

## Relationship of Intestinal Parasites, *H. Pylori* Infection with Anemia or Iron Status Among School age Children in Rural Bangladesh

Ahmed S Rahman, Shafiqul A Sarker, Tahmeed Ahmed, Rafiqul Islam, Mohammad A Wahed, David A Sack

Ahmed S Rahman, Shafiqul A Sarker, Tahmeed Ahmed, Mohammad A Wahed, Centre for Nutrition and Food Security; International Centre for Diarrhoeal Diseases Research, Bangladesh (icddr,b); Mohakhali, Dhaka1212, Bangladesh

Rafiqul Islam, School of Medicine and Public Health, University of Newcastle, Australia

David A Sack, Johns Hopkins University Bloomberg School of Public Health, Baltimore, Maryland, the United States

Correspondence to: Ahmed S Rahman, PhD, Centre for Nutrition and Food Security; International Centre for Diarrhoeal Diseases Research, Bangladesh; Mohakhali, Dhaka-1212, Bangladesh. [ashafiq@icddr.org](mailto:ashafiq@icddr.org)

Telephone:+880-2-9840523-32

Fax:+880-2-9885657

Received: May 20, 2013

Revised: July 17, 2013

Accepted: July 20, 2013

Published online: September 21, 2013

-1.18, -0.59) as well as anemia and low iron status based on serum transferrin receptor (OR 3.57;  $p < 0.01$ ).

**CONCLUSION:** Our results are in line with other studies from developing countries that showed no significant association between intestinal parasites or *Helicobacter pylori* infection and anemia, hemoglobin or iron status.

© 2013 ACT. All rights reserved.

**Key words:** Anemia; *Helicobacter pylori*; intestinal parasites; school age children; rural Bangladesh

Rahman AS, Sarker SA, Ahmed T, Islam R, Wahed ma, Sack DA. Relationship of Intestinal Parasites, *H. Pylori* Infection with Anemia or Iron Status Among School age Children in Rural Bangladesh. *Journal of Gastroenterology and Hepatology Research* 2013; 2(9): 769-773 Available from: URL: <http://www.ghrnet.org/index.php/joghr/article/view/480>

### ABSTRACT

**AIM:** To investigate an association of intestinal parasites or *Helicobacter pylori* infection with hemoglobin, anemia or iron status among rural school aged children in Bangladesh.

**METHODS:** Data and specimens from a controlled trial among children aged 6-15 years old to assess the nutritional impact of fortified flour were used to carry out this additional analysis on factors which effect anemia. Stool samples from 310 children were collected at the end of the trial and were tested for *Helicobacter pylori* stool antigen and intestinal parasites. Data on hematological parameters were obtained from endline measurements of the trial.

**RESULTS:** The overall prevalence of parasitic infection was 84% among children with the highest prevalence for *Ascaris* (71%) followed by *Trichuris* (67%) and Hookworm (31%). The prevalence of *Helicobacter pylori* infection was 39.7%. A total of 26.8% children were anemic, while low iron status as defined by a low serum ferritin (<20 µg/L) or elevated transferrin receptor (>5.0 mg/L) respectively was present in 18% and 11% of the children. No statistically significant association was found between *Helicobacter pylori* or any intestinal parasites and hemoglobin concentration, anemia or iron status among the children. However, there was a significant association between low hemoglobin concentration and low iron status based on serum ferritin (Coefficient: -0.28, 95% CI -0.54, -0.03) or transferrin receptor level (Coefficient: -0.89, 95% CI

### INTRODUCTION

Anemia is still a major public health problem in many developing countries. The World Health Organization (WHO) Global Database on Anemia for 1993-2005 showed that 25% or 1.62 billion people globally suffer from anemia with the highest number of 315.4 million in South-East Asia region<sup>[1]</sup>. Iron deficiency anemia (IDA) during pregnancy increases the risk of death in mothers and neonates during perinatal period. Globally, more than 115000 maternal deaths and 591000 perinatal deaths per year are attributable to anemia<sup>[2]</sup>. Evidence indicates that IDA delay psychomotor development and impairs cognitive performance in children as well as reduces work capacity and productivity in adult life<sup>[3]</sup>. In Bangladesh, over one third of the school-age children (5-11 years) or adolescents (12-19 years) were anemic, some of which is due to iron deficiency<sup>[4]</sup>.

Low dietary intake of bioavailable iron is assumed to be a major cause of anemia in the developing world. Dietary iron consumed in resource poor areas is predominantly non-heme iron of plant origin, containing high amounts of inhibitors of iron absorption such as phytate<sup>[5]</sup>. In addition to low iron bioavailability from the diet, the high prevalence of infections and other nutritional deficiencies in developing countries can also contribute to the development of anemia. The WHO estimated that there were 1 billion cases of *Ascaris*

lumbricoides, and half a billion cases of *Trichuris trichiura* infection worldwide<sup>[6]</sup>. Blood loss caused by gastrointestinal parasites, such as hookworm, is considered to be an important contributing factor in the development of poor iron status leading to iron deficiency anemia<sup>[7]</sup>. More recently, another common infection, *Helicobacter pylori*, has been discussed in the etiology of anemia and IDA<sup>[8-11]</sup>.

*H. pylori* is a common gastrointestinal pathogen world-wide with a very high prevalence in many developing countries. For example, data from India shows that the frequency of *H. pylori* infection can be more than 80% by age 20 years<sup>[12]</sup>, and a study in Bangladesh reported an overall 68% prevalence of *H. pylori* infection in infants and children<sup>[13]</sup>. Once established, *H. pylori* infection is thought to persist life resulting in chronic gastritis, which is a risk factor for development of atrophic gastritis, reduced gastric acid output<sup>[14]</sup>, and gastric cancer<sup>[15]</sup>. Gastric acid is considered to be one of the most important luminal factors necessary for optimal non-heme iron absorption<sup>[16]</sup>. Thus, it is possible that *H. pylori* infections can result in a reduced ability to absorb iron due to gastric atrophy and achlorhydria, or due to a more transient hypochlorhydria during active infections. Both mechanisms would result in an increased susceptibility to IDA. Pervasive occult gastrointestinal bleeding as a result of chronic active gastritis has also been considered as a cause for iron deficiency anemia in *H. pylori* infected subjects<sup>[17]</sup>. Besides its involvement in the etiology of IDA, infection with *H. pylori* has been reported to be linked with therapeutic failure of oral iron therapy in children and adolescent girls with IDA<sup>[18,19]</sup>.

Food fortification with micronutrients is one strategy to address nutritional deficiencies in populations with access to fortified food products. We conducted a double-blind controlled trial during 2002 in a rural area of Bangladesh to investigate the efficacy of wheat flour chapatti (round flat bread) fortified with multiple micronutrients including vitamin A and iron in improving vitamin A and anemia or iron status in healthy, school aged children, many of whom had subclinical anemia<sup>[20]</sup>. Unfortunately the hemoglobin and iron status of those receiving the fortified product did not improve. Because of this lack of improvement, we assessed the potential role of other factors which could reduce the effectiveness of the fortified food, namely coinfection with intestinal parasites and/or *H. pylori*. Thus the primary objective of this exploratory study was to investigate an association of intestinal parasites or *H. pylori* infection with hemoglobin, anemia or iron status among school aged rural Bangladeshi children who participated in the chapatti fortification trial for the total duration of 6 months. Secondly, this study also explored the relationship between iron status with hemoglobin and anemia status among school aged children. Younger children were not included in this study because younger children receive vitamin A capsules regularly through national programs.

## METHODS

### Design, setting and study population

This cross-sectional study was carried out in October 2002 in Mirsarai, a rural sub-district in the district of Chittagong located in the south-eastern part of Bangladesh, among children 6-15 years of age ( $n=334$ ) who participated for 6 months in the efficacy trial of wheat flour chapatti. In the trial, either unfortified or fortified wheat flour was provided to clusters for families to prepare chapattis to the children each day. The fortified flour had added multiple micronutrients including vitamin A, 3030 µg retinol equivalent as retinyl palmitate and 66 mg hydrogen reduced elemental iron per Kg of flour. Children in the efficacy trial, were enrolled from 43 Bari (clusters, composed of ~5-6 households per Bari), randomly selected

from the total list of Bari ( $n=4875$ ) in the study area. Stool samples were collected from 310 children from 42 Bari at the end of the efficacy trial and investigated for *H. pylori* antigen and intestinal parasites.

In the present study, data on hemoglobin concentration, serum ferritin and transferrin receptor concentrations and child characteristics were obtained from final measurements of the efficacy trial. A child was considered anemic when the hemoglobin level was lower than 120 g/L and 115 g/L for 12-15 and 6-11 years old children respectively. They were considered to have low iron status when serum ferritin level was lower than 20 µg/L or serum transferrin receptor level >5 mg/L.

### Ethical approval

The study was approved by the institutional review board of International Centre for Diarrhoeal Diseases Research, Bangladesh (icddr,b). Before enrolment in the study, a written informed consent was obtained from parents and assent from children more than 8 years old.

### Screening of *Helicobacter pylori* infected children

A qualitative enzyme immunoassay test for *H. pylori* stool antigen (HpSA) was used for the detection of *H. pylori* antigens in stool (Premier Platinum HpSA, Meridian Diagnostic Inc, Cincinnati, Ohio, USA). The test was found to be highly sensitive (95%) and specific (95%) against the conventional urea breath test (UBT) and gastric mucosal biopsy<sup>[21,22]</sup>. Stool samples were transported to Dhaka and the tests were carried out according to the manufacturer's direction at the icddr, b laboratory.

### Screening for ova/parasite

Stool parasites were detected by the formalin-ether concentration technique<sup>[23]</sup>. A day before the stool sample collection, a container was distributed to the mothers/caretakers, and they were instructed on how to collect a stool sample and to make sure the specimen was not contaminated with soil or dirt. The specimens were taken within an hour after collection to the research station at Mirsarai where 1.0 to 1.5 g sample was preserved in 9 mL of 10% formalin and kept in room temperature. The samples were transported to the Parasitology Laboratory of icddr, b at Dhaka where they were examined by experienced technicians for the detection of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworm.

### Statistical analysis

Data were entered into SPSS version 10.0 (SPSS Inc., Chicago IL, USA) and analyzed using STATA version 12.0 (Stata Corporation, 4905 Lakeway Drive, College Station, Texas, USA). Univariate analysis was used to find the mean and prevalence of selected variables along with confidence intervals. Body weight and height measurements were converted to height-for-age z-score using WHO AnthroPlus 2007, v 1.0 software. To explain an association of intestinal parasites or *H. pylori* infection with anemia, hemoglobin or iron status indicators; and association of iron status indicators with anemia and hemoglobin concentration, regression analyses were done with adjustment of child's sex and age. All the analyses were performed considering the cluster (Bari) effect. The level of significance was set at  $p$  value <0.05.

## RESULTS

After the completion of the trial, of the 334 children, stool samples were collected from 310 (93%) children. Characteristics of the study

children are presented in table 1. The mean hemoglobin concentration was 12.28 g/dL and 26.8% of the children were anemic where as, 18% and 11% children had low iron status based on serum ferritin and transferrin receptor level respectively.

**Table 1** Characteristics of the study participants (n=310).

Characteristics	Estimates
Age in years, mean±SE	10.4±0.17
Gender (girls), % (95% CI)	51 (44.8, 57.1)
Height-for-age z-score (HAZ), mean±SE	-1.66 ± 0.11
Stunting (HAZ <-2SD), % (95% CI)	36.8 (27.7–45.8)
Hemoglobin (Hb) concentration, g/dL; mean±SE	12.28±0.08
Prevalence of anemia, <sup>1</sup> % (95% CI)	26.8 (20.5-33.1)
Serum ferritin, µg/L; median (25 & 75 percentile)	41.9 (25.6-63.8)
Serum transferrin receptor, mg/L; mean±SE	3.8±0.09
Prevalence of low iron status:	
Serum ferritin <20 µg/L, % (95% CI)	18.1 (12.8-23.3)
Serum transferrin receptor ≥5mg/L, % (95% CI)	11.3 (7.1-15.4)

<sup>1</sup>Hb<115 g/L for 6-11 years and <120 g/L for 12-15 years old children.

Table 2 shows the prevalence of intestinal parasites and *H. pylori* infection among the children. The overall prevalence of parasitic infection was almost 84% with the highest prevalence for Ascaris (71%) followed by Trichuris (67%). Hookworm infection was present in 31% of the children. Thirty nine percent of the children were infected with *H. pylori* infection.

**Table 2** Prevalence of intestinal parasites and *H. pylori* infections among rural school age children (n=310).

Variable	Estimate, % (95% CI)
Parasitic infection	83.9 (78.5–89.3)
Hookworm only	1.3 (0–2.5)
Ascaris only	14.2 (10.3–18.1)
Trichuris only	9.4 (4.7–14)
Ascaris and Trichuris	29.4 (23.8–34.9)
Hookworm and Trichuris	2.3 (0.5–4.1)
Hookworm and Ascaris	1.6 (0.3–2.9)
Ascaris, Trichuris and Hookworm	25.8 (20.9–30.7)
<i>H. pylori</i> infection	39.7 (32.8–46.6)

Tables 3 and 4 show the results of regression analyses. There was no statistically significant association between infection with any of the intestinal parasites or *H. pylori* infection and anemia (Table 3), hemoglobin concentration (data not shown) or low iron status (Table 4). However, a statistically significant association was found between low hemoglobin concentration and low iron status based on both serum ferritin (Coefficient: -0.28, 95% CI -0.54, -0.03; *p*<0.05) and transferrin receptor level (Coefficient: -0.89, 95% CI -1.18, -0.59; *p*<0.01). Also, the odds of anemia was significantly higher for children with low iron status based on transferrin receptor level (Table 3).

**Table 3** Logistic regression analysis assessing the association of anemia with selected variables among children (n=310)<sup>1</sup>.

Variable	Odds ratio (95% CI)	<i>p</i> value
Low iron status (serum transferrin receptor >5 mg/L) <sup>2</sup> :		
Yes	3.57 (1.62-7.88)	0.002
Low iron status (serum ferritin <20 µg/L) <sup>2</sup> :		
Yes	1.48 (0.74-2.95)	0.267
Presence of Ascaris <sup>2</sup> :		
Yes	1.73 (0.89-3.36)	0.104
Presence of hookworm <sup>2</sup> :		
Yes	1.24 (0.69-2.21)	0.474
Presence of <i>H. pylori</i> <sup>2</sup> <i>i</i> :		
Yes	0.72 (0.41-1.29)	0.275
Presence of Trichuris <sup>2</sup> :		
Yes	0.98 (0.55-1.77)	0.950

<sup>1</sup>adjusted for sex, age and cluster (Bari); <sup>2</sup>reference category- No.

**Table 4** Logistic regression analysis assessing association of low iron status with selected variables among children (n=310)<sup>1</sup>.

Variable	Odds ratio (95% CI)	<i>p</i> value
<b>Outcome: Low iron status (serum ferritin &lt;20µg/L)</b>		
Presence of Ascaris <sup>2</sup> :		
Yes	0.75 (0.38-1.47)	0.402
Presence of hookworm <sup>2</sup> :		
Yes	1.48 (0.78-2.81)	0.234
Presence of Trichuris <sup>2</sup> :		
Yes	1.05 (0.54-2.03)	0.887
Presence of <i>H. pylori</i> <sup>2</sup> :		
Yes	0.78 (0.41-1.49)	0.454
<b>Outcome: Low iron status (serum transferrin receptor&gt;5mg/L)</b>		
Presence of Ascaris <sup>2</sup> :		
Yes	1.11 (0.48-2.55)	0.815
Presence of hookworm <sup>2</sup> :		
Yes	1.0 (0.45-2.21)	0.998
Presence of Trichuris <sup>2</sup> :		
Yes	1.15 (0.52-2.56)	0.734
Presence of <i>H. pylori</i> <sup>2</sup> :		
Yes	0.67 (0.3-1.48)	0.321

<sup>1</sup>adjusted for sex, age and cluster (Bari); <sup>2</sup>reference category- No.

## DISCUSSION

The prevalence of both anemia and parasitic infection was high among children in this rural setting of Bangladesh. In the present study, we found an association of low hemoglobin with low iron status based on both serum ferritin and transferrin receptor level and anemia with low iron status based on serum transferrin receptor however, could not detect an association of parasitic infection with anemia, hemoglobin or iron status.

Our results differ with other studies that reported a significant association of intestinal parasites such as, Ascaris<sup>[24]</sup>, Trichuris<sup>[24-26]</sup>, and hookworm<sup>[27-29]</sup>, with anemia or low iron status. The results also partly contradict with the previous study conducted in Bangladesh among school children that reported a significant impact of hookworm but not Ascaris on iron status<sup>[28]</sup>.

A growing body of evidence supports a clinically significant influence of *H. pylori* infection on body iron stores. Despite studies supporting the role of *H. pylori* infection in the development of iron deficiency anemia<sup>[30-33]</sup>, some studies from developing countries failed to find such an association<sup>[34-36]</sup>. A recent report from Bangladesh also concluded that *H. pylori* was neither a cause of IDA, iron deficiency nor a reason for treatment failure of iron supplementation in young Bangladeshi children<sup>[37]</sup>. Our results are in line with these studies that documented no statistically significant association of *H. pylori* infection with anemia or low iron status<sup>[34-37]</sup>.

Overall, our results suggested that the presence of anemia and low iron status in rural Bangladeshi children might be contributed by many factors together. Populations in less developed countries are frequently susceptible to deficiency of various micronutrients needed for hemoglobin synthesis other than iron. These may include folic acid, vitamin B12, vitamin A and low protein intake from poor quality diet. Therefore, apart from geohelminth infections and *H. pylori*; other infections, inadequate bio-available iron, folic acid, vitamin B12, vitamin A as well as low protein intake from poor quality diet might have contributed to the development of anemia or low iron status among these children. Thus the role of *H. pylori* in IDA is less likely to be obvious in less developed countries in contrast to other populations which have shown a link with *H. pylori* infection and anemia/IDA.

In this study most children were younger when compared to other studies where the patients were adolescent or adults in whom the histological damage in the stomach likely to be more pronounced. The observed lack of an effect in iron absorption by *H. pylori* as

observed in young Bangladeshi children<sup>[36]</sup>, supports the notion that *H. pylori* has no link with IDA/ anemia may also be related to the presence of subclinical infection by other organism competing with *H. pylori* for iron uptake resulting the role of *H. pylori* less overt in causing IDA or anemia in underprivileged population.

## CONCLUSION

The present study showed no significant association of intestinal parasites or *H. pylori* infection with hemoglobin, anemia or iron status in rural Bangladeshi school aged children with high burden of the infection and supports other studies from developing countries with similar findings.

## ACKNOWLEDGMENTS

This study was supported by grants from icddr, b core research funds. The authors are grateful to all the study participants. Dr. Ahmed S Rahman was involved in the study concept, design, conduction, data analyses, and writing of the manuscript; Drs. Shafiqul A Sarker, Tahmeed Ahmed and David A Sack, and Mohammad A Wahed were involved in the study concept, design and writing of the manuscript; and Dr. Rafiqul Islam was involved in analyses and manuscript writing. None of the authors has any conflict of interest or any financial interest.

## REFERENCES

- 1 Benoist Bd, McLean E, Egli I, Cogswell M. Worldwide prevalence of anaemia 1993-2005: WHO global database on anaemia. 2008
- 2 Ezzati M, Lopez AD, Rodgers A, Murray CJ. Comparative quantification of health risks: global and regional burden of diseases attributable to selected major risk factors: World Health Organization; 2004
- 3 WHO, UNICEF, UNU. Iron deficiency anaemia: assessment, prevention and control. A guide for programme managers. Geneva: World Health Organization; 2001. WHO/NHD/01.3.
- 4 Jamil KM, Rahman AS, Bardhan PK, Khan AI, Chowdhury F, Sarker SA, Khan AM, Ahmed T. Micronutrients and Anemia. *J Health Popul Nutr* 2008; **26**: 340-355
- 5 Hallberg L, Rossander L, Skanberg A. Phytates and the inhibitory effect of bran on iron absorption in man. *Am J Clin Nutr* 1987; **45**: 988-996
- 6 WHO. Prevention and control of intestinal parasitic infections. *Report of a WHO Expert Committee Ginebra Technical Report Series*. 1987; **749**: 1-86
- 7 Crompton DWT. The public health importance of hookworm disease. *Parasitology* 2000; **121**(S1): S39-S50
- 8 Ashorn M, Ruuska T, Mäkipernaa A. *Helicobacter pylori* and iron deficiency anaemia in children. *Scand J Gastroenterol* 2001; **36**: 701-705
- 9 Carnicer J, Badia R, Argemi J. *Helicobacter pylori* gastritis and sideropenic refractory anemia. *J Pediatr Gastroenterol Nutr* 1997; **25**: 441
- 10 Dufour C, Brisigotti M, Fabretti G, Luxardo P, Mori PG, Barabino A. *Helicobacter pylori* gastric infection and sideropenic refractory anemia. *J Pediatr Gastroenterol Nutr* 1993; **2**: 225-227
- 11 Marignani M, Angeletti S, Bordi C, Malagnino F, Mancino C, Delle Fave G, Annibale B. Reversal of long-standing iron deficiency anaemia after eradication of *Helicobacter pylori* infection. *Scand J Gastroenterol* 1997; **32**: 617-622
- 12 Graham DY, Adam E, Reddy GT, Agarwal JP, Agarwal R, Evans Jr DJ, Malaty HM, Evans DG. Seroepidemiology of *Helicobacter pylori* infection in India; comparison of developing and developed countries. *Dig Dis Sci* 1991; **36**: 1084-1088
- 13 Sarker SA, Mahalanabis D, Hildebrand P, Rahman MM, Bardhan PK, Fuchs G, Gyr N. *Helicobacter pylori*: Prevalence, transmission, and serum pepsinogen II concentrations in children of a poor peri-urban community in Bangladesh. *Clin Infect Dis* 1997; **25**: 990-995
- 14 Sarker SA, Sultana S, Sattar S, Ahmed T, Beglinger C, Gyr N, Fuchs GJ. Influence of *Helicobacter pylori* Infection on Gastric Acid Secretion in Pre-School Bangladeshi Children. *Helicobacter* 2012; **17**: 333-339
- 15 Kuipers EJ, Uytterlinde AM, Peña AS, Roosendaal R, Pals G, Nelis GF, Festen HP, Meuwissen SG. Long-term sequelae of *Helicobacter pylori* gastritis. *The Lancet* 1995; **345**: 1525-1528
- 16 Skikne B, Lynch S, Cook J. Role of gastric acid in food iron absorption. *Gastroenterology* 1981; **81**: 1068-1071
- 17 Yip R, Limburg PJ, Ahlquist DA, Carpenter HA, O'Neill A, Kruse D, Stitham S, Gold BD, Gunter EW, Looker AC, Parkinson AJ, Nobmann ED, Petersen KM, Ellefson M, Schwartz S. Pervasive occult gastrointestinal bleeding in an Alaska native population with prevalent iron deficiency. *JAMA* 1997; **277**: 1135-1139
- 18 Barabino A, Dufour C, Marino CE, Claudiani F, De Alessandri A. Unexplained refractory iron-deficiency anemia associated with *Helicobacter pylori* gastric infection in children: further clinical evidence. *J Pediatr Gastroenterol Nutr* 1999; **28**: 116-119
- 19 Choe Y, Lee J, Kim S. Effect of *helicobacter pylori* eradication on sideropenic refractory anaemia in adolescent girls with *Helicobacter pylori* infection. *Acta paediatrica* 2000; **89**: 154-157
- 20 Rahman AS, Ahmed T, Ahmed F, Alam MS, Wahed MA, Sack DA. Double-blind cluster randomised controlled trial of wheat flour chapatti fortified with micronutrients on the status of vitamin A and iron in school-aged children in rural Bangladesh. *Matern Child Nutr* 2013;
- 21 Braden B, Posselt HG, Ahrens P, Kitz R, Dietrich C, Caspary WF. New immunoassay in stool provides an accurate noninvasive diagnostic method for *Helicobacter pylori* screening in children. *Pediatrics* 2000; **106**: 115-117
- 22 Roggero P, Bonfiglio A, Luzzani S, Valadè A, Cataliotti E, Corno G, Garlaschi MC, Carissimi E, Mosca F, Carnelli V. *Helicobacter pylori* stool antigen test: A method to confirm eradication in children. *J Pediatr* 2002; **140**: 775-777
- 23 WHO. Bench aids for the diagnosis of intestinal helminths: Programme on Intestinal Parasitic Infections, Division of Communicable Diseases, World Health Organization; 1993.
- 24 Wani SA, Ahmad F, Zargar SA, Dar ZA, Dar PA, Tak H, Fomda BA. Soil-transmitted helminths in relation to hemoglobin status among school children of the Kashmir Valley. *J Parasitol* 2008; **94**: 591-593
- 25 Le HT, Brouwer ID, Verhoef H, Nguyen KC, Kok FJ. Anemia and intestinal parasitic infection in school children in rural Vietnam. *Asia Pac J Clin Nutr* 2007; **16**: 716-723
- 26 Ramdath DD, Simeon DT, Wong MS, Grantham-McGregor SM. Iron status of schoolchildren with varying intensities of *Trichuris trichiura* infection. *Parasitology* 1995; **110**: 347-352
- 27 Calis JC, Phiri KS, Faragher EB, Brabin BJ, Bates I, Cuevas LE, de Haan RJ, Phiri AI, Malange P, Khoka M, Hulshof PJ, van Lieshout L, Beld MG, Teo YY, Rockett KA, Richardson A, Kwiatkowski DP, Molyneux ME, van Hensbroek MB. Severe anemia in Malawian children. *N Engl J Med* 2008; **358**: 888-899
- 28 Persson V, Ahmed F, Gebre-Medhin M, Greiner T. Relationships between vitamin A, iron status and helminthiasis in Bangladeshi school children. *Public Health Nutr* 2000; **3**: 83-89

- 29 Stoltzfus RJ, Albonico M, Chwaya HM, Savioli L, Tielsch J, Schulze K, Yip R. Hemoquant determination of hookworm-related blood loss and its role in iron deficiency in African children. *Am J Trop Med Hyg* 1996; **55**: 399-404
- 30 Baysoy G, Ertem D, Ademoglu E, Kotiloglu E, Keskin S, Pehlivanoglu E. Gastric histopathology, iron status and iron deficiency anemia in children with *Helicobacter pylori* infection. *J Pediatr Gastroenterol Nutr* 2004; **38**: 146-151
- 31 Ciacci C, Sabbatini F, Cavallaro R, Castiglione F, Di Bella S, Iovino P, Palumbo A, Tortora R, Amoroso D, Mazzacca G. *Helicobacter pylori* impairs iron absorption in infected individuals. *Dig Liver Dis* 2004; **36**: 455-460
- 32 Milman N, Rosenstock S, Andersen L, Jørgensen T, Bonnevie O. Serum ferritin, hemoglobin, and *Helicobacter pylori* infection: a seroepidemiologic survey comprising 2794 Danish adults. *Gastroenterology* 1998; **115**: 268-274
- 33 Valiyaveetil AN, Hamide A, Bobby Z, Krishnan R. Effect of anti-*Helicobacter pylori* therapy on outcome of iron-deficiency anemia: a randomized, controlled study. *Indian J Gastroenterol* 2005; **24**: 155-157
- 34 Choi JW. Does *Helicobacter pylori* infection relate to iron deficiency anaemia in prepubescent children under 12 years of age? *Acta paediatrica* 2003; **92**: 970-972.
- 35 Pilott A, Fabrello R, Franceschi M, Scagnelli M, Soffiati F, Di Mario F, Fortunato A, Valerio G. *Helicobacter pylori* infection in asymptomatic elderly subjects living at home or in a nursing home: effects on gastric function and nutritional status. *Age and ageing* 1996; **25**: 245-249
- 36 Sarker SA, Davidsson L, Mahmud H, Walczyk T, Hurrell RF, Gyr N, Fuchs GJ. *Helicobacter pylori* infection, iron absorption, and gastric acid secretion in Bangladeshi children. *Am J Clin Nutr* 2004; **80**: 149-153
- 37 Sarker SA, Mahmud H, Davidsson L, Alam NH, Ahmed T, Alam N, Salam MA, Beglinger C, Gyr N, Fuchs GJ. Causal relationship of *Helicobacter pylori* with iron-deficiency anemia or failure of iron supplementation in children. *Gastroenterology* 2008; **135**: 1534-1542

**Peer reviewers:** Petar Ivanovski MD, PhD, Associate Professor of Pediatrics, subspecialist of hematology, General Pediatrics, University Children's Hospital Medical Faculty University of Belgrade, 10 Tirshova str. 11000, Belgrade, Serbia.