An investigation on prevalence of Anaemia in relation to BMI and nutrient intake among adult rural population of West Bengal, India

Amitava Pal[1], Sujaya De[1], Piyali Sengupta[1], Payel Maity[1], Prakash C. Dhara[1]

ABSTRACT

BACKGROUND: Anaemia is now globally recognized as a major public health problem. The present study was undertaken to investigate the prevalence of anaemia and interrelationship of anaemia with BMI among the adult rural population of the state of West Bengal India.

METHODS: Anthropometric measures, nutritional parameters, heart rate and hemoglobin were measured from 311 adult subjects by using standard technique.

RESULTS: The prevalence of anaemia was high among both sexes and more than the global prevalence. The anaemic individuals consumed nutritionally deficient diet than the non-anaemic individuals. The prevalence of anaemia was significantly high in underweight and normal groups. The odd ratio became significantly higher in underweight group than normal and overweight/obese groups of both sexes.

CONCLUSIONS: The prevalence of anaemia in the adult rural population might be related to dietary deficiency and poor dietary patterns. The present study indicated that the subjects with low BMI would have a higher risk of anaemia compared to normal or overweight subjects.

Key words: Anaemia, BMI, Nutritional parameter, adult rural population

(1) Dept. Human Physiology with Community Health, Vidyasagar University, Midnapore-721102, West Bengal, India

CORRESPONDING AUTHOR: *Prakash C. Dhara, Ergonomics and Sports Physiology Division, Dept. Human physiology with Community Health, Vidyasagar University, Midnapore-721102, West Bengal, India. Tel: 91-03222-276554 Extn- 450, Fax 91-03222- 275329. Email: prakashdhara@rediffmail.com*

DOI: ***10.2427/8915***

Published as Online First on June 3, 2014

INTRODUCTION

Anaemia continues to be a major public health problem worldwide; particularly most affected are children and women in both developing and developed countries and it is an indicator of poor nutrition and poor health with major consequences for human health as well as for the social and economic development of a population. Worldwide, at any given moment, more individuals have been suffering from iron-deficiency anaemia

than any other health problem [1]. Globally, anaemia affects about 1.62 billion people, which corresponds to 24.8% of the world population [2]. Prevalence of anaemia in South Asia is the highest in the world, which reflects overall higher rates of malnutrition. Anaemia is one of the most common health problems in India which is much more prevalent in the rural population than the urban [3]. Seshadri S. [4] studied on the prevalence of anaemia among pregnant and lactating females and children and reported that the prevalence of anaemia varies from 50-90% in different parts of India.

In case of both male and female, the prevalence of anaemia was the highest among those with severe undernutrition [5]. Haematological parameter like haemoglobin (Hb) is generally known to be affected by socioeconomic conditions, especially via nutrition, as the nutritional status largely depends upon the socioeconomic condition [6-8]. More than one third of Indian female population has a body mass index (BMI) of below 18.5 kg/m^2, which reflects chronic energy and micronutrient deficit [8].

Anaemia can result in decreased muscular strength, weakness, lowered physical activity, fall injury, diminished physical and mental capacity, increased frailty risk, increased morbidity from infectious diseases, perinatal and neonatal mortality, inadequate iron stores for the newborn, premature delivery, low birth weight and impaired cognitive performance, motor development and scholastic achievement in children [9-11]. Agarwal et al [12] studied nutritional status, physical work capacity and mental function of school children and showed that infants who were born to mothers with severe anaemia had a higher risk of irreversible brain damage, lower school achievement, reduced physical and exercise tolerance and poor immune response. Another report stated that anaemia in young children was a matter of serious concern because it impaired cognitive performance, behavioral and motor development, co-ordination, language development and scholastic achievement which resulted in a lower Intelligence Quotient (IQ) and behavioral abnormalities, as well as retardation of growth and increased morbidity from infectious diseases [13-14]. Anaemia in childbearing female increases the risk of maternal morbidity and mortality, perinatal and neonatal mortality, inadequate iron stores for the newborn, premature delivery and low birth weight [15-16].

Almost all the studies at national and local level have focused predominantly on pregnant and lactating female, and children. Reliable data on the prevalence of anaemia in the adult population (non-pregnant female and adult male) is not much available, especially among the adult rural population in West Bengal. Thus the present study was undertaken to investigate the prevalence of anaemia among the adult male and non-pregnant female in rural areas of the state of West Bengal, India.

MATERIALS AND METHODS

Selection of site and subjects

The study was conducted on 311 subjects of which 148 were male and 163 were female in the age group of 18-60 years, selected from different villages of different districts of West Bengal, India. Most of the subjects were engaged in jobs of low socio-economic status, as per standard scale, ranging from farming to day labour. Ethical approval and prior permission was obtained from Vidyasagar University Ethics Committee before commencement of the study and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. Prior to the experimental trial, the protocol was explained verbally in local language (Bengali) and informed consent was obtained from the subjects during field visits and the available adult male and female members of the households of above mentioned areas were randomly selected as subjects. Pregnant and lactating females were excluded from the study. They were measured on the same day or another as per their agreement by fixing prior appointments. Subjects were interviewed and measured at their respective households. In some cases, due to logistical problems, they were taken to a common place where a number of them were examined.

Measurement of anthropometric dimensions

Anthropometric measurements were taken from the subjects following standard technique and appropriate landmarks. Height

was measured to the nearest 0.1 cm using anthropometer (Hindustan Minerals) and weight to the nearest 0.1 kg using portable weighing machine (Libra). From measures of height and weight of the subjects the body mass index (BMI) was computed using the following standard equation: BMI = weight(kg)/height(m2). Individuals were classified into different nutritional categories using the following World Health Organization prescribed BMI cutoff values [17]:

- Underweight: BMI<18.5 kg/m^2
- Normal : BMI 18.5 to 24.9 kg/m^2
- Overweight: BMI 25-29.9 kg/m^2
- Obese: BMI ≥30 kg/m^2.

The World Health Organization's classification [17] of the public health problem of low BMI based on adult populations worldwide was followed. This classification categorizes prevalence according to percentage of a population with BMI<18·5 kg/m^2:

- Low (5–9%): warning sign, monitoring required
- Medium (10–19%): poor situation
- High (20–39%): serious situation
- Very high (>40%): critical situation.

Assessment of nutritional status

Nutritional status of the subjects was evaluated by 24-hr recall method [18] for the four meals consumed (i.e., breakfast, lunch, snacks and dinner). The person primarily responsible for preparing the meals was questioned about the recipes, ingredients and amount of dishes consumed by household members. From the quantity of the food taken by the subjects, the amounts of energy, carbohydrate, protein, fat, minerals and vitamins were calculated by using Indian Council of Medical Research (ICMR) [19] food composition table.

Determination of Hemoglobin Concentration

The hemoglobin (Hb) status was measured with a finger prick sample of capillary blood and analyzed immediately using a hemoglobinometer (STAT-Site M Hemoglobin Analyzer, STANBIO Laboratory, USA). Both male and female subjects were classified as mildly, moderately or severely anaemic based upon their hemoglobin status following international reference [16]. Anaemia was defined as Hb of <13g/dl in male and Hb of <12g/dl in female. Mild anaemia was defined as Hb of 10-12.9 g/dl in male, Hb of 10 –11.9 g/dl in female. Moderate anaemia was defined as Hb of 7-9.9 g/dl and severe anaemia as an Hb of < 7 g/dl in both male and female population.

Statistical analysis

The sample size was determined by the standard formula ($n=z^2pq/d^2$) [20]. The minimum estimated sample size was 248 [$(1.96^2\times0.63^2\times0.368)/0.06^2$]. The calculation was based on 63.2% prevalence (p) of anaemia among the Bengalee population [21] with desired precision (d) of 6%. Where, q = p-1and z = 1.96. Data were presented by sex. Age, anthropometric measures, heart rate, hemoglobin content and nutritional variables were described by their means and standard deviations. To test the significance of difference of different parameters, the t- test was performed with Bonferroni adjustment. One-way analyses (Scheffe's procedure) were carried out to test differences in mean hemoglobin content across the three BMI categories. Chi-square analysis was done to determine the differences in the prevalence of anaemia among the sexes and different nutritional categories. Odd ratio (OR) were calculated to determine the change in prevalence of anaemia with increasing BMI.

RESULTS

The physical characteristics, hemoglobin content and heart rate values of the subjects were shown in Table 1 according to the sex. Of the 311 subjects, 47.59% were male and 52.41% were female. The mean ages of males and females were 36.58±12.19 years and 34.40±14.64 years respectively. No significant difference in mean age was obtained between the sexes. All the anthropometric measures and hemoglobin content were significantly higher in male than those of female subjects. The result also indicated that the mean values of BMI and physiological parameters of subjects were within the normal range except hemoglobin level of both sexes.

The prevalence of anaemia was studied among the study population (Table 2) based on

TABLE 1

MEAN± SD OF DIFFERENT ANTHROPOMETRIC MEASUREMENTS, HEMOGLOBIN CONTENT AND HEART RATE OF ADULT MALE AND FEMALE SUBJECTS

PARAMETERS	MALE (n=148)	FEMALE (n=163)
AGE (years)	36.58±12.19	34.40±14.64
HEIGHT (cm)	163.37±4.86	151.14±6.20***
WEIGHT (kg)	56.62±8.75	44.69±9.55***
BMI (kg/m^2)	21.20±3.06	19.49±3.57***
HB CONC (g/dl)	12.19±2.27	10.26±2.13***
HEART RATE (beats/min)	81.07±10.40	80.97±12.14

*** p'<0.002

TABLE 2

FREQUENCY (f) AND PERCENTAGE (%) OF MALE AND FEMALE HAVING DIFFERENT CATEGORIES OF ANAEMIA

ANAEMIA CLASSIFICATION	FREQUENCY (f)		PERCENTAGE (%)	
	MALE	FEMALE	MALE	FEMALE
MILD (MALE- HB.10-12.9 g/dl; FEMALE- HB.10 –11.9 g/dl)	44	59	29.73	36.20
MODERATE (HB.7-9.9 g/dl)	18	32	12.16	19.63
SEVERE (HB.< 7 g/dl)	7	18	4.73	11.04
ALL CATEGORY (MALE- HB.<13 g/dl; FEMALE- HB.<12 g/dl)	69	109	46.62	66.87

World Health Organization (WHO) prescribed hemoglobin cutoff values as mentioned earlier [16] and it was found that the prevalence of anaemia was significantly ($p<0.001$) higher among females than males (male 46.62%; female 66.87%). The occurrence of mild anaemia cases was higher (males 29.73%; females 36.20%) than that of moderate anaemia (males 12.16%; females 19.63%) and severe anaemia cases (males 4.73%; females 11.04%) in the study population. Again the subjects were categorized into anaemic and non-anaemic groups and the mean values of physiological parameter of two groups of both sexes have been shown in Table 3. The results indicated that mean values of BMI was significantly lower among anaemic individuals than the non-anaemic individuals. However, the mean value of heart rate was significantly higher in anaemic groups than that of non-anaemic groups.

The energy and macronutrient intake of the subjects were studied (Table 4) and it was revealed that the anaemic individuals had significantly poor consumption of energy, carbohydrate and protein than the non-anaemic individuals. The vitamin and mineral intake of the anaemic subjects were also significantly lower than that of non-anaemic subjects of both sexes.

Based on BMI cut-off value [17] the subjects were again subdivided into three nutritional categories, viz., underweight, normal and overweight/obese. It was found that the underweight was prevalent (male 27.03%; female 44.17%) among them. About 58.78% male and 46.01% female of the subjects were normal while a low percentage (male 14.19%; female 9.82%) of them were overweight / obese. Based on the WHO [17] classification, the prevalence of underweight among this population was studied and it was revealed that the prevalence of underweight was high among male and very high among female and

TABLE 3

MEAN± SD OF AGE, BMI AND HEART RATE OF ANAEMIC AND NON ANAEMIC SUBJECTS

PARAMETERS	MALE		FEMALE	
	NON ANAEMIC (n=79)	ANAEMIC (n=69)	NON ANAEMIC (n=54)	ANAEMIC (n=109)
AGE (years)	37.52±12.62	40.03±14.65	37.83±12.36	32.71±15.42
BMI (kg/m^2)	22.00±3.16	20.28±2.67***	20.52±4.16	18.98±3.13**
HEART RATE (beats/min)	75.67±7.88	87.25±9.44***	73.37±9.14	84.74±11.71***

w.r.t. Non anaemic ** p'<0.02, *** p'<0.002

TABLE 4

COMPARISON OF NUTRIENT INTAKE BETWEEN NON ANAEMIC AND ANAEMIC SUBJECTS

NUTRIENT INTAKE		MALE		FEMALE	
		NON ANAEMIC (n=79)	ANAEMIC (n=69)	NON ANAEMIC (n=54)	ANAEMIC (n=109)
ENERGY (KcaL)		2773.55±467.44	2427.67±376.09***	2537.96±495.11	2003.08±632.76***
CARBOHYDRATE (g)		551.18±102.51	478.31±92.30***	542.46±115.56	424.74±141.38***
TOTAL PROTEIN (g)		74.02±18.99	63.88±16.85***	63.86±19.45	49.21±18.97***
FAT (g)		31.89±15.37	30.99±13.02	28.17±10.09	26.82±9.91
IRON (mg)		25.79±6.87	19.94±6.28***	27.87±16.80	17.86±13.25***
CALCIUM (mg)		566.88±294.33	534.20±270.30	596.94±365.11	458.45±345.56*
VIT-A (µg)		1053.66±2125.72	828.69±1468.84	933.29±1736.88	669.62±1470.70
VIT-B1 (mg)		1.93±0.44	1.66±0.37***	1.68±0.43	1.31±0.50***
VIT-B2 (mg)		0.72±0.28	0.65±0.24	0.59±0.21	0.49±0.23**
NIACIN (mg)		28.15±5.71	23.85±5.01***	25.20±5.97	19.44±7.0***
VIT-B6 (mg)		1.04±0.27	0.91±0.33**	0.91±0.27	0.81±0.32
FOLIC ACID (mg)	FREE	72.81±33.02	60.04±22.38	60.04±22.38	54.92±27.01
	TOTAL	130.30±53.42	118.82±42.76	118.82±42.76	104.19±49.72
VIT-C (mg)		101.43±73.39	93.61±77.80	98.51±67.23	83.22±74.95
CHOLINE (mg)		578.31±331.85	508.24±320.98	571.54±304.31	495.15±349.42

w.r.t. Non anaemic * p'<0.04, ** p'<0.02, *** p'<0.002

thus the situation was serious in male and critical in female.

Table 5 presents the mean values of hemoglobin by BMI categories. Mean values increased steadily from the underweight through the normal to the overweight/obese groups. Overweight/obese subjects had the highest mean value of hemoglobin. In the present study t-test was performed with Bonferroni adjustment and significant differences (p'<0.002) in hemoglobin was observed between underweight and overweight/obese groups. From the results it was also revealed that there was a significant difference (p'<0.002) in hemoglobin level between underweight and normal male subjects; however in female subjects no such significant difference was obtained between underweight and normal groups. Scheffe's test revealed that hemoglobin values differed significantly among all the groups.

The prevalence of anaemia in the individuals of different BMI categories was studied (Table 6) and it was found that the prevalence of anaemia was high in underweight (male 62.5%; female 80.65%) and normal groups (male 45.98%; female 62.67%) as compared to overweight/obese group (male 19.05%; female 25.0%). From the chi-square statistics,

TABLE 5

MEAN±SD OF HEMOGLOBIN CONTENT OF DIFFERENT BMI CATEGORIES		
BMI CATEGORIES	MALE	FEMALE
UNDERWEIGHT (BMI<18.5 kg/m²)	10.79 ±3.02	9.61 ±2.33
NORMAL (BMI 18.5 TO 24.9 kg/m²)	12.52* ±1.77	10.53 ±2.28
OVERWEIGHT/OBESE (BMI ≥25 kg/m²)	13.47* ±0.97	11.9* ±1.65
F RATIO	13.81	7.74

w.r.t Underweight *p'<0.002

TABLE 6

PERCENTAGE OF NORMAL (NON ANAEMIC) AND DIFFERENT GROUPS ANAEMIA ACCORDING TO THE NUTRITIONAL CATEGORIES				
		BMI		
		UNDERWEIGHT	NORMAL	OVERWEIGHT/OBESE
MALE		(n=40)	(n=87)	(n=21)
NORMAL		37.5	54.02	80.05
ANAEMIA	MILD	20.0	36.78	19.05
	MODERATE	25.0	9.20	0
	SEVERE	17.5	0	0
	TOTAL	62.50	45.98	19.05
OR		7.08##	3.62#	1
(95% CI)		(2.0-25.05)	(1.12-11.63)	-
FEMALE		(n=72)	(n=75)	(n=16)
NORMAL		19.44	37.33	75.0
ANAEMIA	MILD	37.50	38.67	18.75
	MODERATE	26.39	16.0	6.25
	SEVERE	16.67	8.0	0
	TOTAL	80.56	62.67	25.0
OR		12.43###	5.04##	1
(95% CI)		(3.48-44.4)	(1.48-17.13)	-

# p<0.05, ##p<0.01, ###p<0.001

statistically significant differences were found in the prevalence of anaemia between groups based upon BMI of both sexes (male χ^2 10.48; female χ^2 19.35). The results also indicated that there were significant differences in the percentage of anaemia among the categories except between the underweight and the normal groups of male subjects. The odd ratio becomes significantly higher in the underweight group than the normal and overweight/obese groups of both sexes. In case of male, it was about seven times higher in underweight and about four times higher in normal groups than the overweight/obese group. In case of female the odd ratio was about twelve times higher in underweight and five times higher in normal groups than overweight/obese group.

DISCUSSION

By any measure, India remains one of the poor countries in the world, with a population of over one billion and a fertility rate above the replacement level [22]. However, there have been impressive improvements in some health

indicators in the last two decades, including a reduction in infant mortality rate and a drop in the fertility rate, but improvements in nutritional status, have been less impressive [22]. More than half of the world's undernourished population lives in India [23]. Apart from overall poverty, the health status of the rural population reflects inequitable distribution of health resources, low purchasing capacity of food and unequal food sharing pattern in the families which make them socially and biologically vulnerable. Anaemia is now globally recognized as a major public health problem and it is an indicator of poor nutrition and poor health of a population. However, there are no widely accepted reference levels and almost all the studies were done on pregnant and lactating females and young children. But reliable data on the prevalence of anaemia in the adult population (adult male and non-pregnant female) is not available, especially among adult rural population in West Bengal. This lack of useful epidemiological data is the reason why we have attempted to investigate the prevalence of anaemia among the adult male and non-pregnant female from the rural areas of West Bengal.

In the study population, the overall prevalence of anaemia was 46.62% in male and 66.87% in female, which was more than the global prevalence [2; 24]. The exact figures for the prevalence of anaemia vary from study to study, but there is no doubt that anaemia is an extremely serious public health problem in India, especially among rural population. But females have a higher percentage of anaemia and lower hemoglobin than the males. The gender difference in anaemia may be due to the fact that adult females experience regular blood loss due to menstruation as well as repeated delivery. The female have to do the household works and in most of the cases, they are used to take lunch or dinner after eating is over by all other members of the family (children, husband, in-laws etc.). As they have to take lunch or dinner last of all, sometimes they do not get sufficient amount of food. Thus the gender bias in intra-household food sharing may be another reason for this difference. In various societies of India, large-scale sex discrimination exists in sharing of food [25-26].

According to the WHO classification of anaemia as a problem of public health significance at community levels, the prevalence of anaemia which was >40% was considered to be a severe public health problem, that which was between 20.0 to 39.9% to be a moderate public health problem, that which was between 5.0 to 19.9% to be a mild public health problem and that which was <4.9% not to be a public health problem [27]. The prevalence of anaemia among the study population was greater than 40%, it was considered as severe public health problem. The present study thus brings out the fact that the problem of anaemia was related to a wider population than the traditionally considered groups of the pregnant and lactating females and children. The adult male population was also equally susceptible in West Bengal.

The present study also indicated that the mean values of heart rate was significantly higher in anaemic individuals than that the non-anaemic individuals. Many studies have reported such differences between anaemic and non-anaemic individuals. Ickx et al. [28] studied on a group of 20 conscious patients and found that their heart rate increased by mean value of 2.2 beats per minute per g hemoglobin decrease when their hemoglobin concentration was reduced from 13.7 g/dl to 8.6 g/dl. Weiskopf et al. [29] also pointed out that the heart rate increased 4 beats per minute for each g per dl decrease of hemoglobin concentration. Severe anaemia might compromise the ability to supply amounts of oxygen sufficient to meet the needs of the increased myocardial oxygen consumption caused by increased heart rate [29].

The dietary habits of the subjects were studied and indicated that the anaemic individuals consumed a nutritionally deficient diet than that the non-anaemic individuals. This may be a possible reason for higher rate of anaemia in the study population as there is poor bio-availability of iron in the Indian diets [30]. Another reason may be the type of diet which was consumed by the study population, as is evident, indicated a higher prevalence of anaemia among the subjects who consumed a vegetarian diet, because vegetarian diets are a poor source of iron [31-32]. Verma et al. [33] found in their studies that there was a higher prevalence of anaemia among the vegetarian than the non-vegetarian people. In developing countries such as India, poor bioavailability of dilatory iron, low intake of iron which was derived from animal foods, are major etiological factor for anaemia [34]. This can be

attributed to the fact that bioavailability of iron is poor owing to presence of phytates, oxalates, carbonates, phosphates and dietary fibre which interferes with iron absorption. Indian diet, predominantly vegetarian food, contains large amounts of inhibitors like phytates in bran, tannin in tea, oxalates in vegetables and phosphates in egg yolk, interfering with iron absorption [35-36]. The prevalence of various parasitic infestations and other chronic illnesses were not studied in present study. Moreover, it was likely that the rural populations have taken a nutritionally deficient diet and are also exposed to diseases due to the insanitary conditions of the environment; they have to wash utensils and clothing in the polluted pond water which may have been more susceptible to parasitic infestations and other chronic infections, thus leading to a higher prevalence of anaemia [13].

Based on BMI, the results of present study have shown that higher percentages (male 27.03%; female 44.17%) of the individuals belongs to underweight group, while a low percentage (male 14.19%; female 9.82%) of them was overweight/obese. This can be related to the nature of the diet and lifestyle of the individual. Based on the WHO [17] classification, the prevalence of underweight among this population was studied and it was revealed that prevalence of underweight was high to very high among them and thus the situation is serious to critical. In the present study hemoglobin content also increased significantly from the underweight group through normal to the overweight group. This study also highlights the facts that the prevalence of anaemia was high in individuals having low BMI. The prevalence of anaemia was the lowest in the overweight (male 19.05%; female 25.0%) and significantly higher prevalence was noted in normal groups (male 45.98%; female 62.67%) and underweight group (male 62.5%; female 80.65%). It is also interesting to mention that the underweight and normal groups of male subjects did not show significant differences in the prevalence of anaemia. The odd ratio became significantly higher in the underweight group than in the normal and overweight groups of both sexes. Therefore, it seems that the low BMI has a significant clinical effect on the prevalence of anaemia. The findings were similar to other studies. Gupta et al. [37] reported that the prevalence of anaemia significantly increases with a decrease in the BMI. Ramachandra et al. [38] studied on anaemia in the elderly South Indian rural population and have shown the association between the higher prevalence of anaemia and a low BMI. In the National Family Health Survey (NFHS-2) study [39], it was stated that subject with a low BMI had a somewhat higher prevalence of anaemia than other.

The higher prevalence of anaemia among both adult male and non-pregnant female in rural areas of West Bengal may be due to dietary deficiency, poor dietary patterns and unequal food sharing in the families. The present study indicated that the subjects with low BMI (<18.5 kg/m2) would have a higher risk of anaemia compared to normal or overweight subjects of both sexes. Improving overall nutrition status and their access to resources will have the greatest impact on reducing anaemia. Iron supplementation programs, may be effective in reducing the prevalence of anaemia. Awareness about the low cost iron rich food among the rural population may be another solution of the problem.

FOUNDING: *Department of Science and Technology (RVPSP), New Delhi, India*

ACKNOWLEDGEMENTS: *This study was carried out by the authors as part of a research project, sponsored by the Department of Science and Technology (RVPSP), New Delhi. The authors gratefully acknowledge the financial assistance provided by the DST (RVPSP), which could make it possible to complete the present study. All the authors wish to express their gratitude to the subjects who volunteered for this study.*

CONFLICT OF INTEREST: *The authors confirm that there are no relevant associations that might pose a conflict of interest.*

References

[1] Global Burdon of Diseases 2004 update, Geneva:World Health Organization, 2008.

[2] de Benoist B, McLean E, Egli I, Cogswell M. Worldwide prevalence of anaemia 1993–2005: WHO global database on anaemia.

[3] National Consultation on the Control of Nutritional Anaemia in India. Department of Family Welfare (Maternal Health Division), Ministry of Health and Family Welfare, Nirman Bhawan, New Delhi, 1998.

[4] Seshadri S. A database on iron deficiency anaemia (IDA) in India: prevalence, causes, consequences and strategies for prevention. Department of Foods and Nutrition. WHO Collaborating Centre for Nutrition Research. The Maharaja Sayajirao University of Baroda, Vadodara, India, 1999.

[5] ACC/SCN. 4th report on the World Nutrition Situation: Nutrition Throughout the Life Cycle. Geneva: World Health Organization,2000.

[6] Bhargava A, Bouis HE, Scrimshaw NS. Dietary Intakes and Socioeconomic Factors Are Associated with the Hemoglobin Concentration of Bangladeshi Women. Journal of Nutrition 2001; 131:758-64.

[7] Bharati P, Ghosh R, Gupta R. Socioeconomic condition and anaemia among the Mahishya population of Southern West Bengal, India. Mal J Nutr 2004; 10(1): 23-30.

[8] Bentley ME, Griffiths PL. The burden of anaemia among women in India. European Journal of Clinical Nutrition 2003; 57: 52–60.

[9] Penninx BWJH, Pahor M, Cesari M, et al. Anaemia is associated with disability and decreased physical performance and muscle strength in the elderly. J Am Geriatr Soc 2004; 52: 719–24.

[10] Brabin BJ, Hakimi M, Pelletier D. An analysis of anaemia and pregnancy-related maternal mortality. Journal of Nutrition 2001; 131: 604S-14S.

[11] Halterman JS, Kaczorowski JM, Aligne CA, Auinger P, Szilagyi PD. Iron deficiency and cognitive achievement among school-aged children and adolescents in the United States. Pediatrics 2001; 107(6): 1381–6.

[12] Agarwal DK, Upadhyay SK, Tripathy AM, Agarwal KN. Nutritional status, physical work capacity and mental function in school children. Nutrition Foundation of India, New Delhi, Scientific Report No. 6; 1987; 16-23.

[13] Seshadri S. Nutritional anaemia in South Asia. In: Malnutrition in South Asia: a regional profile. S Gillespie,editor. UNICEF; 1997; 5:75-124.

[14] Gowri AR, Sangunam HJ. Assessment of the mental and motor abilities of school going children with anaemia. Ind J Nutr Dietet 2005; 42: 99-105.

[15] Schorr TO, Hediger ML. Anaemia and iron-deficiency anaemia: compilation of data on the pregnancy outcome. American Journal of Clinical Nutrition 1994; 59(Suppl.): 492S-501S.

[16] The Prevalence of Anaemia in Women: a Tabulation of Available Indormation. Geneva: World Health Organization,1992.

[17] Physical status: the use and interpretation of anthropometry. Technical Report series no. 854. Geneva: World Health Organization,1995.

[18] Swaminathan M. Advanunder weight Text-Book on Food and Nutrition. 1999; 2: 496-511.

[19] ICMR. Nutrient Requirement and Recommended Dietary Allowance for Indians. New Delhi, 2009.

[20] Naing L, Winn T, Rusli1 BN. Practical Issues in Calculating the Sample Size for Prevalence Studies. Archives of Orofacial Sciences 2006; 1: 9-14.

[21] [International Institute for Population Sciences (IIPS) and Macro International. National Family Health Survey (NFHS-3), 2005–06: India: 2007; Volume I. Mumbai: IIPS.

[22] World Bank. World Development Report 2000/2001: Attacking Poverty. New York: Oxford University Press. 2000.

[23] Krishnaswami K. Country profile: India. nutritional disorders— old and changing. Lancet 2000; 351: 1268 – 9.

[24] De Mayer EM, Tegman A. Prevalence of Anaemia in the World, World Health Statistics Quarterly 1998; 38:302-16.

[25] Basu A, Roy SK, Mukhopadhyay B, Bharati P, Gupta R, Majumdar PP. Sex bias in the intra-household food distribution: roles of ethnicity and other socioeconomic characteristics. Cur Anth 1986b; 27: 536-9.

[26] Khan ME, Anker R, Ghosh Dastidar SK, Bairathi S. Inequalities between men and women in nutrition and family welfare services: an in-depth enquiry in an Indian village. In: Caldwell JC & Santow G, editors. Selected Readings in the Cultural, Social and Behavioural Determinants of Health. Health Transition Series No. 1. Australian National University, Canberra, 1995.

[27] Iron deficiency anaemia: assessment, prevention, and control. A guide for programme managers. Geneva, World Health Organization, 2001.

[28] Ickx BE, Rigolet M, Van der Linden PJ. Cardiovascular and metabolic response to acute normovolemic anaemia. Anesthesiology 2000; 93:1001-16.

[29] Weiskopf RB, Feiner J, Hopf H, et al. Heart rate increases linearly in response to acute isovolemic anaemia. Transfusion 2003; 43: 235-40.

[30] Desai N, Chaudhry VP. Nutritional anaemia in protein energy malnutrition. Indian Pediatr 1993; 30: 1471-83.

[31] Christoffel K. A pediatric perspective on vegetarian nutrition. Clin Pediatr 1981; 20: 632-43.

[32] Dagnelie PC, Staveran WA, Vergote FJ, et al. Increased risk of vitamin B12 and iron deficiency in infants on macrobiotic diets. Am J Clin Nutr 1989; 50: 818-24.

[33] Verma M, Chhatwal J, Kaur G. Prevalence of anaemia among urban school children of Punjab. Indian Pediatrics 1999; 36:1181-86.

[34] Kaur S, Deshmukh PR, Garg BS. Epidemiological correlates of nutritional anaemia in adolescent girls of rural Wardha. Indian J Community Med 2006; 31: 255–58.

[35] De Maeyer EM. Preventing and controlling iron deficiency anaemia through primary health care: a guide for health administrators and program manager. Geneva: World Health Organization, 1989.

[36] Nair KM, Iyengar V. Iron content, bioavailability and factors affecting iron status of Indians. Indian Journal of Medical Research 2009; 130: 634-45.

[37] Gupta VK, Maria AK, Kumar R, et al. To study the prevalence of anaemia in young males and females with respect to the age, body mass index (BMI), activity profile and the socioeconomic status in rural Punjab. Journal of Clinical and Diagnostic Research 2011; 5(5): 1020-6.

[38] Ramachandra SS, Kasthuri A. Anaemia in the elderly who resided in a south Indian rural community. Indian Journal for the Practising Doctor 2008; 10: 5(4):4.

[39] National Family Health Survey (NFHS-2), 1998–99: India. Mumbai: IIPS.