UNIVERSITI PUTRA MALAYSIA

ASSESSMENT OF IRON STATUS AMONG ADOLESCENTS IN THE FISHING VILLAGES OF TUARAN, SABAH

FOO LENG HUAT

FPSK (M) 2002 7

ASSESSMENT OF IRON STATUS AMONG ADOLESCENTS IN THE FISHING VILLAGES OF TUARAN, SABAH

By

FOO LENG HUAT

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

April 2002

DEDICATED TO

My family members, especially my grandmother Mdm. Beh Cheng Goh and loved one, Khor Lee Hua,

For their constant support and unceasing encouragement that has sustained me towards the completion of this thesis

Subjects, subject's parents and friends who were directly or indirectly involved in this project

For their constant support, co-operation and commitment throughout the study

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree Master of Science

ASSESSMENT OF IRON STATUS AMONG ADOLESCENTS IN THE FISHING VILLAGES OF TUARAN, SABAH

By

FOO LENG HUAT

April 2002

Chairman : Professor Dr. Khor Geok Lin

Faculty : Medicine and Heath Sciences

Iron deficiency anaemia is the most common micronutrient deficiency in the world affecting the general health of millions In Malaysia, a moderately high prevalence of anemia is often reported in infants, young children and women of childbearing age Data on anaemia is scant for the adolescents This study was undertaken to assess the iron status of adolescents from six fishing villages in Tuaran, Sabah A total of 199 subjects comprising 94 male and 105 female were included in the study Their ages ranged from 12 to 19 years with a mean of 15 2 years Multiple iron status indicators namely, serum ferritin (SF), transferrin saturation (TS), mean corpuscular volume (MCV) and hemoglobin concentration were used to estimate the stages of iron deficiency The majority of the male (68 1%) and female subjects (82 9%) had normal body mass index (BMI) values, while 25 5% and 14 3% of the males and females respectively were underweight A small percentage of the adolescents was overweight, that is 6 4% and 2 9% of the male and female respectively Male adolescents showed significantly higher mean values for hemoglobin concentration, hematocrit, red blood count, serum iron, transferrin

saturation and serum ferritin than the female subjects. In contrast, female adolescents had a significantly higher level of total iron binding capacity. The prevalence of iron deficiency anaemia, iron deficiency and iron depletion among the adolescents (both sexes) were 17%, 23% and 6% respectively. Approximately 85% of the anaemia prevalence could be attributed to iron deficiency. The prevalence of iron deficiency anaemia was higher among the females (26%) than the male adolescents (5%). Food intake data showed that the male adolescents had significantly higher intakes of energy, carbohydrates, protein, fat, vitamin C, thiamin, riboflavin and niacin than the female subjects. Nonetheless, intake of all nutrients except for protein, niacin and vitamin C by both sexes were below the recommended dietary allowances levels for Malaysia. The dietary iron intake among the adolescents was unsatisfactory with about 98% failing to meet the recommended levels. Majority of the adolescents derived dietary iron mainly from plant foods (78%), that is, only about 22% of the total iron intake was from animal products. A significant correlation was shown between hemoglobin concentrations and body weight, and a negative correlation with age indicating that hemoglobin concentrations tend to increase with body weight and decrease with age. Dietary nutrient intake except for carbohydrates showed significant correlations with serum ferritin, serum iron, transferrin saturation, mean corpuscular volume and hemoglobin. In contrast, total iron binding capacity (TIBC) was negatively correlated with all the nutrients. These results indicated the importance of dietary iron intake in improving the iron stores among the adolescents. Based on the World Health Organization criteria (WHO, 1996), the prevalence of iron deficiency anaemia in the present study population (18%), especially the female adolescents (26%), appears to be a significant public health problem with regards to iron deficiency. It is hoped that with the results of this study, iron deficiency in

adolescents from low-income groups, especially the female adolescents would be accorded greater attention. Nutrition education and other intervention programs including micronutrient supplementation and dietary diversification are recommended for the alleviation of iron deficiency in adolescence.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENILAIAN STATUS FERUM DI KALANGAN REMAJA DI PERKAMPUNGAN NELAYAN TUARAN, SABAH

Oleh

FOO LENG HUAT

April 2002

Pengerusi : Profesor Dr. Khor Geok Lin

Fakulti : Perubatan dan Sains Kesihatan

Anemia kekurangan ferum merupakan kekurangan mikronutrient yang paling tersebar luas di dunia ini dimana mengakibatkan beramai-ramai kemudaratan kesihatan. Di Malaysia, prevalen anemia yang sederhana tinggi kerap dilaporkan di kalangan bayi, kanak-kanak dan wanita dalam lingkungan umur boleh mengandung. Data bagi anemia adalah kurang bagi golongan remaja. Kajian ini dijalankan untuk menilai stàtus ferum di kalangan remaja daripada enam perkanpungan nelayan di Tuaran, Sabah.. Seramai 199 subjek remaja yang terdiri daripada 94 lelaki and 105 perempuan telah menyertai kajian ini. Lingkungan umur mereka adalah daripada 12 hingga 19 tahun. Pelbagai indikator status ferum seperti serum ferritin, kepekatan transferrin, min isipadu corpuscular and kepekatan hemoglobin digunakan bagi menganggar peringkat kekurangan ferum. Majoriti remaja lelaki (68.1%) dan perempuan (82.9%) mempunyai nilai indek jism badan yang normal, sementara 25.5% dan 14.3% remaja lelaki and perempuan masing-masing mengalami kekurangan berat badan. Terdapat peratusan kecil remaja mengalami berlebihan berat badan, iaitu 6.4% dan 2.9% bagi lelaki dan perempuan masing-masing. Remaja

lelaki menunjukkan nilai min yang tinggi secara signifikan bagi kepekatan hemoglobin, hematokrit, kiraan darah merah, serum ferum, kepekatan transferrin, dan serum ferritin berbanding dengan subjek perempuan. Sebaliknya, remaja perempuan mempunyai tahap keupayaan ikatan keseluruhan ferum yang tinggi secara signifikan. Prevalen anemia kekurangan ferum, kekurangan ferum dan kehabisan ferum di kalangan remaja (kedua-dua jantina) ialah 17%, 23% dan 6%. Kira-kira 85% daripada kejadian anemia adalah atribut kepada kekurangan ferum. Kejadian anemia kekurangan ferum adalah tinggi di kalangan remaja perempuan (26%) berbanding dengan remaja lelaki (5%). Data pengambilan makanan menunjukkan remaja lelaki mempunyai pengambilan tenaga, karbohidrat, protein, lemak, vitamin C, thiamin, riboflavin and niasin yang tinggi secara signifikan berbanding dengan subjek perempuan. Namun demikian, pengambilan keseluruhan nutrien kecuali protein, niasin dan vitamin C bagi kedua-dua jantina adalah di bawah tahap cadangan peruntukkan dietari bagi Malaysia. Pengambilan dietari ferum di kalangan remaja adalah paling tidak memuaskan dimana sekitar 98% gagal memenuhi tahap cadangan keizinan dietari. Kebanyakkan remaja memperoleh dietari ferum terutamanya daripada makanan berunsurkan tumbuhan (78%), iaitu hanya kira-kira 22% daripada pengambilan ferum keseluruhan berasal daripada makanan berunsurkan haiwan. Korelasi signifikan yang ditunjukkan di antara kepekatan hemoglobin dan berat badan, dan korelasi negatif dengan umur memperlihatkan bahawa kepekatan hemoglobin cenderung meningkat dengan berat badan dan menurun dengan umur. Pengambilan nutrien dietari kecuali karbohidrat menunjukkan korelasi yang signifikan dengan serum ferritin, serum ferum, kepekatan transferrin, min isipadu cospuscular dan hemoglobin. Sebaliknya, keupayaan ikatan keseluruhan ferum adalah berkorelasi negatif dengan keseluruhan

nutrien. Keputusan ini menunjukkan bahawa kepentingan pengambilan ferum dietari dapat meningkatkan penyimpanan ferum di kalangan remaja. Berdasarkan kriteria Pertubuhan Kesihatan Sedunia (WHO, 1996), prevalen anemia kekurangan ferum di kalangan populasi kajian (18%), terutamanya remaja perempuan (26%), ternyata merupakan masalah kesihatan awam signifikan yang berhubung dengan kekurangan ferum. Diharapkan dengan keputusan kajian ini, kekurangan ferum di kalangan remaja daripada golongan pendapatan rendah, terutamanya remaja perempuan dapat diberikan perhatian yang lebih menyeluruh. Pendidikan pemakanan dan program intervensi yang lain termasuk supplementasi mikronutrien dan pengubahsuaian dietari dicadangkan bagi pengurangan kekurangan ferum di peringkat remaja.

AKNOWLEDGEMENTS

This thesis would not have been possible without the help, support and encouragement of several people who readily gave much of their time and energy selflessly.

My grateful appreciation is extended to my chief supervisor, Professor Dr. Khor Geok Lin, for all her contribution, especially for her insistence for a rigorous and disciplined approach to work throughout my study and thesis preparation. My gratitude is also extended to Dr. Tee E Siong and Dr. Prabakaran Dhanaraj, as members of my supervisory committee, for their critical comments and close cooperation throughout the study.

I wish to convey my sincere appreciation to the Sabah State Health Department and Tuaran District Health Office for their cooperation in permitting this study to be carried out in the fishing villages of the Tuaran district in Sabah. My appreciation also goes to the village head (*Penghulu kampung*), JKKKs in all the fishing villages, Dr. Shanmugam, Dr. George Mathew, Senior MA Rirchard Onong, Mr. John Maluda, Mr. Daniyah, Mr. Chooi Kum Hoong, JM Ariam Nasiri, JM Siti Ramlah, MLT Sudang Tambur, MLT Kathleen Tan, MLT Sulaiman Ibrahim, MLT Aming Jamir, MLT Frankie, Mr. Stuh, Mrs Siti Muskinah and others who rendered assistance and cooperation to me during the field work, laboratory blood analyses and general work throughout the study. I am particularly grateful to all the adolescent subjects and their parents for their full support, dedication and commitment during the study.

I wish to record my sincere appreciation to Dumex (M) Sdn Bhd (Mr. S.M. Ow and Mr. Jainuddin Dunggi), Kelloggs Sdn Bhd (Mr. Ng Kim Keat) and Nestle Products Sdn Bhd (Dr. Zawiah Hashim and Mr. Jason Chong) for their generous contribution of food packets to the participants.

The financial support for this study by the Ministry of Science, Technology and Environment through its Intensification of Research Priority Areas (IRPA) programme is sincerely acknowledged.

Lastly, but far from least, my very sincere appreciation to my family members, in particular my grandmother Mrs Beh Cheng Goh, for their affection and support for my study, and my loved one, Khor Lee Hua for her commitment, care and understanding.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

Problem of Anaemia Worldwide

Undernutrition is the most important nutritional problem involving both protein energy malnutrition and micronutrient deficiencies worldwide (Darnton-Hill *et al.*, 1996). Nutritional anaemia, vitamin A deficiency and iodine deficiency disorders are the major micronutrient deficiencies in many countries (Darnton-Hill *et al.*, 1992). Nutritional anaemia is commonly associated with deficiencies of iron, folate and vitamin B_{12}. Among these, iron deficiency is most frequently encountered and it can be characterised by low hemoglobin and mean corpuscular (MCV)-microcytic hypochromia, decreased levels of transferrin saturation and serum ferritin.

Iron deficiency is a major nutritional deficiency in both industrialized countries (Arija *et al.*, 1990) and developing countries (Tee *et al.*, 1999; Thu *et al.*, 1999; Husaini *et al.*, 1991; Prual *et al.*, 1992; Cornet *et al.*, 1998). The prevalence of anaemia in developing countries is three to four times higher than that in industrialized countries. More than 3.5 billion people in the developing countries are estimated to suffer from anaemia (UNICEF/UNU/WHO/MI, 1999). The World Health Organization (WHO) estimated the prevalence of iron deficiency worldwide is high, affecting the general health and wellbeing of 2000 million people (Underwood, 1999). Pregnant women, children aged 5 to 14 years children and pre-school children are high-risk groups (ACC/SCN, 2000). In some developing

countries such as Argentina, Tanzania, Cameron and Zanzibar, more than 50% of infant, young children and pregnant women are anaemic with hemoglobin level below 110g/l (Calvo and Grazzo, 1990; Tatala *et al.*, 1998; Cornet *et al.*, 1998; Stolzfus *et al.*, 2000; Dugdale, 1994). Women lose storage iron during menstruation and pregnancy when iron is transported for the development of the foetus. Poor quality diet and lack of iron supplementation during pregnancy are contributing factors of iron deficiency in women.

Serious consequences of anaemia include impaired cognitive and optimal behaviour (Bruner *et al.*, 1996; Nelson, 1996), reduced immune functions leading to increased risk of morbidity and mortality (Darnton-Hill *et al.*, 1996). Anaemia also has deleterious effects on school academic performance (Pollitt, 1997; Pollitt *et al.*, 1989), general health and wellbeing, reproductive performance (Darnton-Hill *et al.*, 1996), physical performance (Nelson, 1996; Zhu and Haas, 1997) and work capacity (Li *et al.*, 1994; Pourghassem *et al.*, 2000). These consequences have serious impact on the health, economic and social development of individuals and the country as a whole.

Anaemia in Malaysia- Nature and Dimensions

The overall nutrition situation in Malaysia has greatly improved over the years (Tee and Cavalli-Sforza, 1993). However, pockets of malnutrition still exits in various parts of Malaysia. Several studies undertaken in the 1990s showed that certain "old" nutrition problems persist. These include protein-energy malnutrition in the forms of underweight, stunting and wasting, as well as iron deficiency anaemia, worm infestation and iodine deficiency disorders (Khor, 1997).

Iron deficiency anaemia is one of the most important micronutrient deficiencies in the country for the past several decades (Tee, 1999a). Infancy is highly susceptible to iron deficiency due to rapid growth and inadequate nutritional intake. A study undertaken by Tee and her workers (1994) showed that 16% apparently healthy infants aged 6 to 24 months were anaemic in the Child Health Clinic in University Hospital, Kuala Lumpur (Hb < 11g/dl). Iron deficiency anaemia was the most common problem (35%) among these anaemic children, followed by thalassaemia traits (26.9%). Increased risk of iron deficiency during infancy might be due to inadequate intake of complementary food and exclusive breast-feeding for more than six months (Mills, 1990; Oski, 1993; Booth and Aukett, 1997).

Documentation of iron deficiency anaemia amongst Malaysian children began in the 1940s and it remains a common nutrition problem of childhood. In an early nutrition survey, the prevalence of anaemia (Hb <70% of Tallqvist scale) was found high, ranging from 42 to 90% among the 1,200 children from welfare centers, orphanages and a refugee camp (Bourne, 1949). Studies in the 1970s indicated that the prevalence of iron deficiency anaemia among pre-school children and young children were 23% and 18.6% respectively (Chong, 1974; Kandiah and Lim, 1976). A study in the early 1990s reported the prevalence of anaemia (Hb <11g/dl) in young children aged less than 7 years ranged from 12% to 56% in rural villagers and estates in Peninsular Malaysia (Tee *et al.*, 1998). These studies highlighted the persistence of the anaemia problem among Malaysian children in the past decades.

During pregnancy, iron requirements exceed storage iron for most women due to increases in the red cell mass, iron needs of the foetus and iron losses during delivery (Bothwell *et al.*, 1984). Inadequate iron supply can restrict the expansion of red cell mass and lead to further deterioration in iron status during pregnancy which

may increase risks for the pregnant women and her infant (Allen, 1997). Moderate to severe anaemia during pregnancy is associated with an increased risk of low birth weight and preterm delivery (Scholl *et al.*, 1992; Scholl and Reilly, 2000; Zhou *et al.*, 1998). Incidence of anaemia among pregnant women in Malaysia was high in early studies (Tasker *et al.*, 1956ab, 1958). Anaemia was considered to be one of the main complications of pregnancy (Tasker, 1956b and 1958). A study in the 1980s among pregnant women showed a progressive fall in haematological indicators with the progression of pregnancy from first to third trimester (George *et al.*, 1980). A study carried out by Tee and co-workers (1984) at the Maternity Hospital, Kuala Lumpur showed a high prevalence of anaemia (Hb < 11g/dL) ranging from 30 to 60% among 309 pregnant women. A study on menstruating women indicated that more than half of them were anaemic (Hb < 12g/dl), while 26.6% were iron-deficient (serum ferritin < 12μg/dl) (Goh and Hariharan, 1985). These studies also found that Chinese women had higher mean hemoglobin and serum ferritin levels than the Malays and Indians (Goh *et al.*, 1985; Tee *et al.*, 1984).

Data on nutritional anaemia among Malaysian adolescents are scarce as compared to other age groups such as pre-school children, pregnant and lactating women. A study on female adolescents aged 12 to17 years in Sarawak reported prevalence of anaemia ranging from 9% to 37 % (Tee *et al.*, 1996). The survey conducted in rural villages and estates in Peninsular Malaysia revealed that 18% adolescents aged 13 to 17.9 years suffered from anaemia by the criteria of Hb < 11g/dl (Tee *et al.*, 1998). The prevalence rate of anaemia varied in the different rural communities with the lowest reported for the rubber smallholding community (6%) and highest in the fishing community (45%).

Anaemia in Sabah

There are relatively fewer studies on the nutritional status of the diverse population groups in Sabah. Studies in the early 1980s showed a high prevalence of anaemia ranging from 18% to 67% as determined by hemoglobin level among children (Chen *et al.*, 1981; Kandiah *et al.*, 1984). The former study reported prevalence of anaemia in over 3,000 children aged 0.5 to 13 years of various ethnic groups namely, Kadazans, Chinese, Bajaus, Malays and Muruts in the Interior, West Coast and Kudat Divisions of Sabah **(Table 1)**. The mean prevalence of anaemia among the children was 26% ranging from 16 to 31% in the various age groups. This study also found that children aged below 2 years had the highest prevalence of anaemia (31%). However, there was no significant difference in the prevalence of anaemia according to gender (Chen *et al.*, 1981). Another study found 18 to 67% anaemia in children aged 0 to 6 years in three malaria endemic villages of Bengkoka Peninsula in Sabah (Kandiah *et al.*, 1984).

Problem Statement

Adolescence is characterised by a large growth spurt and maturation (Beard, 2000). Rapid growth during adolescence renders positive iron balance difficult to maintain (Yip, 1994). This is due to the expansion of blood volume that occurs concurrently with growth. It is also a period of increased overall iron requirement because of the adolescent spurt in body mass (Himes *et al.*, 1997), especially among female adolescents because of the onset of menstrual losses (Kim *et al.*, 1993). Iron

Table 1: Prevalence of anaemia amongst children of various ethnic groups in the Interior, West Coast and Kudat Division of Sabah

Age (years)	% Anaemic		Mean
	Male	Female	Combined
0.5- 2	34.5	27.4	30.9
2 – 4	14.8	26.4	20.2
4 – 6	32.4	19.1	25.0
6 – 8	28.1	31.7	29.8
8 – 10	29.6	27.4	28.5
10 – 12	22.8	23.3	23.0
12 – 13	17.6	13.5	15.8
0.5 – 13	26.4	25.6	26.0

(Source: Chen *et al.*, 1981)

Study population: 0 – 4 years = 28
5 – 12 years = 2877
Total = 3672
Criteria for anaemia: 6 months – 6 years: Hb< 11g/dl

status during adolescence may be complicated further by low dietary iron intake (Nelson *et al.*, 1993; Sanders *et al.*, 1994).

Iron deficiency anaemia is widespread among adolescents in developing countries, with prevalence of more than 40% anaemia reported in Asian countries (Kurz, 1996). Iron requirements in adolescence are higher in developing countries because of infectious diseases and parasitic infestations that may cause iron loss, and because of low bioavailability of iron from diets limited in heme iron (Kanani and Poojara, 2000).

In general, the aetiology of iron deficiency anaemia can be viewed as an imbalance between iron absorption and the body's needs as illustrated in **Figure 1**. Such an imbalance generally arises from low dietary iron intake, poor absorption