Current prevalence and determinants of anaemia in under-five children in rural Bangladesh: a cross sectional study

Md. Moniruzzaman Mollah (dr_moniruzzaman@yahoo.com)
Rajshahi University
Ashik Mosaddi
University of Rajshahi
Asgor Hossain
Rajshahi Medical College
Andrew A. Roy
Maastricht University
Sultana Naznin
IBMCH
Parvez Hassan
Rajshahi University

Research Article

Keywords: anaemia prevalence, childhood anaemia, determinants, iron deficiency, under-five children, rural Bangladesh

Posted Date: June 15th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-609632/v1

Abstract

Background Anaemia and its association with low physical and cognitive development in under-five children remain as a common public health burden in developing countries including Bangladesh. Childhood anemia is significantly associated with age, rural residence, infant and young child feeding (IYCF) practices, infectious disease, maternal illiteracy etc. We have studied to identify current prevalence, and to explore associated socio-demographic, health, and nutritional factors of anaemia in under-five children of rural Bangladesh. Methods and materials A cross-sectional study was conducted at five remote northern districts of Bangladesh involving rural children aged 6 - <60 months. We used an interviewer-administered questionnaire for data collection. Potential study subjects were approached conveniently at selected rural health centres. Chi-squared test was the main statistical model to identify association between explanatory variables and anaemia. A p-value <0.05 was considered as significant. Results Overall prevalence of anaemia (N = 258) was 61.23% with mild, moderate and severe anaemia of 28.29%, 28.68% and 4.26% respectively. The prevalence of anaemia was the highest (72%) in age group 6-24 months, which were followed by 63% in >24-36 months and 44.3% in >36-<60 months categories. The following explanatory variables showed statistically significant association with high anaemia: younger-age (p = <0.001), low family income, and maternal education (p = <0.001), exclusive versus non-exclusive breast feeding (p = 0.02), and timely versus delayed or early weaning (p = <0.001). Non consumption of animal proteins, fruits and green leafy vegetables were also significantly linked to high anaemia prevalence (p = 0.001). Further, underweight, stunting, and wasting were significantly related to anaemia (p = 0.02, 0.006, and 0.001 respectively). Conclusion Prevalence of anaemia in under-five children of rural Bangladesh remains noticeably high. Age, maternal education, family income, consumption of animal protein, green leafy vegetables, and fruits along with underweight, stunting and wasting are inversely related to anaemia prevalence. Exclusive breast feeding and timely weaning may reduce risk of anaemia.

Background

Anaemia is one of the major public health burdens in the world particularly for young and preschool children. Globally, nearly 50% of under-five children are suffering from anaemia.[1]. Anaemia is linked to a wide range of childhood disorders such as cognitive development, low scholastic performance, insufficient physical growth and behavioral development and low immunity among others. Because of these adverse health and socio-economic consequences, anaemia prevalence of more than 40% in any population is identified as a serious public health problem.[2] Anemia is the second leading nutritional cause of diverse disorders with adverse effects on socioeconomic development.[3] Anemia is significantly associated with fetal low birth weight (LBW). sex, age, rural residence, infant and young child feeding (IYCF) practices, infectious disease (e.g., malaria, tuberculosis, intestinal parasitic infestation), under-nutrition (e.g., stunting, wasting, and underweight), poor socioeconomic status, household food insecurity, duration of lactation, poor dietary iron intake, maternal illiteracy and maternal anemia are reported as predictors of anaemia. [(4, 5, 6, 7)]

According to recent information from the South-Asian region, nearly 79% Indian children aged 6–35 months suffer from anaemia with a rural predominance.[8, 9] Anaemia still remains as one of the major cause of mortality and morbidity in many developing countries including Bangladesh..[1] In Bangladesh, several studies have reported that anemia among the under-five children is a considerable public health problem. Bangladesh Demographic Health Survey (BDHS) 2011 reported 51% anaemia prevalence in the total population.[10] An anemia prevalence of 33.1% was reported by National Micronutrient Status Survey in pre-school children with rural and urban prevalence of 37.0% and 22.8% respectively.. Several studies found that the prevalence of anemia was higher in children aged < 3 years among under-five children.[11]

Timely starting of complementary feeding at age 6 months is an utmost importance for infant growth and nutrition. In Bangladesh, nearly 62% of children start delayed complementary feeding.[10] The suboptimal infant and young child feeding (IYCF) practices along with early or delayed weaning was found associated with high level nutritional anaemia.[10] Iron deficiency is the most common cause of nutritional anemia in young children.[11, 12] Folic acid and vitamin B12 deficiency are also not uncommon causes of nutritional anaemia.[11,] Prevalence of iron deficiency anemia varies across countries with four-times higher in developing than in developed countries.[5]. Empirically, iron deficiency anemia increases risk of morbidity and mortality from infectious disease.[4,9,13] To eliminate childhood nutritional anemia, particularly iron deficiency anaemia is a public-health priority and reportedly the most common cause of anaemia among under-five children with high prevalence among rural dwellers who occupy nearly 68% of the total population of Bangladesh.[14] However, there are very few studies and consistent data on the current prevalence of anaemia and its determinants in under-five children in rural Bangladesh to fight anaemia. Hence, we aim for such a study.

Materials And Methods

Objective:

This study is aimed (i) to identify the current prevalence of anemia among under-five children in rural Bangladesh, and (ii) to assess if there are any associations of anemia with socio-demographic, health, food and nutritional factors in this target population.

Study design, settings, and population

*A cross-sectional study was conducted in the rural areas of northern Bangladesh. Eleven Upazillas (sub-district) of five districts were selected purposively as the study settings (*Table 1*). The study districts and Upazilla represent typical and nearly homogenous socioeconomic, demographic and cultural contexts of rural Bangladesh. Nearly 85% population of the sample districts were rural residents.*[10]

Table 1
Sample districts with corresponding sample upazillas

District	*Corresponding upazilla**
Joypurhat	*Panchbibi, Jopurhat Sador, Ketlal, Kalai, Akkelpur*
Dinajpur	*Hakimpur, Ghoraghat*
Naugaon	*Dhamuirhat, Bodolgachi*
Gaibandha	*Gobindogong*
Bogura	*Sibgong*

Note: several upazillas form a district.

Under-five children aged 6 - <60 months were the target population. A sample size of 325 was calculated using Cockranch's formula (*where N = Sample size, z = 1.96 (95% confidence level), p = 33% estimated prevalence of anemia in under-five population basing on available information, and e = 0.05 at 5% margin of error).*

Rural children of aged 6 - <60 months whose guardians provided written consent were included in the study. Children who were living in urban, i.e., municipality area, in need of emergency care and hospitalization, and/or having history of blood transfusion within last three months from the date of data collection were not included.

Data collection tools and techniques

A questionnaire was prepared involving three researchers; any contradictions were solved by discussion. A piloting was conducted by the Principal Investigator (PI) involving parents of ten patients for testing mainly the qualitative variables and to develop skills of the PI. The questionnaire was finalized with minimum changes and contained the following four main section : *particulars of the child*ren, *quantitative domains*: nutritional anthropometry (height/length, weight) and laboratory reports (complete hemogram, ferritin level, Hb electrophoresis, Zinc level, Folate and vitamin B_{12} assay); *qualitative domains*: socio- demographic variables (maternal education, income and occupation of household head, number of children, consanguinity), nutrition (breast feeding, IYCF, stunting, wasting, underweight, consumption of protein, fruits, vegetable) and health (maturity at birth and birth size, and history of recent infection.

Data was collected consecutively from purposively selected 22 rural health facilities and EPI outreach centers in the study Upazilas. At first the PI (a child health specialist experienced in primary research), approached the under-five children presented at the out-patient department of the selected health facilities. The objectives of the study and the reason of collecting blood were explained. Parents/guardians were assured free of cost blood tests which would solely be used for the study. They were also assured access to the study findings with a guideline for the next treatment options, but without financial benefits. Following an initial face-to-face interview for collecting qualitative data, parents with eligible child were sent to the assigned laboratory. *Five millilitre (ml) venous blood was drawn using a sterile syringe (3ml blood were preserved into ethylene ediamine tetraacetic acid (EDTA) vial and the next 2ml into another test-tube for separating serum). The EDTA blood was analyzed on the same day with an 'Automated Hematology Analyzer' (Nihon Kohden,Tokyo, Japan) for a Complete Blood Count (CBC; i.e., haemoglobin percentage, hematocrit), Red cell indices (i.e., MCV, MCH, MCHC, RWD), total count of white blood cell (WBC), differential count of WBC and total platelet count. The degree of anaemia was classified into three categories on the basis of hemoglobin level as defined by the World Health Organization.*[3]*Accordingly, mild anaemia was considered with a Hb% of 10.00–10.90 gm/dl, which for moderate and severe anaemia were 7.00–9.90 gm/dl and < 7.00gm/dl respectively.*

Basing on mean corpuscular volume (MCV), anemia were further classified as normocytic (MCV 80–96 fl), microcytic (MCV < 80 fl), and macrocytic (MCV > 96 fl). Serum Ferritin and/or Hb-electrophoresis were done in children with microcytic hypochromic anemia; whereas macrocytic anemias were evaluated assaying Vitamin B_{12} and folic acid levels; and normocytic normochromic anaemia were investigated with Serum Zinc level to reach the etiological pattern of anemia (Fig. 1).

Ethical clearance

Ethical clearance was obtained from the Institutional Animal, Medical Ethics, Bio-safety and Bio-security Committee (IAMEBBC) of the Institute of Biological Sciences, Rajshahi University (memo no: 83/320/IAMEBBC/IBSC, date: 27 August 2017). Informed written consents were taken from parents of the sample children.

Statistical analysis

Data were computed and analyzed using SPSS (version 23.0). Univariate analysis and chai-squared tests were the main models to identify the prevalence of anaemia and to assess any association between the independent variables and anaemia. A p-value < 0.05 was considered as significant.

Results

Because of time and resource constraints, it was possible to collect data from a total of 258 target children from a total of eleven sample upazillas of five districts (Table 2). 60% of the total study subjects were male and the rest were female. Overall prevalence of anaemia was 61.23% (N = 258). Of the total male children (n = 154), nearly 65% were anaemic and that was 56% in female children (n = 104).

Table 2
distribution of sample children across the sample districts

District (No. of Upazilla)	Sampled children (% of total enrolled)
Joypurhat (5)	90 (34.88%)
Dinajpur (2)	59 (22.86%)
Gaibandha (1)	38 (14.73%)
Naugaon (2)	41 (15.90%)
Bogura (1)	30 (11.63%)

The gender difference in prevalence of anaemia was not significant ($p = 0.088$). The majority (50%) children was in age group 6–24 months, which was followed by > 36–60 months (34%) and > 24–36 months (16%). The prevalence of anaemia was 72%, the highest, in 6–24 months

Table 3
Socio-demographic characteristics of the participant children in relation to anaemia

Variables	Subject distribution (%) (N = 258)	Prevalence of anaemia n = 158 (100%)	Chi-squire statistics
Gender		100 (64.93)	χ^2 = 791.22; p = 0.08 phi = − .092
Male	154 (59.7%)		
Female	104 (40.3%)	58 (55.77)	
Age (in month)			χ^2 = 9.1; p = 0.001 phi = .257
6–24	129 (50%)	93 (72.09)	
> 24–36	41 (15.9%)	26 (63.41)	
> 36–59	88 (34.1%)	39 (44.31)	
Religion or ethnicity			χ^2 = 792.4; p = 0.117 phi = .129
Islam	229 (88.8%)	145 (63.31)	
Hinduism	22 (8.5%)	9 (40.90)	
Indigenous	7 (2.7%)	4 (57.14)	
Education level of mother			χ^2 =783.31; p = 0.001 phi = .228
Primary enrollment or below	151 (58.5%)	104 (68.87)	
Secondary enrollment	65 (25.2%)	38 (58.46)	
Above secondary or higher	42 (16.3%)	16 (38.09)	
Number of children (parity)			χ^2 = 478; p = 0.35 phi = − .058
≤ 2	235 (91.1%)	146 (62.12)	
> 2	23 (8.9%)	12 (52.17)	
Occupation of household head			χ^2 = 8.6; p = 0.111 phi = .153
Service (public or private)	89 (34.5%)	54 (60.67)	
Agriculture	63 (24.4%)	41 (65.07)	
Small Business	91 (35.3%)	50 (54.94)	
Day Labour	15 (5.8%)	13 (86.66)	
Monthly (family) income **in Taka**			χ^2=811.62; p = < 0.001 phi = .318
≤ 5000	29 (11.2%)	(21) 72.41	
5001–10000	87 (33.8%)	68 (78.16)	
10001- 20,000	80 (31.0%)	45 (56.25)	
>20,000	62 (24.0%)	24 (38.70)	

group, which was followed by 63% in age group > 24–36 months and 44.3% in > 36–60

months with a statistically significant association between age categories and anaemia ($p = < 0.001$). Among the children, Muslims were from the majority 88.8% and the rest were from Hindu and indigenous population. The prevalence of anaemia was the highest (63.3%) in

Muslims, which was followed by 57.1% in indigenous group and 40.9% in Hindus. The association between religion and anaemia was not significant ($p = 0.12$) (Table 2).

Parity (i.e., mothers with ≤ 2 children (91.1%) versus > 2 children (8.9%)) was found not significantly associated with anaemia ($p = 0.23$). The distribution of small business and service were nearly equal of the children's family heads' occupation, 35.5% and 34.5% respectively and that the rest 24.4% and 5.8% were farming and day labour. Prevalence of anaemia in children belong to the day labour families was noticeably the highest (nearly 87%), which among the children in the other three family occupation groups were nearly equal ranging from 55% in small business family to 65% in farmer family. There was no significant association between anaemia and family occupations ($p = 0.11$).

Among four categories of monthly family income, distributions of children were nearly equal in the middle two family income groups (i.e., 33.8% and 31% in 5,001–10,000 Taka (the Bangladesh currency) and 10,001–20,000 Taka groups respectively). Notably, children of the lowest two family income groups had nearly equally the highest prevalence of anaemia; 78% and 72% in 5,001–10,000 Taka and ≤ 5,000 Taka groups respectively (Table 1). Anaemia was found significantly associated with monthly family income ($p = < 0.001$) (Table 1). The majority, 58.5% of the total mothers' education level was below primary level. Maternal education was found significantly associated with children's anaemia ($p = 0.001$) (Table 3).

Table 4
Nutrition and food related factors associated with the prevalence of anaemia (n = 258)

Variables	Subject distribution (%) (N = 258)	Prevalence of anaemia	Chi-squire statistics
Exclusive Breast feeding			
Yes	186 (72.1%)	106 (56.99%)	$\chi^2 = 5.074$; $p = 0.016$
No	72 (27.9%)	52 (72.22%)	phi = .140
Timely weaning/IYCF practice			
Yes	169 (65.5%)	89 (52.66%)	$\chi^2 = 15.186$; $p = < 0.001$
No	89 (34.5%)	69 (77.52%)	phi = .243
Animal protein intake regularly			
Yes	210 (81.4%)	113 (53.80%)	$\chi^2 = 26.257$; $p = < 0.001$ phi = .319
No	48 (18.6%)	45 (93.75%)	
Plant protein intake regularly			
Yes	93 (36%)	50 (53.76%)	$\chi^2 = 3.425$; $p = 0.064$
No	165 (64%)	108 (65.45%)	phi = .115
Fruits intake regularly			
Yes	141 (54.7%)	70 (49.65%)	$\chi^2 = 17.61$; $p = < 0.001$
No	117 (45.3%)	88 (75.21%)	phi = .261
Green leafy vegetable regularly			
Yes	150 (58.1%)	77 (51.33%	$\chi^2 = 14.81$; $p = < 0.001$
No	108 (41.9%)	81 (75%)	phi = .240
Underweight			
Yes	40 (15.5%)	31 (77.5%)	$\chi^2 = 5.27$; $p = 0.022$
No	218 (84.5%)	127 (58.26%)	phi = .143
Stunted			
Yes	74 (28.7%)	55 (74.32%)	$\chi^2 = 7.48$; $p = 0.007$
No	184 (31.3%)	103 (55.98%)	phi = .170
Wasted			
Yes	29 (11.2%)	26 (89.66%)	$\chi^2 = 11.11$; $p = < 0.001$
No	229 (88.8%)	132 (57.64%)	phi = .208

Exclusive breast feeding children had nearly 18% lower anaemia prevalence than non-exclusive breast feeding group and the difference was statistically significant ($p = 0.02$). Delayed or early weaning-practiced children had nearly 25% higher prevalence of anaemia than their properly weaning counterpart with a statistically significant difference ($p = < 0.001$). Non-consumption of animal protein group were found almost 2 times higher anaemia prevalence than animal protein consumption group, which was statistically significant ($p = 0.001$). Plant protein (pulses) intake group had nearly 10% lower anaemia prevalence than non-consumption group, which was not significant ($p = 0.064$).

Children with regular fruits intake had significantly lower prevalence of anaemia by 26% than non-consumption group ($p = 0.001$). Children with regular intake of green leafy vegetables also had nearly 26% lower anaemia prevalence than in non-consumption group with a statistically significant difference ($p = 0.001$). Underweight children had 1.5 times higher prevalence of anaemia than their normal counterpart with a significant difference ($p = 0.022$). Stunted children were found 20% higher and significant risk of developing anaemia than their counterpart ($p = 0.006$). Acute under-nourished children had nearly twice higher vulnerability of developing anaemia than normal children with a significant difference ($p = 0.001$) (Table 4).

Parents' consanguinity status showed no significant difference in childhood anaemia ($p = 0.373$). Pre-term children had nearly 4.5 times and 9 times higher anaemia prevalence than term and post-term babies respectively although the differences were not significant ($p = 0.153$). Birth size of babies (normal/small/large) had no significant influence on the prevalence of anaemia ($p = 0.69$). Children suffering from chronic illness or recent illness had 23% higher anaemia prevalence than apparently healthy children, which was statistically significant ($p = 0.001$) (Table 5).

Table 5
Association of key health and social factors to anaemia (N = 258)

Variables	Distribution of subjects (%) (N = 258)	Prevalence of anaemia (%)	Chi-squire statistics
Consanguinity of parents			*$\chi^2 = 1.058$; p = .373*
Yes	39 (15.1%)	21 (53.84%)	*Phi = .064*
No	219 (84.9%)	137 (62.55%)	
Maturity level at birth			*$\chi^2 = 3.758$; p = 0.153*
Full term	201 (77.91%)	12 (5.79%)	*Phi = .121*
Pre-term	45 (17.44%)	32 (71.11%)	
Post-term	12(04.65%)	5 (41.67%)	
Size of baby at birth			*$\chi^2 = 0.724$; p = 0.69*
Normal	148 (57.4%)	5 (62.12%)	*Phi = .054*
Small	50 (19.4%)	32 (64.00%)	
Large	60 (23.2)	34 (56.66%)	
Chronic illness or recent illness			*$\chi^2 = 12.867$; p = 0.001*
Yes	97 (37.6%)	73 (75.25%)	*Phi = .223*
No	161 (62.4%)	85 (52.79%)	

Among the anaemic children ($n = 158$), mild (Hb% 10-<11 gm/dl) and moderate (Hb% 7-<10 gm/dl) degree of anaemia were nearly equally distributed 46.2% ($n = 73$) and 47% ($n = 74$) respectively, whereas severe anaemia (Hb% <7 gm/dl) was only 7%.

Discussion

The study was undertaken to assess the current prevalence of anemia and its association with socio-demographic, health and nutritional factors in under-five children in rural Bangladesh.

The overall prevalence of anaemia (N = 258) was 61.23% with proportion of mild, moderate and severe anaemia of 28.29%, 28.68% and 4.26% respectively. High prevalence of anaemia was found in some other studies in India, Tanzania, Kenya, and South Africa where the prevalence of anaemia was observed between (69% – 79%) in under-five children[18–20,29]. The prevalence of severe anaemia (4.26%) was lower than in similar settings; for example, Muoneke et al,[15] reported a prevalence of severe anaemia of 9.7% in Nigerian under-five children. Nearly consistent trends of mild, moderate and severe anaemia and associated factors in under-five children of this study were found in a study of Simbauranga et al at Tanzania.[16] In their study, the mild, moderate and severe anaemia were found 16.5%, 33% and 27.7% respectively. In a study in India, the overall prevalence of anaemia in under-five children was found 69.5% with percentage of mild moderate and severe anaemia were 26.2%,, 40.4%, 2.9% respectively[30], which is nearly consistent with our findings.

Mild and moderate anaemia in the total sample accounted nearly equally, 30% each, may be due to nutritional deficiencies and socio-demography related factors in rural Bangladesh. We found no association between gender and anaemia. Age is a significant factor of anaemia in under-five children with the highest prevalence (73%) in < 24 months age group than their older counterparts. These findings is consistent with the study findings of Goswmai and Das and the authors mentioned that high demand for nutrients to support the rapid body growth of the children at this age against a low supply might be the key underlying factor.[17] We also found that increasing trends of anaemia up to 2 years and then decreasing after 2 years may be relating to the children's ability to eat varieties of foods. This finding is consistent with the study of Gebreweld et al.[18] We found no significant link of ethnicity, religion or consanguinity to childhood anaemia which contradicts the findings of Goswmai and Das.[17] In this Indian study among under-five children, the authors found significant difference in religion and all types of anaemia prevalence (severe, moderate, and mild) were higher among children of Hindu families than other religions. We found that higher the mother's level of education lower the anaemia prevalence in children. Children of mothers with higher/above HSC education level had nearly two times lower risk of developing anaemia than that in below HSC level mothers. This finding is agreed with the studies of Kuziga et al.[19] and Leite et al [20]. We found that neither occupation nor parity is significantly linked to childhood anaemia. However, family income is a significant factor with an inverse relationship between income and prevalence of childhood anaemia. The similar observations were also noted in some previous studies. [20, 21–22] This is may be due to the fact that higher income is linked to good maternal education and better nutritional protection to children.

Both non-exclusive breast feeding and delayed/early weaning were found significant factors of developing anaemia in children. Oppositely, EBF, timely weaning, regular consumption of animal protein, green leafy vegetables and locally available fruits were found protective to childhood anaemia. These findings are consistent with the study of Kejo et al.[23] Stunted, underweight and wasted children were found more anaemic, which is consistent with the study of Kisiangani et al. [24]. Children with chronic illness and recent illness were nearly 1.5 time high risk of developing anaemia which is also comply with the findings of Kumari et al.[25] However, it is not known if those disorders are causing anaemia or vice versa although synergistic effects on each other are well-known.

Limitations and strengths

Because of time and resource limits, the sample size was smaller than expected. The study was confined in northern Bangladesh. However, in nearly a homogenous rural context of the country, this study finding is claimed as a reflection of the childhood anaemia scenario of rural Bangladesh. In regard to the associated factors of anaemia, only univariant analyses were done, but the variants did not put together in a regressive model to identify the potential predictors.

Conclusion

Prevalence of anaemia in under-five children of rural Bangladesh remains noticeably high. Age, maternal education, family income, consumption of animal protein, green leafy vegetables, and fruits along with underweight, stunting and wasting are inversely related to anaemia prevalence. Exclusive breast feeding and timely weaning may reduce risk of anaemia. In addition, chronic and recent illness increase susceptibility to anaemia development.

Abbreviations

BDHS
Bangladesh Demographic Health Survey
CBC
Complete Blood Count
LBW
low birth weight
EDTA
Ethylene-Diamine-Tetraacetic-Acid
EPI
Expanded Programme on Immunization
Hb
Hemoglobin
HKI
Helen Keller International
HIV
Human Immunodeficiency Virus
ICDDR,B
International Centre for Diarrheal Disease Research, Bangladesh
IDA
Iron Deficiency Anaemia
IPHN
Institute of Public Health Nutrition
IYCF
Infant and Young Child Feeding
MCH
Mean corpuscular hemoglobin
MCHC
Mean corpuscular hemoglobin concentration
MCV
Mean corpuscular volume
ORC
Out Reach Centre

PreSAC
Pre-school aged children
RBC
Red Blood Cell
RDW
Red Cell distribution Width
UNICEF
United Nations International Children's Emergency Fund
WHO
World Health Organization.
UHC
Upazila Health Complex
SAC
School aged children

Declarations

Ethics approval

*Ethical clearance was obtained from the Institutional Animal, Medical Ethics, Bio-safety and Bio-security Committee (IAMEBBC) of the Institute of Biological Sciences, Rajshahi University (*memo no: 83/320/IAMEBBC/IBSC, date: 27 August 2017*). Informed written consent were taken from the attending guardian of enrolled children.*

Consent for publication: not applicable.

Availability of data and materials

Data of this study will be made available from the corresponding author on rational request.

Competing interests

All authors declare that they have no competing interests.

Funding

The research was funded by the *Institute of Biological Sciences, Rajshahi University, Rajshahi, Bangladesh*

Authors' contributions

MdMM: research concept, questionnaire development, interview, data collection, nutritional anthropometry, data processing, analyzing, interpreting, and writing the manuscript. AM: research concept, developing questionnaire, reviewing and revising the final manuscript. AH: Checking clinical data, and methodology development, AAR: developing research concept, major contribution in statistical analysis, data interpretation, reviewing the manuscript, and revising the final version. SN: data processing, questionnaire development PH: research concept, developing questionnaire, data interpretation, reviewing and revising the final manuscript. All authors read and approved the final manuscript.

Acknowledgements

Authors of the paper acknowledge and offer thanks to *the Institute of Biological Sciences, Rajshahi University for providing resourceful environment for conducting the research. Also the cooperation of the expert laboratory staff is highly appreciated.*

Authors' information

Md. Moniruzzaman Mollah, (MBBS, DCH) PhD Fellow (IBSc), Assistant Professor, Department of Paediatrics, Shaheed Ziaur Rahman Medical College, Bogura, Bangladesh; Prof. Dr. Ashik Mosaddi PhD, Professor and Chairman, Department of Pharmacy, University of Rajshahi, Rajshahi; Dr. Asgor Hossain, MBBS, FCPS. Associate Prof. (Rtd.), Department of Paediatrics, Rajshahi Medical College, Rajshahi, Bangladesh; Dr. Andrew A. Roy (PhD, MBBS, MSc, MPH) Faculty and Researcher, Department of Medicine and Biomedical Sciences, Maastricht University, the Netherlands; Dr. Sultana Naznin MBBS, DGO. Resident Surgeon, Department of Gynae and Obs, IBMCH, Rajshahi, Bangladesh; Prof. Dr. Parvez Hassan PhD, IBSc, Rajshahi University, Rajshahi, Bangladesh.

References

1. Khan JR, Awan N, Misu F. Determinants of anemia among 6-59 months aged children in Bangladesh: Evidence from nationally representative data. *BMC Pediatr*. 2016;16(1):1-13. doi:10.1186/s12887-015-0536-z

2. World Health Organization. *Iron Deficiency Anaemia: Assessment, Prevention, and Control A Guide for Programme Managers*. 2001;Vol 314.

3. World Health Organization. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993-2005. 2009. doi:10.1017/S1368980008002401

4. Haas JD, Brownlie IV T. Iron deficiency and reduced work capacity: A critical review of the research to determine a causal relationship. *J Nutr*. 2001;131(2 SUPPL. 2):676-690. doi:10.1093/jn/131.2.676s

5. Villalpando S, Shamah-levy T, Sc B, Ramírez-silva CI, Mejía-rodríguez F, Rivera JA. Prevalence of anemia in children 1 to 12 years of age . Results from a nationwide probabilistic survey in Mexico. *salud pública méxico /*. 2003;45(1).

6. Shet A, Mehta S, Rajagopalan N, et al. Anemia and growth failure among HIV-infected children in India: A retrospective analysis. *BMC Pediatr*. 2009;9:1-9. doi:10.1186/1471-2431-9-37

7. S. Akers A, Howard D, Ford J. Distinguishing iron deficiency anaemia from thalassemia trait in clinical obstetric practice. *J Pregnancy Reprod*. 2018;2(1):1-6. doi:10.15761/jpr.1000125

8. USAID. *Overview of the Nutrition Situation in Four Countries in South and Central Asia*.; 2014.

9. Pasricha SR, Black J, Muthayya S, et al. Determinants of anemia among young children in rural India. *Pediatrics*. 2010;126(1). doi:10.1542/peds.2009-3108

10. National Institute of Population Research and Training. *BANGLADESH BANGLADESH AND HEALTH SURVEY 2014*.; 2014.

11. International Centre for Diarrhoeal Disease Research Bangladesh. *National Micronutrients Status Survey 2011-12: Final Report*.; 2013. https://static1.squarespace.com/static/56424f6ce4b0552eb7fdc4e8/t/57490d3159827e39bd4d2314/1464405328062/Bangladesh_NMS_final_report_2011-12.pdf.

12. Gamit M, Talwelkar H. Survey of different types of anemia. *Int J Med Sci Public Heal*. 2017;6(3):1. doi:10.5455/ijmsph.2017.0851807092016

13. Oppenheimer SJ. Iron-deficiency anemia: reexamining the nature and magnitude of the public health problem. *J Nutr*. 2001;131:616-635.

14. Institute of Public Health Nutrition. *Institute of Public Health Nutrition Directorate General of Health Services Ministry of Health and Family Welfare Government of the People's Republic of Bangladesh*.; 2015. http://iphn.dghs.gov.bd/wp-content/uploads/2016/01/NMDCS-.pdf.

15. Muoneke VU, ChidiIbekwe R. Prevalence and Aetiology of Severe Anaemia in Under-5 Children in Abakaliki South Eastern Nigeria. *Pediatr Ther*. 2011;01(03):3-7. doi:10.4172/2161-0665.1000107

16. Simbauranga RH, Kamugisha E, Hokororo A, Kidenya BR, Makani J. Prevalence and factors associated with severe anaemia amongst under-five children hospitalized at Bugando Medical Centre, Mwanza, Tanzania. *BMC Hematol*. 2015;15(1). doi:10.1186/s12878-015-0033-5

17. Goswmai S, Das KK. Socio-economic and demographic determinants of childhood anemia. *J Pediatr (Rio J)*. 2015;91(5):471-477. doi:10.1016/j.jped.2014.09.009

18. Gebreweld A, Ali N, Ali R, Fisha T. Prevalence of anemia and its associated factors among children under five years of age attending at Guguftu health center, South Wollo, Northeast Ethiopia. *PLoS One*. 2019;14(7):1-13. doi:10.1371/journal.pone.0218961

19. Kuziga F, Adoke Y, Wanyenze RK. Prevalence and factors associated with anaemia among children aged 6 to 59 months in Namutumba district, Uganda: A cross- sectional study. *BMC Pediatr*. 2017;17(1):1-9. doi:10.1186/s12887-017-0782-3

20. Leite MS, Cardoso AM, Coimbra CE, et al. Prevalence of anemia and associated factors among indigenous children in Brazil: Results from the First National Survey of Indigenous People's Health and Nutrition. *Nutr J*. 2013;12(1):1-11. doi:10.1186/1475-2891-12-69

21. Parbey PA, Tarkang E, Manu E, et al. Risk Factors of Anaemia among Children under Five Years in the Hohoe Municipality, Ghana: A Case Control Study. *Anemia*. 2019;2019. doi:10.1155/2019/2139717

22. Magalhães RJS, Clements ACA. Mapping the risk of anaemia in preschool-age children: The contribution of malnutrition, malaria, and helminth infections in West Africa. *PLoS Med*. 2011;8(6). doi:10.1371/journal.pmed.1000438

23. Kejo D, Petrucka P, Martin H, Kimanya M, Mosha T. Prevalence and predictors of anemia among children under 5 years of age in Arusha District, Tanzania. *Pediatr Heal Med Ther*. 2018;Volume 9:9-15. doi:10.2147/phmt.s148515

24. Kisiangani I, Mbakaya C, Makokha A. Prevalence of Anaemia and Associated Factors Among Preschool Children (6-59 Months) in Western Province , Kenya. *Public Heal Prev Med*. 2015;1(1):28-32.

25. Kumari S, Garg N, Kumar A, et al. Maternal and severe anaemia in delivering women is associated with risk of preterm and low birth weight: A cross sectional study from Jharkhand, India. *One Heal*. 2019;8(February):100098. doi:10.1016/j.onehlt.2019.100098

Figures

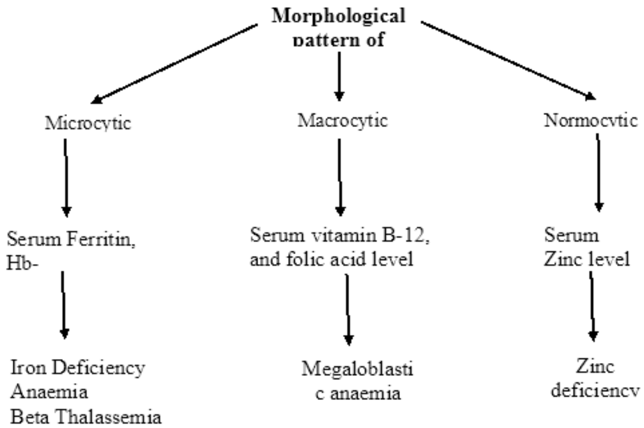

Figure 1

laboratory diagnostic algorithm of anaemia