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INTESTINAL PARASITIC INFECTION IN RELATION TO BODY MASS INDEX IN SCHOOL CHILDREN WITH SPECIAL REFERENCE TO TAENIID CESTODES

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Abstract

Background: Infections with intestinal parasites continue to pose serious threats to global public health, particularly in underdeveloped nations. The health of people is negatively impacted by these parasite infections, particularly that of young children**.**

Objective: To calculate the relationship between intestinal helminth infection and body mass index (BMI) status of school children between 5 and 12 years of age in district Lower Dir, Pakistan.

Methodology: Fecal materials were collected from different government schools of both the genders. Four hundred stool samples were examined for the evidence of eggs of various intestinal helminths under the microscope at the Parasitology Laboratory. Body mass index was taken into account and correlated by standard percentile charts for gender and age.

Results: Four hundred students in all took part in the study, with 72.25% of the participants being male and 58.55% of the participants being female. With a prevalence of 33.1% in both sexes, *Ascaris lumbcoides* had the highest prevalence, followed by *Taenia saginata* (22.64%), and *Schistosoma japonicum* (0.34%) in the male population. Of the examined children 71.75% (n=287) children were found infected with various types of IPIs infection. Out of the 400, 241(83.97%) show low, 45 (15.67%) with normal and 1(0.34%) with high body mass index (P>0.005). Intestinal nematodes and cestodes parasitic infection and body mass index relationship (P>0.05). Intestinal parasite infection was not significantly correlated with the parameters, such as weight for age, height for age, and weight for height (P = 0.005).The presence of parasitic infections decreases the body mass index in the study region of Lower Dir.

Conclusions: It is concluded that intestinal parasitic infection play an important role in reducing anthropometric quantity of school-age children.

Keywords: Pre-school children, Intestinal parasites, Helminthes, Cryptosporidium, *Ascaris lumbricoides*

INTRODUCTION

Children's health in Africa is severely troubled by intestinal parasite infection. Globally, it was predicted that 5.3 billion individuals were at risk of parasitic diseases, including 1 billion school-age children. In sub-Saharan Africa, parasites pose a serious public health risk because of unsanitary living conditions, a tropical environment, illiteracy, a shortage of portable drinking water, and poverty. Approximately 69% of the risk population lives in Asia (Pullan and Broker, 2010). *Ascaris lumbricoides, Ancylostoma duodenale, Taenia Saginata* and *Trichuris trichiura* are the most common parasites found in human intestines. Among the Cestoda ,Taenia species are distinctive in that their life cycles and transmission depend on two different mammalian hosts. In the carnivore, the cestode grows to maturity and releases fertilized eggs (Hoberg *et al*., 2006). Taenia has the ability to tropically infect people if they mistakenly consume eggs or larvae stages in undercooked meat. Humans have been found to harbor the Taenia species *T. saginata* Goeze, 1782, *T. asiatica* Eom & Rim, 1993, and *T. solium* Linnaeus, 1758. *T. taenia eformis* (Batsch, 1786) *T. crassiceps* (Zeder, 1800) T. multiceps Leske, 1780 T. serialis (Gervais, 1847) are zoonotic species are also present in humans. Taenia species infection causes severe health problems as well as significant socioeconomic losses in both humans and livestock (Murell *et al*., 2006). Taeniasis in humans is spread through improperly cooked beef (*T. saginata*) or pork (*T. solium* and *T. asiatica*). In locations where it is prevalent, human neurocysticercosis—the most pervasive helminth infection of the central nervous system in humans—has a significant financial impact. Both adult and larval forms (of several species) can infect people and cause either taeniosis or cysticercosis. Transmission from host to host happens via ingestion and follows a trophic pathway, as it does with all tapeworm species.

Anemia, vitamin A deficiency, malnutrition, intestinal obstruction, stunted growth, and developmental delays can all result from parasitic infections (WHO, 2013). School-aged children are especially exposed to parasitic infections. Only when they are physically and mentally healthy will they be able to receive a proper education. A child's nutritional status is an significant indicator of his or her entire health (Prentice 1993) .The best overall indicator of a child's wellbeing is growth (Assis *et al* .,2004). School age is the most active period of children (Kuczmarski *et al* 2000). The risk factors for a child's growth to be irregular include inadequate nutritional intake, poor hygiene, and recurrent parasitic infectious disease. In primary school students, severe undernutrition has been linked to slower mental development, health complications, and a lower quality of life (Waterlow *et al*.,1977). Due to insufficient food consumption and, most significantly, intestinal parasite infections, malnutrition is a prevalent health issue among African schoolchildren (Walker *et al*., 1997). In order to determine the prevalence of undernourishment and the contribution of intestinal parasite infection to health conditions, the anthropometric index is used.

When certain essential nutrients are either insufficient or inequitably distributed in a children diet, malnutrition results (Blossner *et al*., 2005). According to WHO , who predicted that 29% of malnourished children from developing countries will have stunted development owing to poor nutrition in 2015, malnourished children are easily irritated, lose focus easily, and fail to grow to their needed height. However, a variety of causes, including poor dietary quality, insufficient food intake, severe and recurrent viral infections, or commonly a combination of the three, can result in malnutrition in children (WHO , 2005)

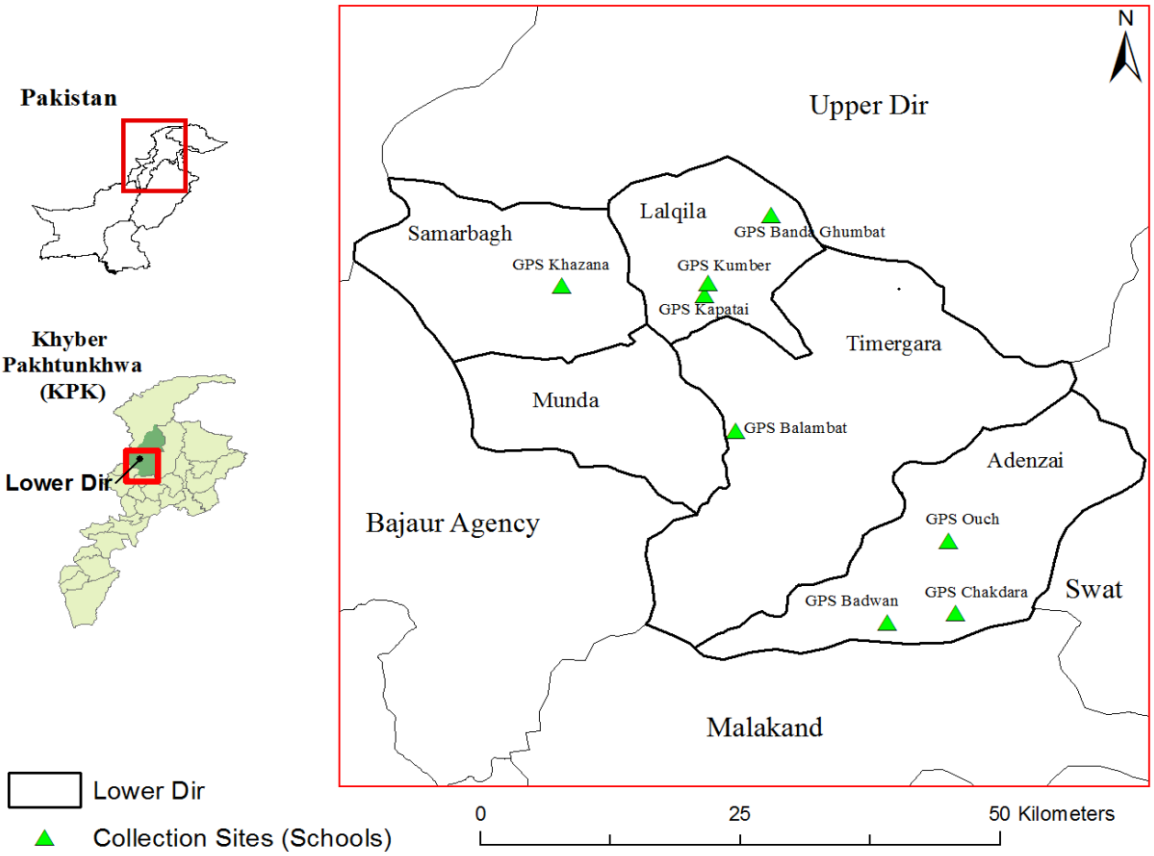
Several studies (Khan *et al.*, 2011; Noor un Nisa *et al*., 2012; Khan *et al*., 2014; Khan *et al*., 2015; Khan *et al*., 2016; Khan *et al*., 2017a;b; Khan *et al*., 2018a;b;c;d; Khan *et al*., 2019a;b; Arshad *et al.*, 2019; Khan *et al.*, 2020; Khan *et al*. 2021a;b; Rahman *et al.*, 2021; Ulhaq *et al*., 2021; Iqbal et al., 2021; Garedaghi et al., 2021; Khan *et al*., 2022, Rahman *et al.*, 2022; Subhan et al., 2023; Khan et al., 2023) have been documented on the prevalence of intestinal parasitic infections among various population of human beings in the study area but no such study was found on the association of IPIs

and BMI, it was therefore the present survey was considered to examined the incidence of IPIs infections in school age children and their relationship with BMI.

MATERIALS AND METHODS

Study Area

Lower District Dir is located at 34.9161N and 71.8097 E. Lower Dir District is located in Khyber Pakhtunkhwa province, 124 kilometers from Peshawar. The total area is 1583 km^2. Roughly 1435917 inhabitants which comprise of 49% male and 51% female population .The total 910 people per km^2 was the population density. The average annual rainfall is 723mm, and the average annual temperature is 20C.The coldest month of the year is January, and the hottest is June, with temperatures of 8.3 C° and 42C°, respectively (Khan *et al* .,2018c).



Study areas of the research region in lower Dir (Khyber, Pakhtunkhwa), as depicted on a GIS map, are displayed in Figure 1.

Data collection

Data for the current study were collected from a variety of Lower Dir Pakistani school children. Only children aged from 5 to 12 were chosen to define the properties of parasite infection and disease lower their health. Most of the children are from lower socioeconomic backgrounds and have challenges with poverty. In addition to precise information for a family and child, such as water source, toilet facility availability, child training, and personal hygiene, a survey was created to collect socioeconomic data, including name, gender, age, presence of animals, family members, and residential area, among other things. The BMI for age percentiles charts were displayed using Charts showing age percentiles for BMI are standard by the WHO.

$$\text{BMI} = \text{weight in kilograms} / \text{height in metres}^2$$

Weight in kilogrammes (kg) divided by height in metres (m) square are the formula for BMI. In order to determine socioeconomic status, a self-made questionnaire was used. It asked questions about the parents' education levels, their sources of profits, the number of children, the presence and kinds of animals and pets, the inhabited part, the approximate family monthly income in rupees, the number of family members overall, and whether or not toilet facilities were available at the household level.

Sample examination

To check for adult intestinal parasites (worms), blood, mucus, and other substances, the stool was macroscopically inspected. The faeces samples were scrutinized under a microscope using the saline and iodine mount method. The egg, cyst or larvae of intestinal parasites were further recognized using the Formalin ethyl acetate stool concentration technique .The cyst, larvae or egg, of intestinal parasites were further recognized by means of the Formalin ethyl acetate stool concentration technique.

Nutritional status determination

An electric weighing scale and a measuring tape were used to get each student's body weight and height measurements, which were then used to determine anthropometric indicators (BMI).

Statistical analysis

In order to define the differences in infection incidence between sexes and ages as well as the connection between intestinal parasite infectiousness and BMI, the graphPad version 5 was used.

RESULTS

A total of 400 students participated in the study, of which 289 (72.25%) are males with infection rates of 77.81% while 111 (27.75%) are females with infection 58.55%. The total prevalence of *Ascaris lumbcoides* 33.1% in both genders had the highest prevalence, followed by *Taenia saginata* (22.64%), and *Schistosoma japonicum* (0.34%) in the population (Table 1). A total of 83.97% of the infected children have lower BMIs, 15.67% have normal BMIs, and just 0.34% have BMIs above normal (Table 2). In study area, the incidence of parasite diseases reduces the body mass index experimentally. The majority of unaffected children (26.54%) have normal BMI, followed by 70.79% who have BMIs below average and 2.65% who have BMIs over average (Figure 1).(n=287/400) .The total prevalence of intestinal parasites was 71.75%.The association of the intestinal parasitic infection with BMI was found significant (P >0.003) at 95% confidence of interval.

The most common parasite was *Ascaris lumbricoides* (29.04%) afterward *T.saginata* (24.89%), hookworm, *(*19.91%), *H. nana* (21.99%) *Enterbious vermicularis* (0.82%), *H .diminuta* (1.24%), *Tricuris tricuris* (0.82%),*Taxocara spp* ,*Cryptosporidium* spp and *Schistosoma japanicum* were recorded (0.41%) (Table 3). The association of nematodes and cestodes with BMI was non-significant (P>0.005).

The normal weight and height of children were recorded at 79.79%, 52.96% respectively. Underweight and stunted height was 52.96% and 47.3% respectively (Table 3).All the factors i.e, weight for height, weight for age, and height for age were non-significantly associated with intestinal parasitic infection.

Table 1: Prevalence of intestinal parasites and sex distributions among primary school children

Parasite species	**Boys (N=289) (%)**	**Girls(N=111)(%)**	**Both sexes(N=400)(%)**
Ascaris lumbcoides	77(26.83)	18(6.27)	95(33.1)
Ancylostoma duodenale	41(14.28)	16(5.57)	57(19.86)
Enterobius **v***ermiculari*	3(1.04)	1(0.34)	4(1.39)
Trichuris trichura	3(1.04)	-	3(1.04)
Taxocara spp	1(0.34)	1(0.34)	2(0.69)
Taenia saginata	**48(16.72)**	**17(5.92)**	**65(22.64)**

Hymenolepis nana	45(15.67)	9(3.13)	54(18.81)
Hymenolepis diminuta	2(0.69)	2(0.69)	4(1.39)
Schistosoma japonicum	1(0.34)	-	1(0.34)
Cryptosporidium spp	1(0.34)	1(0.34)	2(0.69)
Overall prevalence	222(77.81)	65(58.55)	287(71.75)

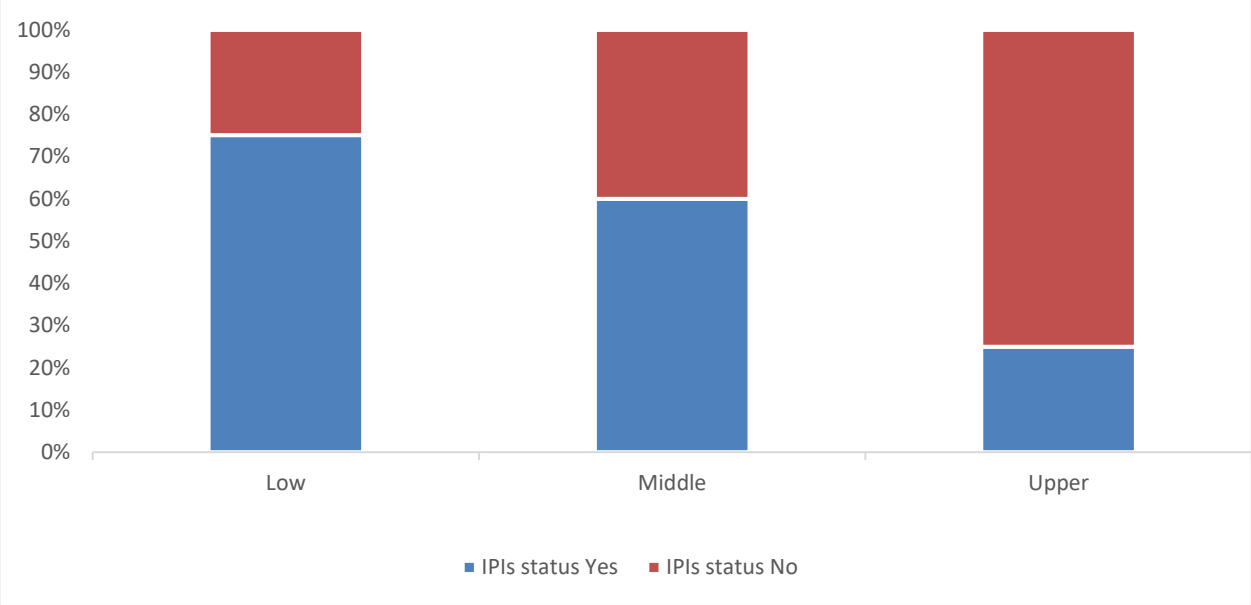


Figure 2 : Distribution of data according to the BMI status in children (n=number)

Table 2: BMI and parasitic infection

Name of Parasite	Low level	Normal level	Upper level	Total	X^2	P Value
Nematode						
Ascaris lumbcoides	70 (29.04%)	24 (53.33%)	1(100%)	95	5.37	0.71
Ancylostomaduodenale	48 (19.91%)	9 (20%)	0	57		
Enterobius vermiculari	2 (0.82%)	2 (4%)	0	4		
Trichuris trichura	2 (0.82%)	1 (2.22%)	0	3		
Taxocara spp	1 (0.41%)	1 (2.22%)	0	2		
Cestodes						
Taenia saginata	60 (24.89%)	5 (11.11%)	0	65	4.74	0.09
Hymenolepis nana	53 (21.99%)	1 (2.22%)	0	54		
Hymenolepis diminuta	3 (1.24%)	1 (2.22%)	0	4		
Trematoda						
Schistosoma japonicum	1 (0.41%)	0	0	1	NA	NA
Protozoans						
Cryptosporidium spp	1 (0.41%)	1 (2.22%)		2	NA	NA
Total No. of infection	241	45	1	287		

Table 3: Anthropometric measurements and parasitic infection

Parasitic infection		**NO**	**Yes**	**Total (n (%)**	**X^2**	**P Value**
Weight for age	Normal weight	113	116	229(79.79)	2.24	0.32
	Under weight	35	23	58(20.20)		
Height for age	Normal height	65	87	152(52.96)	4.68	0.09
	Stunted	75	60	135(47.03)		
Weight for height	No wasting	97	83	180(62.71)	7.19	0.02
	Wasting	59	48	107(37.28)		

DISCUSSION

The purpose of the current study was to understand intestinal parasite infection in schoolchildren in relation to their nutritional state, and focus on taeniid cestodes from the Malakand region of Pakistan. The total positive 71.75% (n=287) of the children who were examined for IPI infections were found to be infected. This was maximum as associated to the incidence of infection in a town in Budhni close to Peshawar, Pakistan (Ramana *et al*., 2012).

Taenia saginata was the most prevalent intestinal parasite identified in 22.6% (n=65) of the subjects in the current survey, which is comparable with studies 32.6% (Khan *et al.,* 2018b), 12.8% (Nisa *et al*., 2011), 16.7% (Khan *et al.,* 2015)) and 12.8% (Khan *et al* 2012) .These cestodes are propagated through the ingestion of undercooked beef, inadvertent ingestion of intermediate hosts, and the growth of the larval phases. The prevalence of the cestode parasitic infection is high in present study as compare to previous ones 9.98% (Khan *et al*., 2017a), 9.70% (Khan *et al.,* 2019), 9.52% (Khan *et al*., 2018b), 8.98% (Khan *et al*., 2017), 7.94% (Khan *et al*., 2019), and 7% (Khan *et al*., 2012). Compared to other research, the infection rate in district Swat was lower then study 32.6% (Khan *et al.,* 2018).The varying ecological, individual behaviors, cultural, and geographic constraints may be the cause of the changing prevalence of intestine pathogenic tapeworms in various locations. In low- and middle-income countries, including Pakistan, diseases brought on by tapeworms are a public health problem (Khan *et al.,* 2018).

According to (Khan *et al*.,2 018) *Hymenolepis nana* was the second most common species in cestodes (18.81%) (n=54), which is comparable to 10.1% in district Swat (Khan *et al*.,2012a). The current study is high when compare to study 10% (Khan *et al*.,2012), 9.36% (Khan *et al.,*2017a), 8.7% (Arshad *et al.,*2019), 8.09% (Anwar *et al*.,2018), and 6.78% (Khan *et al* .,2019) are a few of the percentages that have been noted .Bu study conducted in Lahore 27.8%(Ali *et al* .,2018) is higher than the present study .The overall prevalence of *H. diminuta* it the current study is 1.39 (n=4). In addition to being a common parasite of rats and mice, *H. diminuta* can also be discovered in youngsters. This may be because of contaminated food and water, children playing in dirty ground that might spread infection by mouth contact, or an infection brought on by unintentional flea (insect host) intake.

The prevalence of *A. lumbricoides* was 33.1% in the current study (n=95), making it the most prevalent nematode parasite. The current study is comparable with study in District Swat 39.8% (Khan *et al*., 2015), 31.7%, Khan *et al*.,2019b) ,31.7% (Khan *et al*., 2011) and 30.1% (Nisa *et al*., 2011). But the current study is lower than study conducted in Swat district, 66.4%(Khan *et al* .,2019b), 55.8% in Swat (Khan *et al* ., 2017a) ,53.0% (Khan *et al* .,2017b) ,39.9% (Khan *et al.,* 2011), and 39.8%, (Khan *et al* .,2015) in district Swat. However, the current prevalence rate is high when compare to 20.3% in Swat (Khan *et al*., 2018a), 17% (Khan *et al*.,2018b) .

The prevalence of *ankylostoma duodenale* in the current study is 19.86%. This nematode infection is almost identical to those reported in Lower , Upper Dir and district Swat 20% (Khan *et al*., 2019a) , 6.91% (Khan *et al.,* 2018) ,6.45%, (Khan *et al*., 2017), and 5.79% (Khan *et al*., 2017). The infection rate was higher than that reported in other studies, including 3.64% in district Swat (Khan *et al* ., 2015), 2.90% in Swat (Khan *et al*., 2018), 3.96% in Swat (Khan *et al.,* 2018), 1.08% in Swat (Khan *et al*., 2019), and 33.4% in Swat (Nisa *et al*., 2011).The current study is lower hen studies conducted in lower Dir 53.0% (Khan *et al*., 2017b) .Only 41.7% of people in Punjab were infected, according to a research conducted by (Dar *et al.,* 2013).

The current study found that *E. vermicularis* was more common (1.39%) among children in district lower Dir. Children's with *E. vermicularis* infection is lower 10.3% (Nisa *et al* .,2011), 10.7% (Khan *et al* , 2011), 8.25%(Khan *et al* .,2012a), 12%(Khan *et al*., 2012b), 8.25% (Khan *et al.,*2015), 9.73% (Khan *et al*.,2017a), 14.4%(Khan *et al.,* 2017b), 9.52% (Khan *et al* .,2018b), 6.48% (Khan *et al*.,2018a), and 5.05% (Khan *et al*.,2019a), .Due to the infection's high transmission potential, *E. vermicularis* prevalence in youngsters in the Lower Dir district is significant and not negligible.

The prevalence of *Trichuris trichiura* is currently 1.04%. This is comparable with 1.3% in Quetta (Arshad *et al*., 2019) and 0.42% in Lahore (Anwar *et al*., 2018).The incidence rate of the current

survey is minimum after linked with, 26.2% Swat (Khan *et al.,* 2017), 19.1% Swat (Khan *et al*., 2012), 19.1% in Swat (Khan *et al*., 2015), 14.9% Swat (Khan *et al*., 2015), 14.3% Swat (Khan *et al.,* 2018), and 8.30% in Swat (Khan *et al*., 2019).

Intestinal protozoan parasites known as Cryptosporidium spp which infect both humans and animals worldwide. Cryptosporidium have been found in human blood, *with C. parvum* and *C. hominis* being the maximum prevalent (Ryan and Xiao, 2014). Since infection can occur after contact to a tiny number of Cryptosporidium oocysts, it poses significant dangers to the children health (Gatei *et al.,* 2006). A self-limiting diarrheal illness is brought on by cryptosporidium infection in healthy people (Hunter *et al*., 2004).Two schoolchildren (0.69%) were found to have cryptosporidium oocysts, however there is no information available that shows infection rates lower than the 0.69% currently reported. The current study lower then studies conducted in *Cryptosporidium spp* was recorded as 83.8% (Mumtaz *et al*., 2009), 6.66%(Ayaz *et al*., 2013), , 14.66% (Akbar *et al* .,2015), 7.84% (Alam *et al* .,2014), 21.40% (Saleem *et al* .,2017). The occurrence of *C. parvum* in young offspring (aged 5 to 12 years) was examined in the current study by looking at both asymptomatic and symptomatic school children in different geographic areas of district lower Dir.

Schistosoma japonicum is uncommonly prevalent in urban District Lower Dir, with a prevalence of 0.34% (287), which is less than that discovered in other studies carried out in different regions of Pakistan. Students in schools who have come into contact with eggs, oocysts, or cysts through contaminated water or food, hands, breathing in contaminated air, or skin contact with larvae (Lee *et al*., 2010).

The goal of the present study was to determine how many infections in school children had and how those infections affected their BMI. Anthropometric measurements were taken of each Participant height, weight, and body mass index (BMI) using a conventional weight machine. The results were created using the WHO standard BMI for age percentile graphs to take into account the different nutritional statuses of boys and girls. The Body Mass Index was computed using the WHO standard methodology for each age group. The current study targeted school children of lower Dir Malakand region, Pakistan where 83.96% had BMIs below the average, 15.67% had normal BMIs, and only 0.34% had BMIs above the average. Infection of parasites in the Malakand region extremely have lower BMI. The majority of uninfected children (26.54%) had normal BMIs, compared to 70.79% who have lower BMIs and 2.65% who have higher BMIs. Compared to an Islamabad research, 57.24% of infected children had lower BMIs, 41.4% had normal BMIs, and only 1.4% had BMIs that were above average. Infections with parasites result in considerable loss of body mass

CONCLUSIONS

It was discovered that Lower Dir Malakand region, Pakistan had the highest rate of helminthic infections among schoolchildren. The community health problem designate to shows for the healthy growth and development of children**.** We recommend including the general population in health programs to regulate intestinal parasite infection.

Conflict of interest

No conflict of interest was found among the authors for this publication

Founding sources

For this investigation, there was no accessible money.

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REFERENCES

1. Arshad, S., Khatoon, N., Warind, J.A., Khan, A., Waheed, S. and Khan, W., 2019. The prevalence of human intestinal protozoal and helminthic infection in Karachi. *International Journal of Biology and Biotechnology*, *16*(2):.319-323.
2. Assis AM, Prado MS, Barreto ML, et al. Childhood stunting in Northeast Brazil: the role of Schistosoma mansoni infection and inadequate dietary intake. Eur J Clin Nutr. 2004;58 (7):1022–1029.
3. Blossner, M, Mercedes De Onis, Pruss Ustun, et al. Malnutrition: quantifying the health impact at national and local levels. Geneva, world health organization. geneva : world health organization; 2005. 43 p. 13.
4. Carabin H, Budke C, Cowan L, Willingham A, Torgerson P: 2005 Methods for assessing the burden of parasitic zoonoses: echinococcosis and cysticercosis. Trends Parasitol, 21:327-333.
5. Crompton DWT, Nesheim MC. Nutritional Impact of intestina helminthiasis during the human life cycle. Annu Rev Nutr. 2002;22:35–59.
6. Dar, U.F., Iqbal, M.S., Latif, M.Z., Javaid, M.S., Nayyar, U. and Nizami, R., 2013. Worm infestation among children of rural area of central Punjab. PJMHS, vol. 7, no. 3, pp. 713-715.
7. García HH, Evans CA, Nash TE, Takayanagui OM, White AC Jr, Botero D, Rajshekhar V, Tsang VC, Schantz PM, Allan JC, Flisser A, Correa D, Sarti E, Friedland JS, Martinez SM, Gonzalez AE, Gilman RH, Del Brutto OH: 2002. Current consensus guidelines for treatment of neurocysticercosis. Clin Microbiol Rev, 15:747-756.
8. Garedaghi, Y., Sperança, M.A., Ghimire, T.R. and Khan, W., 2021. Drug Treatment of Hydatid Cyst With Albendazole and Praziquantel in Humans. *Int J Med Parasitol Epidemiol Sci Volume*, *2*(3), p.63.
9. Hakeem R, Shaikh AH, Asar F. Assessment of linear growth of affluent urban Pakistani adolescents according to CDC 2000 references. Ann Hum Biol. 2004;31(3):282–291.
10. Hoberg EP: 2006 Phylogeny of Taenia: species definitions and origins of human parasites. Parasitol Int, 55:S23-S30.
11. Hotez PJ: 2009.One world health: neglected tropical diseases in a flat world. PLoS Negl Trop Dis, 3:e405
12. Hunter, P.R., Hughes, S., Woodhouse, S., Nicholas, R., Syed, Q., Chalmers, R.M., Verlander, N.Q. and Goodacre, J., 2004. Health sequelae of human cryptosporidiosis in immunocompetent patients. Clinical Infectious Diseases, vol. 39, no. 4, pp. 504-510.
13. Iqbal, M., Khan, W., Khan, M.F. and Khan, I., 2021. Albendazole and mebendazole in the treatment of ancylostomiasis in school children between the ages of 6-15 in Swat, Pakistan. *JPMA. The Journal of the Pakistan Medical Association*, *71*(8), pp.2058-2060.
14. Khan, W. .Khan, N. Khan, R. Iqbal, A .Ullah, R. Ghaffar, S.A .Mehmood, S .Ahmad, S. Khan, and F. Ullah,.2019b. Soil-transmitted helminth infections in school children of three districts of Malakand region, Khyber Pakhtunkhwa, Pakistan. Pak. J. Pharm. Sci., Vol.32, No.2 (Suppl), pp.799-803 *ol. 51(2), pp 797-799*, 20, 201.
15. Khan, W. and Khan, A., 2015. Diversity of intestinal parasites in male and female students and workers of Education Department of Swat, Pakistan. *Pakistan Journal of Zoology*, *47*(2).
16. Khan, W. and Khan, A., 2017b. Soil transmitted helminthiasis in different occupational groups in Swat, Khyber Pakhtunkhwa, Pakistan. *Pakistan Journal of Pharmaceutical Sciences*, *30*(4), pp.1345-1351
17. Khan, W. and Khan, A., 2018b. Prevalence of Potentially Important Intestinal Pathogenic Protozoan Parasitic Infections in Different Occupational Groups of Swat, Pakistan. *Pakistan Journal of Zoology*, *50*(1).
18. Khan, W. and Nawaz, M.A., 2018d. Incidence of tapeworm infection in human population of Swat, Pakistan: an occupation based study. *Pakistan Journal of Zoology*, *50*(2), pp.639-639.

19. Khan, W., Arshad, S., Khatoon, N., Khan, I., Ahmad, N., Kamal, M., Ul Hassan, H., Khan, N., Haq, A.U., Ilyas, M. and Ullah, S., 2021a. Food handlers: an important reservoir of protozoans and helminth parasites of public health importance. *Brazilian Journal of Biology*, *82*.
20. Khan, W., Fadladdin, Y.A.J., Rafiq, N., Naz, R., los Rios-Escalante, D., Patricio, R., Ahmad, S., Alrobaish, S.A. and Al-Sowayan, N.S., 2023. Toxoplasmosis—Awareness and Knowledge of Pregnant Women in Rural Areas of Malakand Region, Pakistan. *Journal of Parasitology Research*, *2023*.
21. Khan, W., Gul, S., Gul, M. and Kamal, M., 2018c. Prevalence of parasitic infestation in domestic pigeons at Malakand region, Khyber Pakhtunkhwa, Pakistan. *International Journal of Biosciences*, *12*(4), pp.1-7.
22. Khan, W., Imran, A .Wahab, Intestinal Obstruction by *Ascaris lumbricoides* in a 12 year Old Boy: A Case Report in Pakistan. J Bacteriol Parasitol 7: 262. doi:10.4172/21559597.1000262, 201.
23. Khan, W., Iqbal, M. and Khan, I., 2019c. Albendazole in the treatment of ancylostomiasis, ascariasis, taeniasis and amoebiasis in school children. *Pakistan Journal of Zoology*, *51*(4), p.1587.
24. Khan, W., Khan, J., Ur Rahman, A., Ullah, H., Salim, M., Iqbal, M., Khan, I., Salman, M. and Munir, B., 2018a. Albendazole in the treatment of Hymenolepiasis in school children. *Pakistan Journal of Pharmaceutical Sciences*, *31*.
25. Khan, W., Nisa, N.U., Khan, A. and Naqvi, S.M.H.M., 2012. Endemicity of intestinal parasites with special reference to nematodes in individuals related to education (students, staff & workers) in Swat KP, Pakistan. *Pak J Nematol*, *30*(1), pp.77-85.
26. Khan, W., NOOR-UN-NISA and KHAN, A., 2017a. Prevalence and risk factors associated with intestinal parasitic infections among food handlers of swat, Khyber Pakhtunkhwa, Pakistan. *Journal of Food and Nutrition Research*, *5*(5), pp.331-336.
27. Khan, W., Panhwar, W.A., Mehmood, S.A., Ahmed, S., Ahmed, M.S., Khan, N., Khan, M.M., Akram, W. and Ullah, S., 2021b. Pinworm infection in school children of four districts of Malakand region, Khyber Pakhtunkhwa, Pakistan. *Brazilian Journal of Biology*, *82*, p.e238769.
28. Khan, W., Panhwar, W.A., Mehmood, S.A., Ahmed, S., Ahmed, M.S., Khan, N., Khan, M.M., Akram, W. and Ullah, S., 2021. Pinworm infection in school children of four districts of Malakand region, Khyber Pakhtunkhwa, Pakistan. *Brazilian Journal of Biology*, *82*.
29. Khan, W., Rahman, H., Rafiq, N., Kabir, M., Ahmed, M.S. and Escalante, P.D.L.R., 2022. Risk factors associated with intestinal pathogenic parasites in schoolchildren. *Saudi Journal of Biological Sciences*, *29*(4), pp.2782-2786..
30. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the united states: methods and development. Vital Health Stat. 2002;11(246):1–190.
31. Lee, A.C., Montgomery, S.P., Theis, J.H., Blagburn, B.L. and Eberhard, M.L., 2010. Public health issues concerning the widespread distribution of canine heartworm disease. Trends in Parasitology, vol. 26, no. 4, pp. 168-173. http://dx.doi. org/10.1016/j.pt.2010.01.003. PMid:20181530.
32. Murell KD: 2005 Epidemiology of taeniosis and cysticercosis. WHO/FAO/OIE Guidelines for the Surveillance, Prevention and Control of Taeniosis/ Cysticercosis Paris: OIEMurell KD, 27-44.
33. Noor-Un-Nisa, W.K. and Khan, A., 2014. A Case of Fasciola hepatica Infection in Swat Pakistan. *Pakistan Journal of Zoology*, *46*(6).
34. Onis Mde, Frongillo EA, Blossner M. Is malnutrition declining? An analysis of change in levels of child malnutrition since 1980. Bull World Health Organ. 2000;78(10):1222–1223.
35. Prentice A. Nutritional requirements for growth, pregnancy and lactation: the keneba experience. South African Journal of Clinical Nutrition. 1993;6:33–38.

36. Quihui Cota L, Valencia M, Crompton D, et al. Prevalence and intensity of intestinal parasitic infections in relation to nutritional status in Mexican schoolchildren. Trans R Soc Trop Med Hyg. 2004;98(11):653–659.
37. Rahman, H.U., Khan, W., Mehmood, S.A., Ahmed, S., Yasmin, S., Ahmad, W., Haq, Z.U., Shah, M.I.A., Khan, R., Ahmad, U. and Khan, A.A., 2021. Prevalence of cestodes infection among school children of urban parts of Lower Dir district, Pakistan. *Brazilian Journal of Biology*, *82*.
38. Rahman, H.U., Khatoon, N., Arshad, S., Masood, Z., Ahmad, B., Khan, W., Rafiq, N., Khan, M.I., Kabir, M., Haq, Z.U. and Kamal, I., 2022. Prevalence of intestinal nematodes infection in school children of urban areas of district Lower Dir, Pakistan. *Brazilian Journal of Biology*, *82*.
39. Ramana, K., 2012. Intestinal parasitic infections: An overview. *Annals of Tropical Medicine and Public Health*, *5*(4), p.279.
40. Ryan, U. and Xiao, L., 2014. Taxonomy and molecular taxonomy. In: S. CACCIÒ and G. WIDMER, eds. Cryptosporidium: parasite and disease. Vienna: Springer, pp. 3-41. http://dx.doi. org/10.1007/978-3-7091-1562-6_1.
41. Shakoor, M.A., Khan, I.A., Ahmed, H., Safdar, M., Ahmed, Z. and Afreen, A., 2018. Prevalence of Worm Infection in Relation to Body Mass Index in Children of 5-10 Yrs of Age in Tehsil Narowal, Pakistan.
42. Subhan, F., Khan, W., Rahman, H.U., Ahmed, S., Mehmood, S.A., Garedaghi, Y. and Fadladdin, Y.A.J., 2023. Prevalence of Intestinal Parasitic Infection Among School Children of Bajawar, Pakistan. *Int J Med Parasitol Epidemiol Sci Volume*, *4*(1), p.20.
43. Tsuyuoka R, Bailey JW, Nery Guimaraes AM, et al. Anaemia and intestinal parasitic infections in primary school students in Aracaju, Sergipe, Brazil. Cad Saude Publica. 1999;15(2):413–421.
44. Ulhaq, Z., Khan, W., Khan, M.F., Kabir, M., Ujjan, A.A., Ullah, W., Masood, Z., Khan, S. and De los Ríos Escalante, P., 2021. Prevalence of intestinal parasitic diseases in school children of rural areas of district Lower Dir, Pakistan. *Brazilian Journal of Biology*, *82*.
45. Wali, K. and Aly, K., 2011. An investigation on incidence of intestinal parasites in under and above 15 years age in farmers of SWAT, Pakistan. *Proceedings of Parasitology*, (52), pp.43-53.
46. Wali, K.H.A.N., Iqbal, M. and Omer, D.A.D., 2020. Have we forgotten the threat posed by fascioliasis? A potential threat to public health. *Iranian Journal of Public Health*, *49*(4), p.814.
47. Wali, K.H.A.N., Khan, N.I., Bukhari, S.N.F. and Begum, N., 2019a. Prevalence of intestinal parasitic infection among drug addicts in District Swat, Khyber Pakhtunkhwa, Pakistan. *Iranian journal of parasitology*, *14*(2), pp.359-361.
48. Walker A, Walker B. Moderate to mild malnutrition in African children of 10-12 years: roles of dietary and non-dietary factors. Int J Food Sci Nutr. 1997;48(2):95–101
49. Waterlow IC, Buzina R, Keller W, et al. The presentation and use of height and weight data for comparing the nutritional status of groups of children under the age of 10 years. Bull World Health Organ. 1977;55(4):489–498.
50. World Health Organization, 2013. *Sustaining the drive to overcome the global impact of neglected tropical diseases: second WHO report on neglected diseases* (No. WHO/HTM /NTD/2013.1). World Health Organization.
51. World health organization. 2005.Prevention and control of schistosomiasis and soil-transmitted helminthiasis. World Health Organ Tech Rep Ser.;912(i-vi):1–57.