UNIVERSITI PUTRA MALAYSIA

FACTORS ASSOCIATED WITH ACADEMIC ACHIEVEMENT IN URBAN PRIMARY SCHOOL CHILDREN WITH SPECIAL REFERENCE TO IRON STATUS AND BLOOD LEAD CONCENTRATIONS

ABDELHAMID M.S. FLAILIH

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ABDELHAMID M.S. FLAILIH

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

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Chairman: Associate Professor Maznah Ismail, Ph.D.

Faculty: Medicine and Health Sciences

The overall aim of the study was to examine the relationship between iron status, blood lead concentration and academic achievement of selected urban primary school children. The specific objectives were to assess the iron status and blood lead concentration of subjects and to determine the relationship between these parameters and their academic achievement. In addition, other factors such as socioeconomic status were examined. Study subjects were 108 (47 male and 61 female) aged 132 ± 9 months with good health and nutritional status. Study subjects were urban Malay primary school children attending two schools (Sekolah Kebangsaan Jalan Pasar 1 and Sekolah Kebangsaan Jalan Pasar 2) in Kuala Lumpur. Five-ml venous blood sample was collected from each subject. The hematological parameters (hemoglobin and hematocrit) were measured by using the Cyanmethemoglobin and Microhematocrit methods respectively. The biochemical indices of iron status (serum iron, serum ferritin and total iron-binding capacity) were measured by using the methods of colorimetric test with Ferrozin®/ascorbic acid, IMX® Ferritin assay-Micropartical Enzyme Immunoassay (MEIA), and

precipitation with Magnesium Hydroxide Carbonate respectively. Transferrin saturation was calculated as the ratio of serum iron to iron-binding capacity. Blood lead concentration was measured using the GBC 908 Atomic Absorption Spectrophotometer and system 3000 automated graphite furnace. A structured questionnaire was used to obtain information from the subject's parents regarding socioeconomic background and selected confounding factors. School attendance and academic achievement data were obtained from the schools. Multiple regression analysis was used to test the various hypotheses in this study with significant level of $p < 0.05$.

Measurement of iron status indices showed that only 2.8% of total subjects were anemic but 16.7% of them were iron-deficient. Blood lead concentration (PbB) ranged from 0.175 μg/dl to 21.026 μg/dl with a mean of 5.865 ±4.516 μg/dl. About 47.2% of subjects had PbB < 5 μg/dl and 36.1% of them had PbB ranged from 5 to < 10 μg/dl. About 13.0% of subjects had PbB ranged from 10 to 15 μg/dl. The remaining (3.7%) had PbB > 15 to 21.02 μg/dl. Serum ferritin was negatively correlated ($r = -0.183$, $p = 0.0450$) with blood lead concentration which indicates that iron deficiency is associated with lead concentration. Poor academic achievement is attributable to many factors. Both iron deficiency and high blood lead concentration (≥10 μg/dl) produced significant effects on academic achievement. Certain socioeconomic and confounding factors were also shown to be important influences on the subject's academic achievement. Academic achievement scores tended to be higher in children from smaller families. Father's education level and income tended to be associated with academic achievement scores. In addition, days absent from school were negatively associated with subject's academic achievement. The simultaneous influence of iron status and confounding factors on subject's academic achievement was assessed using a final general linear model. Hemoglobin level was the factor most strongly associated with the child's academic achievement.

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

FAKTOR-FAKTOR BERKAITAN DENGAN PENCAPAIAN AKADEMIK DI KALANGAN PELAJAR SEKOLAH RENDAH DI KAWASAN BANDAR MERUJUK KEPADA STATUS FERUM DAN KEPEKATAN PLUMBUM DARAH

Oleh

ABDELHAMID M.S. FLAILIH

Januari 2001

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Objektif am kajian ini adalah untuk mengenalpasti perkaitan di antara status ferum, kepekatan plumbum darah dan pencapaian akademik pelajar sekolah rendah terpilih di kawasan bandar. Objektif khusus kajian pula adalah untuk menilai status ferum dan kepekatan plumbum darah bagi subjek dan menentukan perkaitan di antara parameter –parameter tersebut dengan pencapaian akademik. Sebagai tambahan, faktor lain seperti status sosioekonomi telah dikaji. Subjek kajian adalah seramai 108 pelajar (47 lelaki dan 61 perempuan) berumur di antara 12 $\pm$ 9 bulan yang memiliki status kesihatan dan pemakanan yang baik. Subjek kajian adalah pelajar sekolah rendah berbangsa Melayu yang bersekolah di kawasan bandar (Sekolah Kebangsaan Jalan Pasar 1 dan Sekolah Kebangsaan Jalan Pasar 2) di Kuala Lumpur. Sebanyak 5 ml sampel darah dari vena diambil dari setiap subjek. Parameter hematologi (hemoglobin dan hematokrit) diukur dengan menggunakan kaedah "Cyanmethemoglobin" dan "Microhematocrit". Petunjuk biokimia bagi status ferum (serum ferum, serum feritin dan jumlah kapasiti ferum-pengikat) dinilai menggunakan kaedah ujian kolorimetrik dengan Ferrozin® / ascorbic acid, IMX® Ferritin assay–Micropartical Enzyme Immunoassay (MEIA), dan pemendakan

dengan Magnesium Hidroksida Karbonat. Ketepuan transferin dikira sebagai nisbah ferum serum dengan kapasiti ferum-pengikat. Paras plumbum darah ditentukan dengan menggunakan Sistem Grafit Spektrofotometer Serapan Atom. Borang soal selidik digunakan untuk mendapatkan maklumat latar belakang sosioekonomi dan faktor keluarga terpilih daripada ibubapa pelajar. Analisis *multiple regression* digunakan untuk menguji hipotesis kajian pada paras $p<0.05$.

Pengukuran status ferum menunjukkan hanya 2.8% subjek adalah anemik tetapi 16.7% didapati mengalami masalah kekurangan ferum. Paras Plumbum darah (PbB) berada di antara lingkungan 0.175 μg/dl dan 21.026 μg/dl dengan purata 5.865 $\pm$ 4.516 μg/dl. Lebih kurang 42.7% subjek mempunyai PbB < 5 μg/dl dan 36.1% pula mempunyai PbB dalam lingkungan antara 5 hingga < 10μg/dl. Kira-kira 13.0% subjek mempunyai PbB di antara 10 hingga 15μg/dl. Selebihnya (3.7%) mempunyai PbB > 15 hingga 21.02μg/dl. Serum feritin didapati berkolerasi secara negatif ($r=-0.183$, $p=0.0450$) dengan paras plumbum darah. Ini menunjukkan kekurangan ferum mempunyai perkaitan dengan penyerapan plumbum. Pencapaian akademik yang kurang baik adalah disebabkan oleh pelbagai faktor. Hasil utama kajian ini mendapati kekurangan ferum dan paras plumbum darah yang tinggi ($\geq$ 10μg/dl) memberi kesan terhadap pencapaian akademik. Sesetengah faktor sosioekonomi dan faktor luaran juga mempengaruhi pencapaian akademik subjek. Skor pencapaian akademik adalah berkecendurangan tinggi di kalangan kanak-kanak dari keluarga kecil. Pendidikan dan pendapatan ayah juga berkait dengan skor pencapaian akademik. Ketidakhadiran ke sekolah juga berkait secara negatif dengan pencapaian akademik subjek. Pengaruh status ferum dan faktor luaran terhadap pencapaian akademik subjek dinilai menggunakan 'final general linear model'. Secara keseluruhan, paras hemoglobin merupakan faktor yang paling berkait rapat dengan pencapaian akademik kanak-kanak.

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I would also like to acknowledge Dr. Zainab Abd. Majeed of the Faculty of Medicine and Health Sciences for helping me with blood collection. My deepest gratitude to the Laboratory of Haematology and Clinical Biochemistry, Faculty of Veterinary Medicine and Animal Science; Research and Development Laboratory, Haematology Division, Institute for Medical Research (IMR) for the use of their facilities as well as for their assistance. I am thankful to many people who have in one way or another helped to make this study a success.

I certify that an Examination Committee met on 29th January 2001 to conduct the final examination of Abdelhamid M. S. Flailih on his Master of Science thesis entitled "Factors Associated with Academic Achievement in Urban Primary School Children with Special Reference to Iron Status and Blood Lead Concentrations" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This Thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of the requirement for the degree of Master of Science.

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

Name: ABDELHAMID M.S. FLAILIH

Date: 1 March, 2001

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LIST OF ABBREVIATIONS

AA	Academic Achievement
Hb	Hemoglobin
HCT	Hematocrit
SF	Serum Ferritin
SI	Serum Iron
TS	Transferrin Saturation
TIBC	Total Iron-Binding Capacity
PCV	Packed Cell Volume
rpm	Rotate per minute
MEIA	Microparticle Enzyme Immunoassay
MUP	4-methylumbelliferyl Phosphate
MU	Methylumbelliferone
EP	Erythrocyte Protoporphyrin
BMI	Body Mass Index = weight (kg) / height $(m)^2$
UIBC	Unsaturated iron-Binding Capacity
IMR	Institute For Medical Research
PbB	Blood Lead

CHAPTER I

INTRODUCTION

Iron deficiency is the most frequently occurring nutritional problem across the world. It affects all age groups, but especially among children and women of childbearing age particularly pregnant women. It has been estimated that there are more than 500 million people throughout the world with iron deficiency and about 20 million in the United States mostly children and women actually have iron deficiency and iron deficiency anemia (Scholl et al., 1992).

In Malaysia numerous studies have been devoted specially to the problem of anemia in children. With some exception, all of the studies reviewed were community-based studies. For example, the prevalence of iron deficiency anemia in preschool children reported ranges from 10% to more than 30% in villages throughout Peninsular Malaysia, while in Sabah, the levels recorded were 26% among children aged 0 to 12 years and 44% for young children aged 0 to 72 months (Khor, 1997).

Iron deficiency prevalence varies from one country to another, and in the same country, from one place to another and in the same place, among different community groups. The high prevalence may be due to factors causing iron deficiency, which are many, and varied. However the main cause of iron deficiency is insufficient supply of absorbable dietary iron. An increased physiological iron requirement, which cannot be compensated by available iron stores and increased food iron absorption, is also responsible for iron deficiency. For example, the requirement of iron increases during puberty and in close relation to growth and weight gain. Growth implies a corresponding increase in the total hemoglobin mass, and for this formation of new hemoglobin iron is needed. In girls, menstrual blood loss means an extra loss of iron, which must be compensated for by a further increase in iron intake. Blood donation and increased gastrointestinal blood losses are also frequently the reason for the development of iron deficiency. Iron losses due to malaria and parasites, particularly hookworm is considered as the main cause of iron deficiency in certain parts of the world.

Anemia is often thought to be the end the result of iron deficiency. However, iron deficiency has many other manifestations, including non-hematological manifestations. These manifestations vary according to sex and different age groups. In infants, Oski and Honig in 1978 produced the first influential study, which showed that iron deficient infants have behavioral abnormalities. Since then, increasingly convincing evidence began to accumulate to suggest that iron deficiency impaired psychomotor development and cognitive function (Lozoff, 1988). Numerous studies performed in different cultures have shown that anemic infants tend to score more poorly on intellectual and motor tests (Oski 1983, Walter 1989, Lozoff 1987, Lozoff 1991, Aukett 1986, Idjradinta 1993).

In this country, there are few studies that have been carried out on the relationships between iron deficiency and school performance. One of these studies is that of Kandiah et al. (1993). The sample population was 207 rural Malay school children aged 98 ±2.3 months. Iron- deficient anemic children appeared to have improved significantly in school achievement scores. This improvement was obtained after treatment with iron supplement for a 3 months period which produced significant increases in hematological parameters among the iron-deficient anemic children. The author suggested that iron supplementation appears to have a beneficial effect on the learning process as measured by the school achievement scores. Other studies have been conducted to investigate the effect of iron deficiency anemia on academic achievement of school-age children (Pollitt, 1985; Soemantri, 1989). The finding of these studies suggested that iron deficiency anemia was associated with poor academic achievement in school-age children. The effects of iron deficiency on adult males and females have also been studied. Many studies have shown that work capacity is impaired as a consequence of iron deficiency. For example, study in Beijing has found that iron deficiency (with and without anemia) had deleterious functional consequences and impaired energy expenditure over a long working period in female cotton workers (Li et al., 1994). After iron supplementation, mean heart rate and energy expenditure at work were reduced and production efficiency was increased. In pregnant women, iron deficiency increases the risk for a preterm delivery and delivering a low-birth weight baby. Studies on adolescent athletes have shown that non-anemic iron deficiency condition can be an obstacle to performance, in other words leading to impaired endurance time among runners (Rowland, 1988).

A further complicating factor for iron deficiency is the iron-lead interaction. Lead inhibits the body's ability to make hemoglobin by interfering with several enzymatic steps in the heme pathway and gives the effect of iron deficiency and resultant anemia. (Albert, 1974; ATSDR, 1990). Many studies showed that the degree of anemia produced by the combination of iron deficiency and lead intoxication is greater than that result from either alone (Mahaffey and Annest, 1986). In addition, both iron deficiency and lead exposure produce effects on cognitive function among infants and children (Ruff et al., 1996).

The highest concentration of lead in air is found in the areas of dense population, since it is in these areas that most petrol-driven vehicles are to be found. In United States, Mc Mullen et al (1972) reported that lead concentration in non-urban stations averaged 0.21 $\mu g/m^3$ near the city, 0.96 $\mu g/m^3$ at intermediate distance from the city and 1.1$\mu g/m^3$ in the urban station. In Malaysia, Halimah (1981) reported that the average concentration of lead in air 4.11 $\mu g/m^3$ at a station within Kuala Lumpur city limits monitored at Jalan Klang Lama, while that from a rural setting (Universiti Putra Malaysia) was 0.99 $\mu g/m^3$. The result of this study indicated that the mean blood lead concentration was higher in the traffic policeman than the general population. In a studies carried out by Zailina, et. al., (1994) showed that children in urban areas were highly exposed to lead when compared to children in sub-urban area.

In children, direct exposure is one way that lead in the air can cause health effects. Alternatively, as the lead settles out from the air, it may be ingested through soil or dust consumption or by consumption of contaminated food. Many scientific investigations have established the relationship especially in children, between lead concentration in the body and the lead contained in soil and house dust (Lepow et al., 1975; Duggan, 1980; CDC, 1991). Lead exposure adversely affects the cognitive development and behavior of young children (ATSD, 1999). Cognitive and growth defects may occur in infants whose mothers are exposed to lead during pregnancy. For children aged less than 6 years, Center for Disease Control (CDC) has defined an elevated blood lead concentration as ≥ 10 μg/dl, but evidence exists for subtle effects at lower concentration (Herbert et al., 1990; Schwartz, 1994).

In other study that measured total body burden, primary school children with high tooth lead concentration had larger deficits in psychometric intelligence scores, speech and language processing, attention, and classroom performance than children with lower concentration of lead. As example, a study carried out on 509 primary schools children living near a lead smelter in Lavrion area, Greece. The psychometric intelligence and the blood lead concentration (PbB) were evaluated. The mean PbB was 23.7 μg/dl with a range of 7.4 μg/dl to 63.9μg/dl. After controlling for 17 variables, including parent IQ, with a multiple linear regression model, it was found that PbB was significantly associated with full-scale IQ of the WISC-R (β= -0.270, p= 0.000069). Verbal and performance were almost equally affected. The adjusted Full-scale IQ difference between high (> 45 μg/dl) and low PbB children was 9.1 units (Hatzakis et al, 1985). Hearing acuity, particularly at higher frequencies has been found to decrease with increasing blood lead concentration. Hearing loss may contribute to the apparent learning disabilities or poor classroom behavior exhibited by children with lead intoxication.

As mentioned earlier, iron deficiency with and without anemia as well as lead pollution are considered as public health problem worldwide, particularly for children and women of childbearing age. Poor academic achievement in school age children as a consequence of iron deficiency anemia and lead poisoning is considered as problem for this age group. Unfortunately, little attention has been given to investigate the effect of iron deficiency and lead exposure on academic achievement in school-age children. Nonetheless, most attention has been given to lower primary school children i.e., among children below nine years old. I have therefore chosen to focus this study to investigate the relationship between iron status, blood lead concentration and academic achievement, among eleven-year-old children. The conceptual framework shown in Figure 1 illustrates the overall scope of the study.