (27.5)	29 (72.5)	
Three	29 (70.7)	12 (29.3)	
Four or more	13 (81.3)	3 (18.7)	

SE: socioeconomic status. *Two-sided P value as evaluated by Chi square test

stunting and wasting increased with increased age upto 5 years. Intestinal parasitoses were also significantly associated with

increased age in under-five children with maximum positivity in 4 to 5 years (75%), probably attributable to chronicity or repeated infection. This finding is similar to a few other studies,^[19,23,25,26] though some showed a peak in 2 to 3 years.^[27] So most likely, the timely diagnosis and management of milder grades of undernutrition at a younger age can break the vicious cycle of malnutrition and infection, thereby preventing deterioration to more severe forms of malnutrition and decreasing the burden of IPI. This could be essentially a critical finding from the point of view of prevention and primary care of this problem.

Gender stratification in this study showed no difference in IPI prevalence. Few earlier studies indicated a female preponderance in parasite positivity,^[28] while hookworm infections were more common in males.^[29] But most studies had a similar finding as ours in this matter.^[1,17,21,23-25,30]

Despite many efforts for awareness/prevention, malnutrition and IPIs are still major public health concerns in LMICs. Both generally affect the poorest communities and are prevalent in the same geographical regions. IPI transmission mainly occurs through fecal contamination due to poor sanitation practices. Unacceptable quality of water, poor personal hygiene, low parental literacy, lack of awareness on hygienic practices, etc., are found to have abearing on the prevalence of IPIs.^[1,23,24,30-32] In our study, also a majority of the malnourished children belonged to lower socioeconomic strata (78%), and IPIs were significantly found in economically weaker classes (50% in low compared with 40% in middle and 28.5% in high). Open-air defecation was strongly associated with IPIs (*P-value*: 0.028). Low maternal education also was significantly linked to IPIs (*P-value*: 0.030), as uneducated mothers are unaware of clean and safe hygienic practices. Zonta *et al.*^[24] also observed that 63.7% of infected children had mothers educated up to only primary level. In contrast, Okay *et al.*^[31] reported that 42.6% of children with IPIs had an illiterate mother. Hailegebriel^[17] reported that the risk of IPI doubles being born to an illiterate mother. More number of children in the family was also found to be a predictor of IPIs (*P-value* < 0.001). Yoseph *et al.*^[23] observed that IPIs were

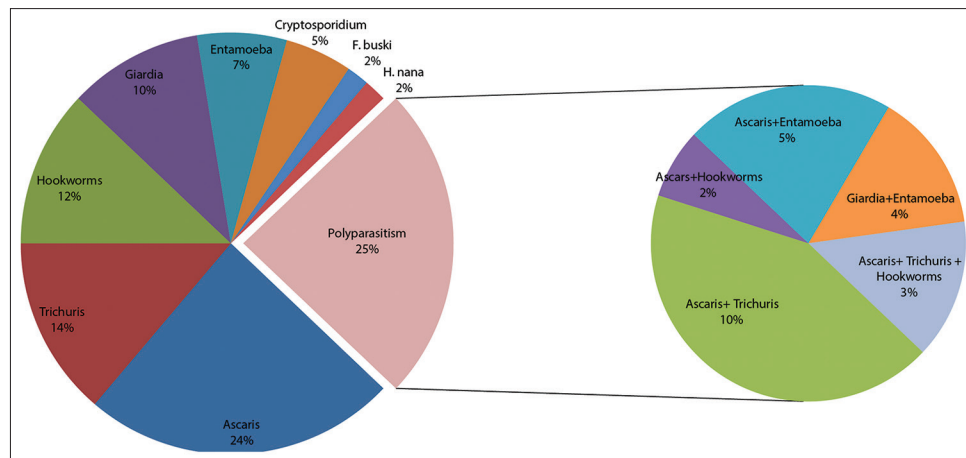


Figure 2: Percentage prevalence of various species of intestinal parasites isolated from under-five children

Table 4: Association of intestinal parasitic infection with nutritional status of under-five children

Nutritional status	Intestinal parasite		P
	Present	Absent	
Grades of PEM			
I	22 (34.4)	42 (65.6)	0.029
II	24 (61.5)	15 (38.5)	
III	10 (66.7)	5 (33.3)	
IV	2 (40)	3 (60)	
Stunting			
Present	40 (54.1)	34 (45.9)	0.031
Absent	18 (36.7)	31 (63.3)	
Wasting			
Present	27 (60.0)	18 (40.0)	0.016
Absent	31 (39.7)	47 (60.3)	

Table 5: Relation of stunting and wasting with individual parasites detected in the study population

Parasites present	Stunting			Wasting		
	Present	Absent	P	Present	Absent	P
<i>Ascaris lumbricoides</i>	19	7	0.028	11	15	0.251
<i>Trichuris trichiura</i>	11	5	0.237	7	9	0.267
Hookworms	9	1	0.023	5	5	0.191
<i>Entamoeba histolytica</i>	5	4	0.386	3	6	0.431
<i>Giardia lamblia</i>	6	2	0.086	4	4	0.221
<i>Cryptosporidium spp</i>	2	1	0.433	3	0	0.024
<i>Fasciolopsis buski</i> *	1	0	-	1	44	-
<i>Hymenolepis nana</i> *	1	0	-	0	45	-

*Relationship with *F. buski* and *H. nana* could not be analyzed due to less number of cases

2.7 times more in children living in large families and Feleke reported 2.06 times more chance of IPIs in families with > 4 members,^[18] while Mulatu *et al.*^[25] did not find any significant relationship between family size and IPIs.

Our study result showed that IPI was significantly associated with Grade II and III undernutrition, possibly indicating that parasitic diseases are more common in moderate malnutrition than mild or severe forms. This finding corroborates well with a few other

studies.^[19,24,32] One implication of this could help in undertaking a targeted approach (focusing on moderate malnutrition) for IPI management in resource scant primary care setup. The level of adult helminths infection in a host is determined by the balance between establishing the parasites (inputs) and their death and expulsion (output). Input depends on public health sanitation, while for output to occur, a hostile environment to prevent the worm's continuation of development and maintenance of position must be created.^[24,33] Thus, in severe malnutrition, a shortage of essential nutrients and an unfavorable microenvironment is detrimental to the parasite's survival for a longer time. While in milder forms, immunity might have a protective role.

Association of IPIs with stunting (*P*-value: 0.031) hints that the intestinal parasites (repeated or untreated) might play an essential role in the chronicity of malnutrition. This positive association was reported by multiple other studies,^[17,23,24,27] while few other works did not find any association between IPI and stunting.^[14-16] Yoseph *et al.*^[23] observed that IPI was positively associated with stunting but not wasting. But we found a strong association of IPI with wasting (*P*-value: 0.016), indicating that parasitic diseases could further worsen the nutritional status of children with chronic malnutrition (acute or chronic).

In this work, STH, *Ascaris*, and Hookworm were significantly associated with stunting (*P*-value: 0.028 and 0.023, respectively), while the protozoan parasite *cryptosporidium* was associated with wasting (*P*-value: 0.024). Hailegebriel^[17] too observed a strong association of stunting with *Ascaris* but not with hookworm. Contrary to some studies that reported a strong association of protozoa like *Giardia* and *Entamoeba* with chronic malnutrition,^[19-21] we did not find any such significant association. Yones *et al.*^[20] found that stunting and wasting were more dominant among children infected with *Giardia* and *Cryptosporidium*. In our study, the child with *Fasciolopsis buski* infection was also wasted. Thus, our study hints that intestinal helminths might lead to chronic malnutrition (stunting), and infection by protozoa like

Cryptosporidium can further deteriorate the condition of the chronically malnourished child (wasting).

Being a hospital-based study, our current work may not reflect the actual disease load of IPI in malnourished children in the community. Most of the malnourished children suffering from IPI in our study hailed from low socioeconomic status, raising the probability that there might be a more significant proportion of affected children, much neglected, and without any means to attend hospital. Hence, current data can provide an essential ground for a future community-based study, including underprivileged children (dwelling in slums, street dwellers, homeless, etc.). Because of the study's design (cross-sectional), a temporal link between malnutrition and IPIs to ascertain causality could not be determined.

The study's major strength was that we pursued a holistic approach to assess the nutritional status of the study population and correlate the grades with IPIs—the first from our region likely contributing to baseline information on malnutrition and intestinal parasites from northeast India.

Conclusion

A high proportion of the under-five malnourished children harbor IPI in our region with risk factors like low income, insanitary excreta disposal, low maternal education, bigger family size, etc., Association of IPI with stunting (chronic malnutrition) and wasting (acute on chronic malnutrition) suggests that intestinal parasites could be an initial step in the evolution of malnutrition. Early intervention to combat IPI and awareness of hygiene and sanitary practices will help immensely address the problem.

Key points

- IPI is high amongst undernourished preschool kids of our region, infected mainly by soil-transmitted helminths.
- IPI is more in moderate degree malnutrition and older kids (3–5 years group) than younger under-fives.
- There are identified associated factors like lack of sanitary practices and personal hygiene, absence of awareness about these, low maternal education, big family size, etc.
- For curative and preventive purposes, these risk factors need to be addressed, which could be crucial for managing the malnutrition problem.

Acknowledgements

The authors would like to thank Principal cum Chief superintendent and administration of Gauhati Medical College and hospital for allowing us to carry out this study. We offer our sincere thanks to all the supporting staff of Pediatrics and Microbiology department for their in-state time and support in data collection. Finally but not the least, we offer our gratitude to the children and their parents for consenting to participate in the survey.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Shrestha A, Schindler C, Odermatt P, Gerold J, Erisman S, Sharma S, *et al.* Intestinal parasite infections and associated risk factors among schoolchildren in Dolakha and Ramechhap districts, Nepal: Across-sectional study. *Parasit Vectors* 2018;11:532.
2. UNICEF data. Malnutrition in children. April 2021. Available from: <https://data.unicef.org/topic/nutrition/malnutrition/>. [Last accessed on 2021Aug 15].
3. Haque R. Human intestinal parasites. *J Health Popul Nutr* 2007;25:387-91.
4. World Health Organisation 2020. Soil Transmitted Helminth infections. 02 March 2020. Available from: <https://www.who.int/news-room/fact-sheets/detail/soil-transmitted-helminth-infections>. [Last accessed on 2021Aug 15].
5. Cox FE, Wakelin D, Stephen HG, Gillespie SH, Despommier DD, editors. *Topley and Wilson's Microbiology and Microbial infection: Parasitology*. 10th ed. London: Hodder Arnold; 2006.
6. Taylor-Robinson DC, Maayan N, Donegan S, Chaplin M, Garner P. Public health deworming programmes for soil-transmitted helminths in children living in endemic areas. *Cochrane Database Syst Rev* 2019;9:CD000371.
7. NFHS 4 (2015–16) India Fact sheet. Available from: <https://www.aidsdatahub.org/sites/default/files/resource/national-family-health-survey-4-2015-2016-india-fact-sheet.pdf> [Last accessed on 2018 Aug 15]
8. Murarkar S, Gothankar J, Doke P, Pore P, Lalwani S, Dhumale G, *et al.* Prevalence and determinants of undernutrition among under-five children residing in urban slums and rural area, Maharashtra, India: A community-based cross-sectional study. *BMC Public Health* 2020;20:1559.
9. UNICEF data. Progress for children: A report card on nutrition. UNICEF, New York, July 2006. Available from: <https://data.unicef.org/resources/progress-for-children-a-report-card-on-nutrition/>. [Last accessed on 2020Aug 16].
10. Almeida MM, Monteiro KJL, Bacelar PAA, Santos JPD, Freitas SPC, Evangelista BBC, *et al.* Interactions between malnutrition, soil-transmitted helminthiasis and poverty among children living in periurban communities in Maranhao State, Northeastern Brazil. *Rev Inst Med Trop Sao Paulo* 2020;62:e73.
11. Djuardi Y, Lazarus G, Stefanie D, Fahmida U, Ariawan I, Supali T. Soil-transmitted helminth infection, anemia, and malnutrition among preschool-age children in Nangapanda subdistrict, Indonesia. *PLoS Negl Trop Dis* 2021;15:e0009506.
12. Calegar DA, Bacelar PA, Monteiro KJL, Dos Santos JP, Gonçalves AB, Boia MN, *et al.* A community-based, cross-sectional study to assess interactions between income, nutritional status and enteric parasitism in two Brazilian cities: Are we moving positively towards 2030? *J Health Popul Nutr* 2021;40:26.

13. Chomicz L, Conn DB, Szaflik JP, Szostakowska B. Newly emerging parasitic threats for human health: National and international trends. *Biomed Res Int* 2016;2016:4283270.
14. Awasthi S, Pande VK. Prevalence of malnutrition and intestinal parasites in preschool slum children in Lucknow. *Indian Pediatr* 1997;34:599-605.
15. Ihejirika OC, Nwaorgu OC, Ehirim CI, Nwokeji CM. Effects of intestinal parasitic infections on nutritional status of primary children in Imo State Nigeria. *Pan Afr Med J* 2019;33:34.
16. Amare B, Ali J, Moges B, Yismaw G, Belyhun Y, Gebretsadik S, *et al.* Nutritional status, intestinal parasite infection and allergy among school children in northwest Ethiopia. *BMC Pediatr* 2013;13:7.
17. Hailegebriel T. Undernutrition, intestinal parasitic infection and associated risk factors among selected primary school children in Bahir Dar, Ethiopia. *BMC Infect Dis* 2018;18:394.
18. Feleke BE. Nutritional status and intestinal parasite in school age children: A comparative cross-sectional study. *Int J Pediatr* 2016;2016:1962128.
19. Habib A, Andrianonimiadana L, Rakotondrainipiana M, Andriantsalama P, Randriamparany R, Randremanana RV, *et al.* High prevalence of intestinal parasite infestations among stunted and control children aged 2 to 5 years old in two neighborhoods of Antananarivo, Madagascar. *PLoS Negl Trop Dis* 2021;15:e0009333.
20. Yones DA, Galal LA, Abdallah AM, Zaghlol KS. Effect of enteric parasitic infection on serum trace elements and nutritional status in upper Egyptian children. *Trop Parasitol* 2015;5:29-35.
21. Osman KA, Zinsstag J, Tschopp R, Schelling E, Hattendorf J, Umer A, *et al.* Nutritional status and intestinal parasites among young children from pastoralist communities of the Ethiopian Somali region. *Matern Child Nutr* 2020;16:e12955.
22. Jayaram S, Saya GK, Rajkumari N, Ulaganeethi R, Roy PK, Mathavaswami V. Prevalence of intestinal parasitic infection and its associated factors among children in Puducherry, South India: A community-based study. *J Parasit Dis* 2021;45:897-902.
23. Yoseph A, Beyene H. The high prevalence of intestinal parasitic infections is associated with stunting among children aged 6-59 months in Boricha Woreda, Southern Ethiopia: A cross-sectional study. *BMC Public Health* 2020;20:1270.
24. Zonta ML, Cociancic P, Oyhenart EE, Navone GT. Intestinal parasitosis, undernutrition and socio-environmental factors in schoolchildren from Clorinda Formosa, Argentina. *Rev Salud Publica (Bogota)* 2019;21:224-31.
25. Mulatu G, Zeynudin A, Zemene E, Debalke S, Beyene G. Intestinal parasitic infections among children under five years of age presenting with diarrhoeal diseases to two public health facilities in Hawassa, South Ethiopia. *Infect Dis Poverty* 2015;4:49.
26. Mekonnen Z, Hassen D, Debalke S, Tiruneh A, Asres Y, Chelkeba L, *et al.* Soil-transmitted helminth infections and nutritional status of school children in government elementary schools in Jimma Town, Southwestern Ethiopia. *SAGE Open Med* 2020;8. doi: 10.1177/2050312120954696.
27. Bechir M, Schelling E, Hamit MA, Tanner M, Zinsstag J. Parasitic infections, anemia and malnutrition among rural settled and mobile pastoralist mothers and their children in Chad. *Ecohealth* 2012;9:122-31.
28. Rijal B, Oda Y, Basnet R, Rijal B, Parajuli K, Gurung CK, *et al.* Gender variations in the prevalence of parasitic infections and the level of awareness in adolescents in rural Nepal. *Southeast Asian J Trop Med Public Health* 2001;32:575-80.
29. Hotez PJ, Brooker S, Bethony JM, Bottazzi ME, Loukas A, Xiao S. Hookworm infection. *N Engl J Med* 2004;351:799-807.
30. Deka S, Barua D, Bahurupi Y, Kalita D. Assessment of the prevalence of soil-transmitted helminth infections and associated risk factors among school-aged children in a flood affected area of Northeast India. *Am J Trop Med Hyg* 2021;105:480-9.
31. Okyay P, Ertug S, Gultekin B, Onen O, Beser E. Intestinal parasites prevalence and related factors in school children, A western city sample--Turkey. *BMC Public Health* 2004;4:64.
32. Elmonir W, Elaadli H, Amer A, El-Sharkawy H, Bessat M, Mahmoud SF, *et al.* Prevalence of intestinal parasitic infections and their associated risk factors among preschool and school children in Egypt. *PLoS One* 2021;16:e0258037.
33. Bundy DA, Medley GF. Immuno-epidemiology of human geohelminthiasis: Ecological and immunological determinants of worm burden. *Parasitology* 1992;104 (Suppl):S105-19.