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Nutritional status and haemoglobin level among adult Bengalee women in a sub-urban area in West Bengal

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Abstract

Nutritional status measured by anthropometry has been a reliable indicator of individual as well as population health. It is associated with morbidities, reduced activity and fitness, impaired cognitive development and also early mortality in adults. On the other hand, Iron Deficiency Anaemia, indicated by low haemoglobin level is a considered as a global health hazard, especially in women from the developing countries. States of undernutrition and anaemia were pointed out to be linked at the population level. The present study was conducted to estimate the prevalence of undernutrition and anaemia among the Bengalee adult females in a sub urban municipal locality in West Bengal. The study included 222 adult women aged $\geq$ 18 years. Height, weight and haemoglobin level were measured; nutritional- and anaemic status were determined as per WHO guidelines. The prevalence of chronic energy deficiency (CED) and anaemia were 25.2% and 58.4%, respectively. Both the prevalence of CED and anaemia were the lowest in the eldest and the youngest age groups. Higher prevalence of CED were associated with lower mean Hb level and higher frequency of anaemia. The women with low BMI had higher chance of being diagnosed with anaemia. The situation indicated towards a serious health problem in respect of CED and moderate in respect of anaemia.

Keywords: Anaemia, BMI, CED, haemoglobin, women.

Introduction

Nutritional status is a tested and well trusted indicator of overall health and well being of an individual (WHO, 1995). It is also a reliable indicator of standard of living of an individual and community (Nube et al., 1994). Nutritional status of an individual can be classified as *Normal* or *Malnourished*. Malnutrition refers to a state deviated from adequate and optimal nutritional status. It refers not only to inadequate dietary intake or undernutrition but also to over- nutrition characterized by obesity (Khongsdier, 2006). Thus, the term 'malnutrition' refers to under nutrition, over nutrition, specific nutrient deficiencies or imbalance (Chen et al., 2001). Anthropometry is recognized as one of the best indicators of NS (Khongsdier, 2002).

The adult population is the productive sector of society and illness or disability will have inevitable adverse consequences for

families and communities (Feachem at al., 1992). Among the adults, the health of women has been a global concern for many decades (WHO, 1996). The persistence of hunger and abject poverty in India and other parts of the world is due in large measure to the subjugation, marginalization and disempowerment of women. Women suffer from hunger and poverty in greater numbers and to a great degree than do men. At the same time, it is women who bear the primary responsibility for actions needed to end hunger: education, nutrition, health and family income. According to the 3rd National Family Heath Survey of India, the overall prevalence of undernutrition among women aged 15-49 was 35.2%. It was as highest (45%) in Bihar and 39.1% in West Bengal (IIPS and MI, 2007). The women in the lowest economic category were the worst sufferer with prevalence over 50%. A 55% of Indian Women were reported to be anemic. It is as high as over 64% in the lowest economic stratum. 63% women in West Bengal were also anemic (IIPS and MI, 2007). Besides, a considerable prevalence of overweight and obesity was also reported among Indian women (Bharati et al., 2007).

There are several physiological parameters of importance in the assessment of nutritional status. Hemoglobin (Hb) level is one of the very important, well-established markers of nutritional status in both children and adults. Hb level has long been considered as a useful parameter in the diagnosis of iron deficiency anemia (IDA), which, in turn, is one of the indicators of nutritional status (Desai et al., 1980). Anemia is defined as the lack of sufficient (≥ 13- and 12 g/dL, respectively for men and women) Hb concentration in blood (WHO, 1992, Bharati et al., 2008).In both men and women, the prevalence of anemia was highest among those with severe undernutrition (ACC/SCN, 2000, Ghosh and Bharati, 2003). Hematological parameters, e.g., hemoglobin (Hb) also depends upon the socioeconomic condition and the cultural practices (Devadas et al., 1980; Kaur et al., 1982). IDA affects more than 1.6 billion people in the developing world(WHO, 2008). It mostly affects women of reproductive age and the pre-school children. Severe anemia in developing countries causes maternal mortality and morbidity (WHO, 1992). IDA has recently been ranked as the third leading problem for 15-44 year old women (Murray and Lopez, 1990). Prevalence of anaemia in South Asia is the highest in the world, which was linked to overall higher rates of malnutrition. A study on the prevalence of anaemia among pregnant and lactating females and children reported that the prevalence of anaemia varied from 50-90% in different parts of India (Seshadri, 1999).

Poor nutrition among women begins in infancy and continues throughout their lifetime (Desai, 1994). Unequal access to food, heavy work demands, nutritional deficiencies including iron, makes Indian women susceptible to illness, and anemia (Seshadri, 1997). The gender difference in anemia may be due to the other fact that adult females experience regular blood loss due to menstruation as well as repeated delivery in addition to their malnourishment, which is due to gender bias in intra-household food sharing. Moreover, women living in poor, unhygienic conditions, such as in slums, are also exposed to diseases, which in turn affect the hematological parameter (Bharati, 1983). A high prevalence of anaemia among women of reproductive age was reported in India and inadequate nutrition was again held responsible for it (Bentley and Griffiths, 2003; Rammohan et al., 2012). Poor health and nutrition of women are associated with closely spaced pregnancies that progressively reduce women's nutritional reserves to the

point of nutritional depletion (Martorell, 1991; Bracher, 1992).

Most of the studies on haemoglobin at the population level in India were on pregnant and lactating female, children or adolescents. Data are scanty on the prevalence of anaemia among the adults, more particularly, on the non-pregnant females or more so for the urban poor. In view of the above context and also lack of studies in India and more particularly in West Bengal, the present study was carried out among the adult women in a sub-urban area near the Kolkata metropolitan to assess the nutritional status in relation to serum haemoglobin level and anaemic status.

Materials and Methods

The participants and settings

This cross sectional study was carried out in a neighbourhood called Bidhanpally, in Madhyamgram, which is a growing urban centre within the periphery of the greater or extended Kolkata city. It is situated in the district of North 24 Parganas of the state of West Bengal, India. The area is under the jurisdiction of the Madhyamgram Municipality. The participants were the Bengalee-Hindu adult women aged $\geq$ 18 years. They were included randomly from approximately 150 households of the neighbourhood. A total of 222 women were recruited in the study sample. The area was predominantly populated by the Hindu-Bengalee caste groups. Most of the women were home makers. There were landlords who were the first settlers of the locality and a huge number of tenants to them. The general hygienic condition clearly seems to be poor. The sanitation, sewerage systems and household structures are the silent but definite indications of their poverty and poor quality of life. Households were selected randomly and the healthy (with no apparent acute disease and in their normal working condition) females aged 18 years and above were recruited after obtaining their informed consent. Information on family composition, socio-economic condition, habitual physical activities, food habits, and other life-style parameters were collected by a standard questionnaire.

Anthropometry

All the anthropometric measurements were taken in the households of individuals by single researcher following standard guidelines (Lohman et al., 1988). Height was measured with a standard anthropometer to the nearest 1 mm. Body-weight was taken to the nearest 500g on a standard Weight scale with the subject wearing light clothing. Body Mass Index (BMI) was computed using standard equation (WHO, 1995): BMI = Weight (kg) / Height (meter ^{2}).

Measurement of Nutritional Status

Nutritional status was determined following World Health Organisation guidelines (WHO, 1995). The following cut-off points of BMI (kg/m^2) were used :

CED:	BMI	< 18.4
Normal:	BMI	= 18.5 – 24.9
Overweight:	BMI	= 25.0 -- 30
Obese	BMI	$\geq$ 30

Therefore CED (Chronic Energy Deficiency), in general was defined as BMI < 18.5 kg/m^2 .

Data Management and statistics

Descriptive statistics for metric variables were computed by mean, and standard deviation (SD). Necessary statistical tests were performed as per requirements to see the differences between groups in means or percentages. Contingency Chi^2 test was performed to test the significance of differences in percentages. All the analysis as performed in SPSS software.

Results and discussion

The mean (SD) monthly family income was 3661.7 INR (1969.3), the maximum and minimum being 800 and 14000 INR respectively, the median value was 3000 INR. Thus most of the families have low monthly incomes. 44.8 per cent families lived in bamboo fenced rooms. 61.4 and 30.9 per cent of the families had one and two living rooms, respectively, and only about 8 per cent had between three and four rooms to live in. 84.6 per cent did not have their separate toilet but shared with one or more families. In a recent study in a West Bengal slum reported a mean monthly family income and monthly per capita income were INR 7239·2 (SD 5070·9) and 1602·6 (SD 1179·0), respectively, higher than in the families of the present women. Thus the results clearly indicated that the participant women of this study belonged to low socio-economic condition.

Mean (SD) age of the participants was 38.5 (14.25) years. The mean (SD) height, weight and BMI were 152.3 (6.64) cm, 46.8 (7.65)kg and 20.5 (4.2)kg/m^2, respectively. Table 1 shows the Nutritional Status according to WHO recommended BMI cut off values across age groups. The overall frequency of the CED (BMI < 18.5 kg/m^2) was 25.2%. However, there were significant differences in the prevalence of nutritional status in different age groups (Chi-Square = 18.6; p <0.05) showing a curvilinear trend. Percentage of under nutrition or CED (BMI <18.5 kg/m^2) was highest (46.2%) in the eldest group (aged 60 years and above). It was also high (30.6%) in the youngest group (aged 18-29.9 years). It then dropped down to 22.4% in the next age group (aged 30-39 years) and increased slightly (26.7%) in the next elder group (aged 40-49.9 years) and then increased steadily in the next two groups. Percentage of overweight and obese (BMI > 25.0 kg/m^2) was highest in the age group of 40-49.9 years (12.2%) followed by 8.5% in the next higher age group and lowest in the eldest age group (3.2%) followed by the youngest group (3.3%).

Studies showed that the prevalence of low BMI is higher in the low SES groups (Ferro-Luzzi et al., 1992, Chakraborty and Mistri, 2012). Some studies in India also have found association of low SES with smaller body size, and poor nutrition (Bharati, 1989) and fatness (Sanjeev, 1991). Studies in the developed World showed inverse relationship between BMI values and social status (class) (Seidell et al., 1995; Bielicki et al., 2001). But it is very interesting to also find co-existence of both under-nutrition and obesity in the low SES group of the developing World (Sawaya et al., 1995; Misra et al., 2001). Thus, it is specially interesting and essential to study the etiology of this co-existence of both the ends of malnutrition in the low SES groups of the developing countries like India. Ahmed et al (1998) found that the women aged >35 years were more prone to be undernourished. Bharati et al., (2007) investigated the nutritional status (BMI-based) of adult women in India (aged 15-49 years) and reported the prevalence of CED, overweight, and obesity in India as 31.2%, 9.4%, and 2.6%, respectively.

In a cross sectional study (Bose et al 2007a) on 283 adult females belonging to Bathudi tribal group of Keonjhar district of Orissa, the age variations of anthropometric and body composition variables and nutritional status were investigated. Significant age variation in anthropometric and body composition measures was reported. Age had significant negative impact on most of these variables including weight and BMI. With increasing age there was also a significant increase in the prevalence of CED. Bose et al., (2007b) found that the overall rate of CED among slum dwelling women in West Bengal was 46.8% and among males 38.2%. Therefore although the rate of CED in this study was lower than in

many studies, it was still 'high' (within 20-39%) as per the WHO classification (WHO, 1995) and may be classed under the head of 'Serious Situation' as per the same classification.

In the present study, the mean (SD) hemoglobin concentration among the participants was 11.8 (1.2) g/d (Table 2). The range of Hb values was 7.8 to 16.8 g/dl. The overall prevalence of anaemia (Hb < 12 g/dl) was 58.4%, which was quite high. The lowest mean Hb concentration (9.8 g/dl) as well as the highest prevalence of anaemia (80%) was found in the eldest group and the second lowest Hb level (10.1) and the second highest prevalence of anaemia (60.3%) was found in the age group of 18-29.9 years. The mean Hb concentration continued to raise by small amounts up to the age group of 50-59.9 years and then again drop down abruptly to the lowest in the eldest group. The prevalence of anaemia followed the opposite trend as expected.

There were numerous studies on Hb level and anemia status among adolescent and adult females reporting the prevalence. Some studies among different populations in different countries like the Au of Papua New Guinea (Tracer, 1997), Kuwait (Ezzat et al., 1996), Kazhakstan (Dangour et al., 2001), Malaysia (Chang et al., 2009), Nepal (Tiwari, 2000), and Bangladesh (Hyder et al., 2000), reported prevalence of anemia between 28 and 98%. In different regions of India e.g., Orissa (Patil et al., 2009), Chandigarh (Basu et al., 2005), Gujarat (Kotecha et al., 2009), Hyderabad (Sharma et al., 2000), the prevalence of anemia was reported between 13 and 85%. Works on Hb status among the urban slum dwellers are also scanty. In a community-based, cross-sectional study among unmarried, adolescent South Indian girls in an urban slum setting, the prevalence of anemia (Hb<12 g%) was 29% (Choudhary et al., 2006). In another study (Disler et al., 1975) among adolescent girls from an urban slum and rural areas was assessed. Overall anemia was observed in 25% of the girls irrespective of their urban or rural residence. Another recent study showed that the prevalence of anaemia in rural adult women was as high as nearly 67% (Pal et al., 2014).

In terms of Iron Deficiency Anemia (IDA) the most highly affected population groups in the developing countries were the pregnant women (56%), school age children (53%), non-pregnant women (44%) and preschool children (42%) (ACC/SCN, 2000). In rural areas in northern and southern India, the prevalence of anemia ranged from 40-70%, while in villages near Kolkata, more than 90% of the population was reported to be anemic (AJCN, 1982). The state of West Bengal had a high percentage of anemia (78.3%) among the women aged 15-49 years when compared with all India (74.3%) and states like Kerala (43.9%) and Manipur (45.2) (UNICEF, 1999). Moreover, the city of Kolkata also revealed a very high percentage of anemia of about 97% among the women aged 15-44 years (GOI, 1996). In any comparison, our study population, although had a prevalence lower than many of the above populations, still showed a concerning rate of 58.4%. The prevalence of anaemia was the highest (80%) in the eldest age group and the second highest in the youngest group (60.3%). The prevalence decreased in the second age category (30-39.9 years) by 11.5% and then again increased in steadily in the next higher age categories by 2-3% o average. But it jumped to increase by about 30% in women aged 60 years and above. The mean haemoglobin level showed the opposite trend, as expected, with the lowest value in the eldest and the next lowest in the youngest and highest in the age category of 50-59.9 years.

Table 1. Nutritional Status of the participants by BMI according to age group.

Age Group	N	Nutritional Status by BMI (%)		
		CED (N=56)	Normal (N=141)	Overweight and Obese(N=25)
18-29.9	73	30.6	66.1	3.3
30-39.9	43	22.4	71.3	6.3
40-49.9	44	26.7	61.1	12.2
50-59.9	32	33.1	58.4	8.5
60 and above	30	46.2	50.6	3.2
All age	222	25.2	63.5	11.3
Chi-Square = 18.6; *p <0.05*				

Table 2. Hb Concentration and prevalence of CED and anaemia according to age group.

Age Group	N	CED (%)	Hb (g/dl)	Anaemia (%)	Normal (%)
18-29.9	73	30.6	10.1	60.3	39.7
30-39.9	43	22.4	11.2	48.8	51.2
40-49.9	44	26.7	11.9	50.0	50.0
50-59.9	32	33.1	12.3	53.1	46.9
60 and above	30	46.2	9.8	80.0	20.0
All age	222	25.2	11.8	58.4	41.6

Table 3. Prevalence of anaemia according to nutritional status.

Anaemia Category	NUTRITIONAL STATUS (%)			
	CED	Normal	Overweight	Overall
Mild	58.6	27.6	13.8	24.8
Moderate	66.8	20.6	12.6	18.4
Severe	72.4	16.8	10.8	15.2
Overall	67.8	22.8	9.4	58.4

These results indicated a higher vulnerability both in terms of CED as well as anaemic condition. Thus the youngest adults and the elder women were the most vulnerable group as regards anaemic condition in the present study population.

Table 3 shows the prevalence of anaemia according to nutritional status determined by BMI cut off points. Overall, 18.4% women had moderate (Hb 7.0-9.9 g/dl), 24.8% mild anaemia (Hb 10-11.9 g/dl) and 15.2% had severe anaemia (Hb< 7 g/dl). The undernourished females had all levels of anaemia higher than those in the normal and overweight females. But it is striking to note that normal as well as the overweight-obese counterparts also had a considerable share of anaemia, be it mild, moderate or severe. Among the severely anaemic females, 27.6% are normal or overweight-obese. About 33% of moderate and over 41% of mild anaemic females were normal or overweight-obese.

Very few studies were undertaken on association of anthropometric measurements

and nutritional status and Hb level. In a study among adult non-pregnant women in the Kzyl-Orda region of Kazakhstan, Hb concentration was found to be positively associated with body mass index (BMI). There was a significant curvilinear relationship between haemoglobin concentration and age (Dangour et al., 2001). Such a curvilinear relationship was not found among the US population, although Hb concentration values did rise slightly among elderly women, probably as a result of the onset of menopause (Yip, 1988). With increasing age, urban girls who had attained menarche showed an increase in the prevalence of anemia (Vasanthi et al., 1994). Among non pregnant-non lactating 15-49 years old women living in East Azarbaijan (Iran) means of Hb and Hematocrit (Hct) were significantly different between BMI quartiles and only Hct was significantly different between weight quartiles (Paknahad et al., 2008). Among the Indian women, increase of 1 cm height was found to be associated with decreased risk of anemia (Subramanian et al., 2009).

Studies involving the Hb status among women in West Bengal are also handful. A micro level study (Ghosh and Bharati, 2003) among Munda (a tribe) and Poundrakshatriya (Pod) (caste) women indicate a very high percentage of anemia in both the ethnic groups and 100 percent anaemia was observed among the Munda. Mean hemoglobin level was higher among the women of both the ethnic groups, consuming calorie, protein, iron and folic acid, above the recommended value. However, women below the age of 30 years were found to be more anaemic, as in the present study. Haemoglobin level of both ethnic groups was found to increase with increase in Body Mass Index. Low socioeconomic condition, very low literacy rates, poverty and higher live births were associated with anemia in Munda women. In a nationally representative cohort of non-pregnant women in India, women aged less than 25 years were most affected by anemia. Higher socioeconomic status including education and standard of living had positive association with Hb level. The severity of anemia was higher among pregnant women (Bharati et al., 2008). According to the National Family Health Survey II, 2002-04, education and standard of living had positive effect on Hb level among adolescent girls in India (Bharati et al., 2009). In our present study also, the women belonged to the low socio-economic status and the youngest age group was also highly affected.

Studies provided evidence of reduced physical activity, work capacity and productivity in individuals with low BMI level (Satyanarayan et al., 1989; Latham, 1989). On the other hand, anaemia leads to impaired muscle strength, weakness, low physical activity, diminished physical and mental capacity, higher morbidity (Brabin et al., 2001, Penninx et al., 2004). Maternal anaemia was shown to produce higher risk of irreversible brain damage, lower school achievement, reduced physical and exercise tolerance and poor immune response in children (Agarwal et al., 1987). On the other hand, anaemia in childbearing women had increased risk of maternal morbidity and mortality, perinatal and neonatal mortality, iron deficiency in newborn, premature delivery and low birth weight. With this background realities, the results of this present study also indicated that even in the peri-urban areas near a metropolitan city like Kolkata, the women were significantly predisposed to negative health situations in relation to iron deficiency anaemia and chronic energy deficiency. Therefore, organized efforts should immediately be taken to effectively manage

such public health hazard to avoid long term negative impact on the next generation.

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References

ACC/SCN, (2000). 4th report on the World Nutrition Situation: Nutrition throughout the Life Cycle. Geneva: World Health Organisation.

Agarwal, D. K., Upadhyay, S. K., Tripathy, A. M. and Agarwal, K. N. (1987). Nutritional status, physical work capacity and mental function in school children. Nutrition Foundation of India, New Delhi, Scientific Report No. 6. Pp. 16-23.

Ahmed, S. M., Adams, A., Chowdhury, A. M. and Bhuiya, A. (1998). Chronic energy deficiency in women from rural Bangladesh: Some socioeconomic determinants. *J. Bio.soc. Sci*. 30: 349-358.

AJCN, (1982). Report of the working group on fortification of salt. *Am. J. Clin. Nutr.* 34: 1442.

Basu, S., Basu, S., Hazarika, R. and Parmar, V. (2005). Prevalence of Anemia Among School Going Adolescents of Chandigarh. *Ind. Ped.* 42: 593-97.

Bentley, M. E. and Griffiths, P. L. (2003). The burden of anaemia among women in India. *Eur. J. Clin. Nutr.* 57: 52–60.

Bharati, P. (1983). A study on the relationship between socioeconomic condition, nutrition and health in a Mahishya population sample. PhD Thesis in Anthropology, University of Calcutta, Kolkata, India.

Bharati, P. (1989). Variation in adult body dimensions in relation to economic condition among the Mahishya of Howrah district, West Bengal, India. *Ann. Hum. Biol.*16: 529-541.

Bharati, S., Pal, M., Bhattacharya, B. N. and Bharati, P. (2007). Prevalence and causes of chronic energy defficiency and obesity in women in India. *Hum. Biol.* 79: 395-412.

Bharati, P., Som, S., Chakrabarty, S., Bharati, S. and Pal, M. (2008). Prevalence of anemia and its determinants among nonpregnant and pregnant women in India. *Asia Pac. J. Pub. Health.* 20: 347-59.

Bharati, P., Som, S., Chakrabarty, S., Bharati, S. and Pal, M. (2009). Burden of anemia and its determinants among adolescent girls in India. *Food Nutr. Bull*. 30: 217-26.

Bielicki, T., Szklarska, A., Welon, Z. and Malina, R. M. (2000). Variation in the body mass index among young adult Polish females between 1965 and 1995. *Int. J. Obes*. 24: 658-662.

Bielicki, T., Szalarska, A., Welon, Z. and Rogucka, E. (2001). Variation in body mass index among Polish adults: effects of sex, age, birth cohort, and social class. *Am. J. Phys. Anthropol*. 116: 166-170.

Bose, K., Bisai, S. and Chakraborty, F. (2007a). Age variations in anthropometric and body composition variables and undernutrition in adult female Bathudis: a tribal population of Keonjhar district, Orissa, India. *Anthrop. Anz.* 3: 1-7.

Bose, K., Bisai, S., Das, P., Dikshit, S. and Pradhan, S. (2007b). Relationship of income with anthropometric indicators of chronic energy deficiency among adult female slum dwellers of

Midnapore town. *J. Hum. Ecol.* 22: 171-176.

Brabin, B. J. Hakimi, M. and Pelletier, D. (2001). An analysis of anaemia and pregnancy-related maternal mortality. *J. Nutr.* 131: 604S-14S.

Bracher, M. (1992). Breast feeding, lactation on fecundity, contraception and the space of births. *Health. Trans. Rev*. 2: 19-47.

Chakraborty, R. and Mistri, A. (2012). Anthropometry and undernutrition among the adult Bengalee males in a slum in Eastern India: a comparative assessment. In: Bose K (Editor): Human Undernutrition: dual burden of under- and over nutrition. New York: NOVA Science Pub. Pp. 227-238.

Chang, M. C., Poh, B. K., June, J., Jefrydin, N. and Das, S. (2009). A study of prevalence of anaemia in adolescent girls and reproductive-age women in Kuala Lumpur. *Arch. Med. Sci.* 5: 63-68.

Chen, C. H. C., Schilling, L. S. and Lyder, C. H. (2001). A concept analysis of malnutrition in the community. *J. Adv. Nurs.* 36: 131-142.

Dangour, A. D., Hill, H. L. and Ismail, S. J. (2001). Hemoglobin status of adult non-pregnant Kazakh women living in Kzyl-Orda region, Kazakhstan. *Eur. J. Clin. Nutr.* 55: 1068-1075.

Desai, S. (1994). Gender inequalities and demographic behaviour. India. New York: Population Council.

Desai, I. D., Garcia Tavares, M. L., Dutra de Oliveira, B. S., Pharm, B., Douglas, A., Duarte, A. M. and Dutra de Oliveira, J. E. (1980). Food habits and nutritional status of agricultural migrant workers in Southern Brazil. *Am. J. Clin. Nutr.* 33: 702-714.

Devadas, R. P., Vijayalakshmi, P. and Chandy, A. (1980). Nutritional status of the expectant mothers and their offspring. *Ind. J. Nutri. Diet.* 17: 275-280.

Choudhary, A., Prabhakar, D. M., Mony, P. and Mathai, M. (2006)Prevalence of anaemia among adolescent girls in the urban slums of Vellore, south India. *Trop. Doct.* **36**: 167-169.

Disler, P. H., Lynch, S. R., Charlton, R. W., Torrance, J. D., Bothwell, T. H., Walker, R. B. and Mayet, F. (1975). The effect of tea on iron absorption. *Gut* 16: 193-200.

Ezzat, K., Fawzia, A. and Al-Awadi, A. (1996). Nutritional status survey of preschool children in Kuwait. *Eastern Med. Health J.* 2: 386-95.

Feachem, G. A., Kjellstrom, T., Murray, C. J. L., Over, M. and Phillips, M. A. (Eds). (1992). The Health of Adults in Developing World. Oxford: Oxford University Press.

Ferro-Luzzi, A., Sette, S., Franklinm M. and James, W.P.T. (1992). A simplified approach of assessing adult chronic energy deficiency. *Eur. J. Clin. Nutr*. 46: 173-186.

Ghosh, R. and Bharati, P. (2003). Haemoglobin status of adult women of two ethnic groups living in a peri-urban area of Kolkata city, India: a micro-level study. *Asia Pac. J. Clin. Nutr.* 12: 451-459.

GOI, Ministry of Human Resource Development. (1996). Report of the Task Force on Micronutrients (Vitamin A and Iron). New Delhi: Government of India.

Hyder, S. M. Z., Persson, L., Chowdhury, A. M. R. and EkstroÈm, E. (2000). Anaemia among non-pregnant women in rural Bangladesh. *Pub. Health Nutr*. 4: 79-83.

IIPS and MI (International Institute of Population Sciences and Macro International). (2007*).* National Family Health Survey(NFHS-3, 2005-06: India: Volume I. Mumbai: IIPS.

Kaur, Y. P., Sagar, V. and Khirwar, S. S. (1982). Nutritional ecology and food

consumption pattern of expectant mothers in selected villages and suburbs of Hissar. *Ind. J. Nutr. Diet.* 19: 50-58.

Khongsdier, R. (2002). Body mass index and morbidity in adult females of the War Khasi in Northeast India. *Eur. J. Clin. Nutr.* 56:484-89.

Khongsdier, R. (2006). Malnutrition, Social inequality and natural selection in human populations. In: K Bose (Ed). *Ecology, Culture, Nutrition, Health and Disease*. *Hum. Ecol.* (Special Issue). 14: 39-47.

Kotecha, P. V., Nirupam, S. and Karkar, P. D. (2009). Adolescent girls' anaemia control programme, Gujarat, India. *Indian J. Med. Res.* 130: 584-589.

Lohman, T. G., Roche, A. F. and Martorell, R. (1988). Anthropometric Standardization Reference Manual. Illinois: Human Kinetics Books.

Martorell, R. (1991). Maternal height as an indicator of risk. In: Krasovec, K., Anderson, M. A., (eds). Maternal Nutrition and Pregnancy Outcomes: Anthropometric Assessment, Part III: Height. Washington DC: Pan American Health Organization. Pp. 104-111.

Misra, A., Pandey, R. M., Rama Devi, J., Sharma, R., Vikram, N. K. and Khanna, N. (2001). High prevalence of diabetes, obesity and dyslipidemia in urban slum population in Northern India. *Int. J. Obes.* 25: 1722-9.

Murray, C. J. L. and Lopez, A. D. (1996). The global burden of disease in 1990: Final results and their sensitivity to alternate epidemiological perspectives, discount rates, age weights and disability weights. In: Murray, C. J. L., Lopez, A.D. (eds). The Global Burden of Diseases, Injuries and Risk factors in 1990 and projected to 2020, Vol. 1. Cambridge, MA: Harvard University Press.

Nube, M., Asenso Okyere, W. K. and van den Bloom, G.J.M. (1998). Body mass index as an indicator of standard of living in developing countries. *Eur. J. Clin. Nutr*. 77: 1186-91.

Paknahad, Z., Mahboobm, S., Omidvar, N., Ebrahimi, M., Ostadrahimi, A., Afiatmilani, Sh. (2008). Body Mass Index and its Relationship with Hematological Indices in Iranian Women. *Pak J. Nutr.* 7: 377-380.

Pal, A., Sengupta, P. and Dhara, P. C. (2014). An investigation on prevalence of Anemia in relation to BMI and nutrient intake among adult rural population of West Bengal, India. *Epidemiol. Biostats. Pub. Health.* 11: e-8915.

Patil, S. N., Wasnik, V. and Wadke, R. (2009). Health Problems amongst Adolescent Girls In Rural Areas Of Ratnagiri District Of Maharashtra India. *J. Clin. Diag. Res.* 3: 1784-1790.

Penninx, B. W. J. H., Pahor, M. and Cesari, M. (2004). Anaemia is associated with disability and decreased physical performance and muscle strength in the elderly. *J. Am. Geriatr. Soc.* 52: 719–724.

Rammohan, A., Awofeso, N. and Robitaille, M. C. (2012). Addressing female iron-deficiency anaemia in India: is vegetarianism the major obstacle? ISRN Public Health Article ID 765476, 8 pages. doi:10.5402/2012/765476.

Sanjeev, I., G. D. Indech, I. and Johnston, F. E. (1991). Skin fold thickness, body circumferences and their relationship to age, sex, and socio-economic status in adults from North-West India. *Am. J. Hum. Biol.* 3: 469-477.

Sathyanarayana, K., Venkataramana, Y. and Rao, S. M. (1989). Nutrition and work performance; studies carried out in India. In: : WA Kim (ed). *Proc. Internatl. Cong.*

Nutr. Seoul, Internatl. *Union of Nutr. Sci*. Pp. 302-305.

Sawaya, A. L., Dallal, G. and Solymos, G. (1995). Obesity and malnutrition in a shantytown population in the city of Sao Paolo, Brazil. *Obes. Res.* 3(suppl.2): 135S-143S.

Seidell, J. C., Verschuren, W. M. and Kromhout, D. (1995). Prevalence and trends of obesity in the Netherlands, 1987-1991. *Int. J. Obes. Relat. Metab. Disord.* 12: 924-927.

Seshadri, S. (1997). Nutritional anaemia in South Asia. In: Malnutrition in South Asia: a regional profile. Gillespie, S. (ed.). UNICEF: ROSA Publication. Pp. 75-124.

Sharma, A., Prasad, K. and Visweswara Rao, K. (2000). Identification of an appropriate strategy to control anaemia in adolescent girls of poor communities. New Delhi : Nutrition Foundation of India.

Seshadri, S. (1999). 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.

Subramanian, S. V., Ackerson, L. K., Davey Smith, G. and John, N. A. (2009). Association of maternal height with child mortality, anthropometric failure and anemia in India. *JAMA*. 301: 1691-1701.

Tiwari, K. and Seshadri, S. (2000). The prevalence of anaemia and morbidity profile among school going adolescent girls of urban Kathmandu, Nepal. *J. Nep. Med. Assoc*. 39: 319-325.

Tracer, D. P. (1997). Reproductive and socio-economic correlates of maternal haemoglobin levels in a rural area of Papua New Guinea. *Trop. Med. Int. Health.* 2: 513-18.

UNICEF/UNU/WHO/MI. (1999). Preventing iron deficiency in women and children: background and consensus on key technical issues and resources for advocacy, planning and implementing National Programs. Geneva: WHO.

Vasanthi, G., Fawashe, A. B., Susie, H., Sujatha, T. and Raman, L. (1994). Iron nutritional status of adolescent girls from rural area and urban slum. *Indian. Ped*. 31: 127-132.

World Health Organisation (WHO). (1992). The Prevalence of Anemia in Women: A Tabulation of Available Information. Geneva, Switzerland: WHO.

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

World Health Organization. (1996). The world health report 1996 - Fighting disease, fostering development. Geneva, Switzerland: WHO.

World Health Organization. (2008). Worldwide prevalence of anaemia 1993-2005 : WHO global database on anaemia. / Edited by Bruno de Benoist, Erin McLean, Ines Egli and Mary Cogswell. World Health Organization. http://www.who.int/iris/handle/10665/43894.

Yip, R. (1988). Iron fortification: prevention of iron deficiency for developing countries. Paper presented at: Institute of Food Technologies Annual meeting: June 20-24, 1988; Atlanta, G.A.