

OR 1685

Parasitic infections, malnutrition and anemia among preschool children living in rural areas of Peshawar, Pakistan

Infecciones parasitarias, desnutrición y anemia en niños en edad preescolar que viven en áreas rurales de Peshawar, Pakistán

Zia ud Din¹, Lubna Pervez¹, Arshad Amir², Muhammad Abbas¹, Imran Khan¹, Zafar Iqbal³ and Mudassar Iqbal³

Departments of ¹Human Nutrition and ³Agricultural Chemistry. University of Agriculture. Peshawar, Pakistan. ²Department of Health. Government of KPK. Pakistan

Received: 20/11/2017

Accepted: 02/06/2018

Correspondence: Zia ud Din. Department of Human Nutrition. University of Agriculture. xx

e-mail: ziaud.din@au.p.edu.pk

DOI: 10.20960/nh.1685

ABSTRACT

Introduction: it has previously been shown that parasitic infections (PI) have deleterious effects on the nutritional status of the host, particularly among young children.

Objective: the objective of this study was to estimate the severity of the problem of malnutrition and anemia in association with PI in preschool children and to identify the possible risk factors that contribute to these health problems.

Methods: four hundred and thirty-seven mother-child pairs were randomly selected from rural areas of Peshawar, Pakistan. Children with visible and invisible worms were identified. The nutritional status of the respondents was evaluated. Structured

questionnaires were used to collect data on relevant parameters. Appropriate statistical tests were used to analyze the data.

Results: the average age of the children was 24 ± 10 months. A total of 120 (27.5%) fecal samples of children tested positive for several parasites. Of the total, 267 (61%), 205 (47%), 109 (25%) and 140 (32%) children were anemic, stunted, wasted and underweight, respectively. The majority of wasted children (59% wasted *versus* 41% normal) and anemic (66% anemic *versus* 34% non-anemic) were infected with parasites ($p < 0.05$). Independent factors related to child anemia included child age, family size, mothers' awareness of overall child healthcare, and PIs. PIs were independent risk factors for malnutrition and general child wasting. Sociodemographic, parental and child-related risk factors for PIs included mothers' poor nutritional status and awareness level regarding overall child healthcare, fathers' formal education, child's pica habit, child's age, open sewage system in the houses and family size.

Conclusion: in general, malnutrition and anemia were highly prevalent in children in association with PI.

Key words: Intestinal parasitic infection. Malnutrition. Anemia. Preschool children.

RESUMEN

Introducción: se ha demostrado previamente que las infecciones parasitarias (PI) tienen efectos nocivos sobre el estado nutricional del huésped, particularmente entre los niños pequeños.

Objetivo: el presente estudio tuvo como objetivo estimar la gravedad del problema de desnutrición y anemia en asociación con IP en niños en edad preescolar e identificar los posibles factores de riesgo que contribuyen a estos problemas de salud.

Métodos: se seleccionaron al azar 437 parejas madre-hijo de zonas rurales de Peshawar, Pakistán. Se identificaron niños con gusanos visibles y no visibles. Se evaluó el estado nutricional de los encuestados. Se usaron cuestionarios estructurados para recopilar datos sobre parámetros relevantes y pruebas estadísticas apropiadas para analizar los datos.

Resultados: la edad promedio de los niños fue de 24 ± 10 meses. Un total de 120 (27,5%) muestras fecales de niños dieron positivo para varios parásitos. Del total, 267 (61%), 205 (47%), 109 (25%) y 140 (32%) niños eran anémicos, presentaban atrofia, desgaste y bajo peso, respectivamente. Los factores independientes relacionados con la anemia infantil incluyen la edad del niño, el tamaño de la familia, el nivel de conciencia de las madres sobre el cuidado de la salud general del niño y los IP. Los IP fueron factores de riesgo independientes para la malnutrición y el desgaste general de los niños. Los factores de riesgo independientes para los IP incluyeron un estado nutricional deficiente de las madres, bajo nivel de conciencia de las madres con respecto a la atención médica general del niño, la educación formal de los padres, el patrón pica en niños, la edad, el sistema de alcantarillado abierto en las casas y el tamaño de la familia.

Conclusión: en general, la malnutrición y la anemia fueron muy prevalentes en los niños en asociación con IP.

Palabras claves: Infección parasitaria intestinal. Desnutrición. Anemia. Niños preescolares.

INTRODUCTION

Intestinal parasitic infection (PI) is a major health problem in developing countries. Globally, two billion individuals are infected with intestinal parasites; out of these, the majority of them are children. An increasing trend in intestinal PIs has been recorded in developing countries because of low socioeconomic status, low literacy rate, poor awareness among the parents regarding PI and their mode of transmission, poor quality of drinking water, inappropriate hygiene and sanitation and hot and humid tropical climate (1,2). Parasitic infection has been linked with an increased risk for nutritional anemia, protein-energy malnutrition and growth deficits in children, loss of weight in pregnancy and intrauterine growth retardation followed by low birth weight (1,3).

Globally, worm infestation is the most common health issue among children in developing countries, particularly in those living in the rural and remote areas. However, wide ranges in the prevalence of PI among children have been reported

within regions or countries and between the countries. In recent studies, enormously different prevalence rates in intestinal parasites were observed in different developing countries: 60% in Rwanda (age: 5-60 months) (4), 47% in Peru (3-12 years) (5), 51.7% in Nigeria (2-5 years) (6), 26% in Venezuela (< 2 years) (7), 25-70% in Cambodia in different child age groups of children (8-10), 51% in India (< 24 months) (11), and 20-70% reported from various regions of Pakistan in different child age groups (12,13). Children under five years of age present higher risk of malnutrition because of their high nutrient requirements for rapid physical and physiological growth. Multidimensional biological, environmental and behavioral factors influence childhood malnutrition (14). A number of previous studies demonstrated association between PI and different forms of malnutrition in children (4,15). Similarly, anemia, being characterized by blood hemoglobin concentration below the established cut-off level, is also a common public health problem of the developing world. The global prevalence of anemia in the preschool children is 43% (16), which contributes substantially to childhood mortality and morbidity. In Pakistan, the reported prevalence of anemia in preschoolers is between 40-70% in different areas and regions. The previous literature has shown significant association of anemia with impaired brain development and cognitive functions among children. A diverse range of risk factors including PIs likely contribute to its etiology in various age groups (1,17). Several studies have been conducted in Pakistan to estimate the severity of the problem of PI in different age groups. Most of these studies focused on the prevalence rate of PI in the community. There is no recent information about intestinal PI and its impact on nutritional status of young children in Pakistan. The present study was designed to estimate the severity of the problem of malnutrition and anemia in association with PI among the young children and to identify the potential risk factors contributing to these health issues.

METHODS

Study location and settings

This cross-sectional study was conducted in a rural area of Peshawar, the capital city of the Khyber Pakhtunkhwa province of Pakistan. The study was conducted between March 2014 and October 2016 on preschool children (6-59 months). Peshawar has a

semi-arid climate, with very hot summers and mild winters. Winter in Peshawar starts in November and ends in late March, although it sometimes extends into mid-April, while the summer months are from mid-May to mid-September or early October. The mean maximum summer temperature surpasses 40 °C (104 °F) during the hottest month, and the mean minimum temperature is 25 °C (77 °F). The mean minimum temperature during the coolest month is 4 °C (39 °F), while the maximum is 18.3 °C (64.9 °F).

Sample size and procedure

A sample size of 385 children was estimated considering a prevalence of worm infestation of 50% in rural and semi-urban areas, with a precision of 5% and alpha-error of 0.05. However, the sample size was increased to 450 in order to compensate the expected 15-20% non-response rate. Peshawar has three rural health centers where households and families from the surrounding rural areas (villages and remote countryside) get registration of their children for routine immunization and other health facilities. Children aged 6-59 months were identified and randomly selected from the records of the three rural health centers. Inclusion criteria were: children free from any chronic/inborn disease, and who had no acute diarrhea, constipation or dysentery. Infants > 6 months with exclusively breastfeeding were also excluded. Children's families were approached; only one child per household was included after obtaining written informed consent from the parent/caregiver. The study was approved by the university ethical review committee.

Data collection

Pretested questionnaires, containing both closed and open ended questions, were used to collect data on socioeconomic-demographic status, child medical history including worm infection in the past and health characteristics, and household hygiene and sanitation status. Child's mothers, fathers or caregivers were thoroughly interviewed by trained graduates to gather all the required information. Standardized equipment was used to assess maternal and child nutritional, and child worm infestation statuses in well-established laboratories of the health centers.

A structured questionnaire was used to collect data on socioeconomic-demographic status and health characteristics of the children. The questionnaire included information on household monthly income (in Pakistani rupees), family type (joint or nuclear) and size, home infrastructure (muddy or concrete), and parental characteristics (such as age and formal education). Family size was defined as the total number of individuals, including the child parents, grandparents, parity, and other relatives sharing the same kitchen. Questions on child characteristics included recent medical history (such as any digestive or respiratory problems), current use of medicine, regular medication for worm infestation and pica habit. Questions were asked in the local language and all the information was recorded on the questionnaire. A pretested questionnaire was used to assess awareness level and perception of mothers about PI, mode of parasites transmission, safety and precautionary measures to control worms, child caring and nutrition, and home hygiene and sanitation. The questionnaire had specific close-ended questions for each section. Mothers' responses were indicated on a three point scale, ranging from "totally wrong", "partially true", and "correct". A total score for each section was calculated and a grand score value for each respondent was obtained by adding the scores of each section. Mothers above the median of grand score were considered as having "sufficient awareness of overall child health" as compared to those below the median. Children with both visible and invisible worms were identified by trained graduates using the recommended procedure under the supervision of project investigators. For stool collection, mothers/caretakers were properly guided regarding sample collection in dry, clean leak proof containers labelled with the name and identification number of the child. Physical examination of the stool samples was done by noticing stool color, consistency, presence or absence of mucus and blood and the visibility of worms. Type of worms present in the stool was confirmed and recorded.

Recommended laboratory techniques were used to diagnose invisible worms (18). Invisible worms in fresh stool samples were diagnosed using the "direct wet mount method", in which microscope slides were made from fecal specimen (about 2 mg), 1-2 drops of saline solution and a drop of Lugol's iodine for examination under low (x10) and high power (x40). The addition of a drop of Lugol's iodine stains the cysts, making them easier to identify. Saline iodine wet mount identified parasites, protozoan

trophozoites and cyst, helminth ova and larvae. All stool samples were then processed by formalin-ether sedimentation concentration and examined similarly under 10x and 40x magnifications to identify the protozoan cysts. Pictures and atlases provided by authentic and well-established sources were used to identify parasites.

Nutritional statuses of mothers and their children were assessed. Mothers of the selected children were assessed for nutritional status by taking body weight and height without shoes and in lightweight clothing to the nearest 0.1 kg and 0.1 cm, respectively. Mothers' body mass indexes (BMI) were calculated using their weight and height measurements. Children nutritional and anemia statuses were evaluated by measuring their body weight, length/height and blood hemoglobin level. Weight was taken to the nearest 0.1 kg by using pediatrics scale for less than two-year-old children and electronic digital scale for younger children (3-5 years). Length board/recombinant length scale was used for measuring the length of infants and height scale was used for younger children to the nearest 0.1 cm. All of the anthropometric measurements were taken using recommended procedures of the World Health Organization (WHO) and standardized equipment.

The children anthropometric measurements were compared with the WHO 2006 growth standards to identify malnourished children. Standard deviation or Z-scores for "weight-for-age" (WAZ), "length/height-for-age" (L/HAZ) and "weight-for-length/height" (WAL/HZ) of the children were generated using the WHO recommended Anthro software. Children with standard deviation score < -2 for WAZ, L/HAZ and WAL/HZ were identified as underweight, stunted and wasted, respectively. However, children who had all of the WAZ, L/HAZ and WAL/HZ values below -2 were grouped together and collectively declared as *undernourished*.

HemoCue[®] was used to measure the hemoglobin concentration of children by taking 2-3 drops of blood in disposable strips used in the HemoCue[®] micro-cuvette (19). First, the instrument was calibrated for the accuracy of hemoglobin level. A control cuvette was applied to the instrument holder to verify the stability of the HemoCue[®]. The accuracy of the instrument was checked repeatedly with the control cuvette after the analysis of 10-12 blood samples. To measure Hb levels, the middle/ring finger of the child was cleaned at the side of the fingertip by alcohol swab, and then punctured with the lancet. First, 2-3 drops were wiped away; the next large drop of blood was

transferred to a micro-cuvette and placed in the HemoCue® for the results. The results appeared in approximately 15-60 seconds in g/dl and recorded. Anemia was defined as a hemoglobin < 12 g/dl.

Statistical analysis

Data were entered and analyzed using the statistical package SPSS version 20 (SPSS, Inc., Chicago, IL, USA). Data was first checked for entry errors and distribution using appropriate descriptive tests such as frequency, mean, mode, and Kolmogorov-Smirnov. The 95% confidence intervals (95% CI) of percentages were calculated based on the standard error. Logistic regression tests were used to investigate the association of potential social, demographic, health and nutritional variables with the status of PI among children; independent predictors of PI were identified and their associations with the outcome variable were reported as adjusted odds ratio (OR) with 95% CI. The differences were considered to be statistically significant at $p < 0.05$.

RESULTS

Required information for the current analysis was available on 437 (97%) mother-child pairs, including data on socioeconomic-demographic status, nutritional indicators, worm infestation among children, and hygiene and sanitation status at household levels. General characteristics of the study participants are summarized in table I. The mean age of the mothers and children was 27 ± 3.7 year and 24 ± 10 months, respectively; 48% ($n = 210$) of the study children were female. Average family size of the respondents was 6 ± 1.6 , with a mean monthly income (thousands) of PKR 18 ± 5.5 . The mean monthly income of the families was closed to the 3rd quintile of the national monthly household income of Pakistani rural population (20). Most of the children were living in joint family systems, muddy homes with open sewage system, and had illiterate or low-educated parents. However, 58% ($n = 253$) of mothers had some knowledge of overall child health, i.e., awareness on PI, mode of parasites transmission, safety and precautionary measures to control worms, child caring and nutrition, and home hygiene and sanitation.

Table II shows results on the respondents' health and nutritional status. A total of 120 (27.5%) fecal samples were positive for various worms, including both visible (round

worm, tape worm, pin worm and thread worms) and invisible worms (giardia, coccidia, whip worm and hook worm). A child being positive for single or multiple worm infestation was declared as “infected” and compared with the rest of children for different characteristics. Average WAZ, WL/HZ and L/HAZ of the children was -1.5 ± 1.2 , -1.4 ± 1.5 and -1.7 ± 1.4 , respectively. Of the total, 205 (47%), 109 (25%) and 140 (32%) children were stunted, wasted and underweight, respectively. Overall, 83 (19%) of the children had z-scores below -2 for all the three indicators of malnutrition and were grouped as “*undernourished*”. Based on the recommended cut-off value for blood Hb, 267 (61%) children were found as anemic. The mean BMI of mothers was 21.08 ± 3.7 (range: 14.87-33.19); the minimum and maximum BMI values showed the presence of both underweight and overweight mothers in the study sample.

Prevalence of malnutrition (undernutrition, underweight, wasting and stunting) and anemia among children by Pls status was evaluated (Fig. 1). There were no statistical differences among the groups in the prevalence of “underweight” and “stunting” ($p > 0.05$). Most of the wasted (59% *versus* 41%) and anemic (66% *versus* 34%) children were worm infested; these differences in the percentages were statistically different ($p < 0.05$). Overall, 61% of the *undernourished* children were infected ($p < 0.05$).

Figure 2 displays findings on risk factors and their corresponding adjusted OR (95% CI) for Pls in children. Among parental characteristics, mothers’ BMI (adjusted OR: 0.56, 95% CI: 0.07-0.98) and awareness (adjusted OR: 3.00, 95% CI: 2.45-3.60) and fathers’ formal education (adjusted OR: 2.43, 95% CI: 1.09-3.10) had independent association with Pls. Similarly, among child characteristics examined, pica habit (adjusted OR: 2.23, 95% CI: 1.89-3.03) and age (adjusted OR: 2.32, 95% CI: 1.70-3.21) were associated with Pls. Children living in the houses with open sewage system were 1.76 time more at risk for worm infestation as compared to those living with closed sewage system (adjusted OR: 1.76, 95% CI: 1.06-2.61). Among sociodemographic characteristics, only family size had association with Pls (adjusted OR: 2.02, 95% CI: 1.61-2.71).

DISCUSSION

Epidemiological studies on the prevalence of acute and chronic health problems and predisposing risk factors are essential to design appropriate intervention strategies,

particularly for the vulnerable population of young children. The current study was aimed to assess the status of malnutrition and anemia in association with PI among the young children and to identify the potential risk factors for PI in the study area. Parasitic infection has been reported among the major contributing factors for child malnutrition and anemia in the developing world, leading to growth retardation and other adverse health consequences. Findings of the current study revealed the prevalence of malnutrition and anemia in association with worm infestation in a significant number of the study children. Other risk factors associated with anemia and malnutrition were age, family size, family income, mothers' BMI and awareness level, fathers' education and child recent medical history.

Our data found associations of malnutrition (based on anthropometric measurements) with PI; infected children were more likely to be wasted in comparison to the rest. There are discrepancies in the available literature on the association between the anthropometric indices and PI as some studies had positive results (21,22) whereas others reported no relationship (12,23,24). Our findings demonstrated an association between the prevalence of malnutrition and worm infestation among the study children. The overall prevalence of anemia in the current study was 61%, which is closed to the 2011 national prevalence report for the country for children under five years of age (25). Our study confirmed the association between worm infestation and the risk of anemia in the subjects as well. Children infected with intestinal parasites were more anemic than those who were not infected, which shows a similar association as the one previously reported in different developing countries (26,27). Parasitic infections are closely related to anemia and malnutrition. Most of the parasites, such as hookworm infections, cause mucosal damage resulting in endogenous losses of iron and other trace micronutrients. Parasitic infections resulting in bleeding (e.g., hookworm infection) are known to be predictors for iron deficiency anemia (28,29). Results of the current study suggest that infected children might have parasites-related comorbidities such as anorexia, nausea and vomiting, reductions in digestion and absorption, increased metabolic requirements, and enhanced nutrient losses that could lead to adverse health consequences (30-32).

Previous studies from different developing countries have identified various socio-demographic and environmental factors associated with PI among children. The

findings from multivariate logistic regression analyses in the current study showed a considerably higher risk of worm infestation among children having various characteristics, including mothers' low BMI, open sewage system or poor sanitation at home, pica habit, child age, family size, fathers' illiteracy and mothers' poor awareness level. The association between mothers' nutritional status as manifested by BMI and PI could be explained by the fact that malnourished and unhealthy mothers might not be able to properly maintain the household hygiene status and look after their children. Previous literature supported the relationship between maternal and child health and nutrition status (33-35). Most mothers in the current study were not educated formally, but showed somehow awareness of PI and related health knowledge. A negative association between maternal awareness level and the odds of PI in the children was evident. Mothers' awareness level played a significant role in lowering the likelihood of PI among children. Awareness, particularly about the mode of parasitic transmission, could enable the mothers or caregivers to modify the child's life style and living environment. Paternal formal education was significantly associated with the absence of PI among children. Education levels, particularly regarding decision-making partners such as fathers in the study area, might have a direct impact on children's health because it increases the ability to acquire and process information. Overall education helps parents to make better health investments for themselves and their children and may result in better parenting in general (36).

Visible sewage and poor sanitation, child pica, and exposure to soil-transmitted parasites have been frequently reported among the leading causes for PIs among children. Child age had a significant effect, probably because we studied such a wide age range (6-59 months). On average, for a unit increase in child age, the odds of having worm infestation increases by a factor of 2.32 (Fig. 2). As the children get older, exposure to soil-transmitted parasites becomes higher than that of their younger counterparts because of the increase in indoor and outdoor physical activities. The current study was conducted in rural slums where most of the constructions are either muddy or semi-cemented and most houses have open sanitation and sewage systems. This increases the risk of parasite transmission in preschool children. Hands and fingers of children might be easily contaminated with soil that contains cyst and eggs

of parasitic organism, leading to intestinal PI. Parasitic infection had been shown to be initiated in early childhood in different previous research (32,37,38).

The present study showed that the likelihood of PI in children increased with the increase in family size. Previous studies conducted in different developing countries showed a similar trend (39). The possible explanation for this association might be that overcrowding and larger family sizes can easily lead to major problems, such as poor sanitation and personal hygiene, which promote the likelihood of parasitic transmission and increase the susceptibility of family members to PIs.

Our study has certain limitations. This study was of cross-sectional study in nature; therefore, our results only reflect one point in time in the study area which has a hot humid summer season between March and October. It was assumed that prevalence of PIs might be higher in this season as children are more exposed to dust, mud and consumption of unwashed fresh foods such as fruits. This exposure is much higher in children living in the rural slums of developing countries where most of the constructions are not cemented. The second limitation is the unavailability of dietary information for current analysis to explore its association with the subjects' nutritional and hemoglobin status. However, this limitation was offset by adding the variable of family income in the analysis, which predicts the level of household food security. Third, the findings presented here are representative of the selected rural areas of the north western region and cannot be generalized for all of the country.

This study has certain strengths. The sample size was pretty large to represent the study area. Among the participants, gender distribution was fair, with 48 percent of females and 52 percent of males. As per the knowledge of the investigators, this is the first study in the north-west region of Pakistan focusing on preschool children of rural slum areas to investigate the association of anemia and malnutrition with PI. A major strength of the study is the high response rate (97%). Similarly, as planned, the stool sample testing was conducted within 2-3 hours of collection. This was possible as the facilities of worm infestation determination were available in the laboratories of local hospitals. Based on previous literature, potential confounders were identified and detailed data were collected to adjust their effects.

CONCLUSIONS

Our results showed that almost one third of the children had infestation of different parasites which were associated with poor health outcomes among children. Overall malnutrition and anemia were highly prevalent in children in association with PI. Parasitic infection was found to be an independent risk factor for malnutrition and anemia among preschoolers. Among the different possible risk factors evaluated in the current study, mother nutrition status as assessed by BMI, open home sewage, larger family size, child pica habit, child increasing age and mothers' poor awareness of overall child health were strongly associated with intestinal PI.

Mothers health and awareness level play a significant role in the control of worm infestation among young children. Similarly, household hygiene and sanitation has a direct impact on overall child health. Therefore, all relevant stakeholders should be involved to design and implement mini developmental projects for the promotion of maternal nutrition status and awareness level, personal and environmental hygiene, household sanitation, control of PI, and drinking water quality improvement.

ACKNOWLEDGMENTS

We are grateful to all mothers and their children who participated in the study.

REFERENCES

1. Zanin FH, Da Silva CA, Bonomo E, Teixeira RA, Pereira CA, Dos Santos KB, et al. Determinants of iron deficiency anemia in a cohort of children aged 6-71 months living in the Northeast of Minas Gerais, Brazil. *PLoS One* 2015;10(10):e0139555.
2. Tulu B, Taye S, Amsalu E. Prevalence and its associated risk factors of intestinal parasitic infections among Yadot primary school children of South Eastern Ethiopia: a cross-sectional study. *BMC Res Notes* 2014;7:848.
3. Derso A, Nibret E, Munshea A. Prevalence of intestinal parasitic infections and associated risk factors among pregnant women attending antenatal care center at Felege Hiwot Referral Hospital, northwest Ethiopia. *BMC Infect Dis* 2016;16(1):530.
4. Ignatius R, Gahutu JB, Klotz C, Steininger C, Shyirambere C, Lyng M, et al. High prevalence of *Giardia duodenalis* Assemblage B infection and association with underweight in Rwandan children. *PLoS Negl Trop Dis* 2012;6(6):e1677.

5. Cabada MM, Goodrich MR, Graham B, Villanueva-Meyer PG, Deichsel EL, López M, et al. Prevalence of intestinal helminths, anemia, and malnutrition in Paucartambo, Peru. *Rev Panam Salud Publica* 2015;37(2):69-75.
6. Tyoalumun K, Abubakar S, Christopher N. Prevalence of intestinal parasitic infections and their association with nutritional status of rural and urban pre-school children in Benue State, Nigeria. *Int J MCH AIDS* 2016;5(2):146-52.
7. Overeem MM, Verhagen LM, Hermans PW, Del Nogal B, Sánchez AM, Acevedo NM, et al. Recurrent wheezing is associated with intestinal protozoan infections in Warao Amerindian children in Venezuela: a cross-sectional survey. *BMC Infect Dis* 2014;14:293.
8. Liao CW, Chiu KC, Chiang IC, Cheng PC, Chuang TW, Kuo JH, et al. Prevalence and risk factors for intestinal parasitic infection in schoolchildren in Battambang, Cambodia. *Am J Trop Med Hyg* 2017;96(3):583-8.
9. Moore CE, Elwin K, Phot N, Seng C, Mao S, Suy K, et al. Molecular characterization of cryptosporidium species and *Giardia duodenalis* from symptomatic Cambodian children. *PLoS Negl Trop Dis* 2016;10(7):e0004822.
10. Moore CE, Nget P, Saroeun M, Kuong S, Chanthou S, Kumar V, et al. Intestinal parasite infections in symptomatic children attending hospital in Siem Reap, Cambodia. *PLoS One* 2015;10(5):e0123719.
11. Rizvi AN, Maity P, Bursey CR. Three new species of Pharygodonidae (Nematoda: Oxyuridea) in *Laudakia tuberculata* (Squamata: Agamidae) from Dehradun, Uttarakhand, India. *Acta Parasitol* 2017;62(2):273-89.
12. Mehraj V, Hatcher J, Akhtar S, Rafique G, Beg MA. Prevalence and factors associated with intestinal parasitic infection among children in an urban slum of Karachi. *PLoS One* 2008;3(11):e3680.
13. Hussain I, Qureshi NA, Afzal M, Shaheen N, Ali A, Ashraf A. Prevalence and distribution of human Plasmodium infection in Federally Administrative Tribal Areas of Pakistan. *Acta Parasitol* 2016;61(3):537-43.
14. Dewey KG. Reducing stunting by improving maternal, infant and young child nutrition in regions such as South Asia: evidence, challenges and opportunities. *Matern Child Nutr* 2016;12(Suppl 1):27-38.

15. Gutiérrez-Jiménez J, Torres-Sánchez MG, Fajardo-Martínez LP, Schlie-Guzman MA, Luna-Cazares LM, González-Esquinca AR, et al. Malnutrition and the presence of intestinal parasites in children from the poorest municipalities of Mexico. *J Infect Dev Ctries* 2013;7(10):741-7.
16. World Health Organization (WHO). The global prevalence of anaemia in 2011. Accessed Oct 10th 2017. Available from: http://apps.who.int/iris/bitstream/10665/177094/1/9789241564960_eng.pdf?ua=1
17. Bates I, McKew S, Sarkinfada F. Anaemia: a useful indicator of neglected disease burden and control. *PLoS Med* 2007;4(8):e231.
18. Garcia LS. Diagnostic medical parasitology: American Society for Microbiology Press; 2006.
19. Cohen AR, Seidl-Friedman J. HemoCue system for hemoglobin measurement. Evaluation in anemic and nonanemic children. *Am J Clin Pathol* 1988;90(3):302-5.
20. Government of Pakistan. Household Integrated Economic Survey (HIES). Islamabad - Pakistan, Statistics SD-PBo; 2012-2013.
21. Stephenson LS, Latham MC, Ottesen EA. Malnutrition and parasitic helminth infections. *Parasitology* 2000;121(Suppl):S23-38.
22. Crompton DW, Nesheim MC. Nutritional impact of intestinal helminthiasis during the human life cycle. *Annu Rev Nutr* 2002;22:35-59.
23. Pegelow K, Gross R, Pietrzik K, Lukito W, Richards AL, Fryauff DJ. Parasitological and nutritional situation of school children in the Sukaraja district, West Java, Indonesia. *Southeast Asian J Trop Med Public Health* 1997;28(1):173-90.
24. Muniz PT, Ferreira MU, Ferreira CS, Conde WL, Monteiro CA. Intestinal parasitic infections in young children in Sao Paulo, Brazil: prevalences, temporal trends and associations with physical growth. *Ann Trop Med Parasitol* 2002;96(5):503-12.
25. Habib MA, Black K, Soofi SB, Hussain I, Bhatti Z, Bhutta ZA, et al. Prevalence and predictors of iron deficiency anemia in children under five years of age in Pakistan, a secondary analysis of National Nutrition Survey Data 2011-2012. *PLoS One* 2016;11(5):e0155051.
26. 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(2):122-31.

27. Sousa-Figueiredo JC, Basanez MG, Mgeni AF, Khamis IS, Rollinson D, Stothard JR. A parasitological survey, in rural Zanzibar, of pre-school children and their mothers for urinary schistosomiasis, soil-transmitted helminthiasis and malaria, with observations on the prevalence of anaemia. *Ann Trop Med Parasitol* 2008;102(8):679-92.
28. Ramdath DD, Simeon D, Wong M, Grantham-McGregor S. Iron status of schoolchildren with varying intensities of *Trichuris trichiura* infection. *Parasitology* 1995;110(3):347-51.
29. Robertson LJ, Crompton DW, Sanjur D, Nesheim MC. Haemoglobin concentrations and concomitant infections of hookworm and *Trichuris trichiura* in Panamanian primary schoolchildren. *Trans R Soc Trop Med Hyg* 1992;86(6):654-6.
30. Koski KG, Scott ME. Gastrointestinal nematodes, nutrition and immunity: breaking the negative spiral. *Annu Rev Nutr* 2001;21:297-321.
31. Wordemann M, Polman K, Menocal Heredia LT, Díaz RJ, Madurga AM, Núñez Fernández FA, et al. Prevalence and risk factors of intestinal parasites in Cuban children. *Trop Med Int Health* 2006;11(12):1813-20.
32. Harhay MO, Horton J, Olliaro PL. Epidemiology and control of human gastrointestinal parasites in children. *Expert Rev Anti Infect Ther* 2010;8(2):219-34.
33. Felisbino-Mendes MS, Villamor E, Velasquez-Meléndez G. Association of maternal and child nutritional status in Brazil: a population based cross-sectional study. *PLoS One* 2014;9(1):e87486.
34. Negash C, Whiting SJ, Henry CJ, Belachew T, Hailemariam TG. Association between maternal and child nutritional status in Hula, Rural Southern Ethiopia: a cross sectional study. *PLoS One* 2015;10(11):e0142301.
35. Rondo PH, Rezende G, Lemos JO, Pereira JA. Maternal stress and distress and child nutritional status. *Eur J Clin Nutr* 2013;67(4):348-52.
36. Lindeboom M, Llana-Nozal A, Van der Klaauw B. Parental education and child health: evidence from a schooling reform. *J Health Econ* 2009;28(1):109-31.
37. Bethony J, Brooker S, Albonico M, Geiger SM, Loukas A, Diemert D, et al. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet* 2006;367(9521):1521-32.

38. Jardim-Botelho A, Brooker S, Geiger SM, Fleming F, Souza Lopes AC, Diemert DJ, et al. Age patterns in undernutrition and helminth infection in a rural area of Brazil: associations with ascariasis and hookworm. *Trop Med Int Health* 2008;13(4):458-67.
39. Abera A, Nibret E. Prevalence of gastrointestinal helminthic infections and associated risk factors among schoolchildren in Tilili town, northwest Ethiopia. *Asian Pac J Trop Med* 2014;7(7):525-30.



Table I. General characteristics of the study subjects (n = 437)

<i>Characteristics</i>	<i>Mean ± SD - n (%)</i>
Child age (months)	24 ± 10 (6-58 months)
Child age groups	
6-36 months	249 (57%)
37-59 months	188 (43%)
Child sex	
Male	227 (52%)
Female	210 (48%)
Mother age	27 ± 3.7 (17-39 years)
Family income (Rs.)*	18 ± 5.5
Family type	
Joint	275 (63%)
Nuclear	162 (37%)
Family size	6 ± 1.6
Father school education (years)	
Illiterate	142 (32%)
< 10 years	201 (46%)
10-14 years	77 (18%)
> 14 years	17 (4%)
Mother school education (years)	
Illiterate	297 (68%)
5-8 years	109 (25%)
10 years	31 (07%)
Home construction	
Muddy	258 (59%)
Cemented/partially cemented	179 (41%)
Home sewage	
Open	293 (67%)
Closed	144 (33%)

Mothers awareness [†]	
Yes	253 (58%)
No	184 (42%)

*In thousands (Pakistani rupees [PKR], 1 USD = 105 PKR). [†]Awareness of PIs, mode of parasites transmission, safety and precautionary measures to control worms, child caring and nutrition, and home hygiene and sanitation



Table II. Health and nutritional status of the children

<i>Indicators</i>		<i>n (%) / mean \pm SD (range)</i>
Worm infestation status		
	Yes*	120 (27.5%)
	No	317 (72.5%)
Nutritional measurements		
	Weight (kg)	12.4 \pm 2.5 (5.8-19.2)
	Height/length (cm)	93 \pm 6.1 (62.5-110.3)
	WAZ	-1.5 \pm 1.2 (-4.1-3.1)
	WL/HZ	-1.4 \pm 1.5 (-4.6-2.9)
	L/HAZ	-1.7 \pm 1.4 (-4.4-2.6)
Malnutrition status		
	Stunted	205 (47%)
	Wasted	109 (25%)
	Underweight	140 (32%)
	<i>Undernourished^f</i>	83 (19%)
Blood hemoglobin level		11.8 \pm 3.1 (4.9-15.2)
Anemia status		
	Anemia (< 12 g/dl)	267 (61%)
	Non-anemic	170 (39%)
Mother BMI		21.08 \pm 3.7 (14.87-33.19)

*Infections with single or multiple parasites. Children had WAZ, L/HAZ and WAL/HZ values < -2.

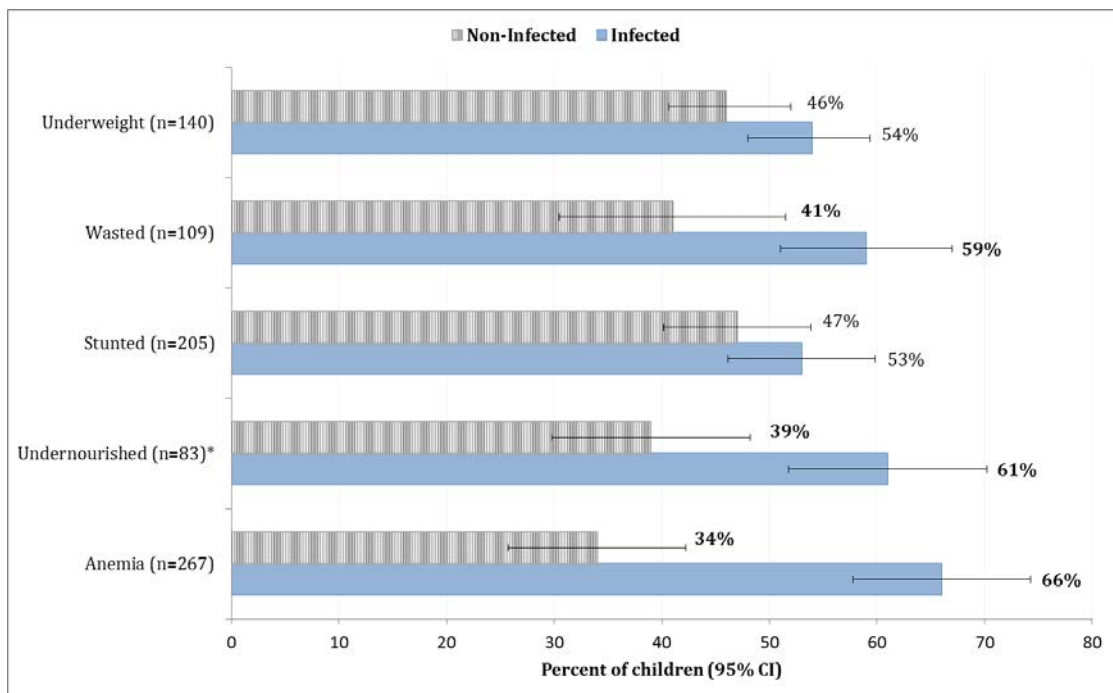


Fig. 1. Malnutrition and anemia in children by parasitic infection status. Note: percent values in bold are statistically different between the groups ($p < 0.05$). *Children had $WAZ, L/HAZ$ and $WAL/H < -2$.

Nutrición Hospitalaria

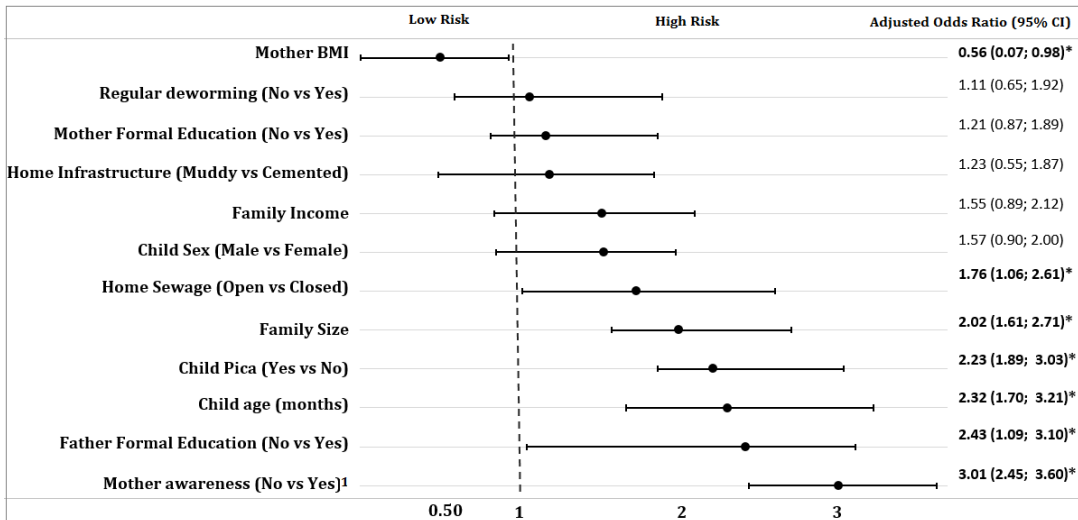


Fig. 2. Maternal and child health, and sociodemographic associates of worm infestation. ¹Awareness of PIs, mode of parasites transmission, safety and precautionary measures to control worms, child caring and nutrition, and home hygiene and sanitation. *p < 0.05.

