THE PREVALENCE AND RISK FACTORS OF IRON DEFICIENCY ANEMIA AMONG RURAL SCHOOLCHILDREN IN KUDAT, SABAH.

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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

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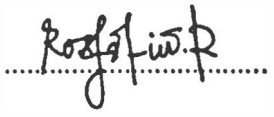

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ABSTRACT

Iron deficiency anaemia (IDA) is the most common nutritional anaemia in the world that affects individuals in both developed and developing countries including Malaysia. Several previous researches have shown association between iron deficiency anaemia and risk factors in demographic, socio-economic, nutritional status and soil-transmitted helminthes exposure. The data of IDA among schoolchildren is crucial in order to know the iron status of the schoolchildren and its associated risk factors as IDA may contribute to poor mental and school academic performance. Hence, the objective of the study was to diagnose the present prevalence of IDA and to analyse the association of probable demographic, socio-economic, nutritional and soil-transmitted helminthes exposure risk factors with schoolchildren. This cross-sectional study was carried out from August 2017 to February 2018, among 261 schoolchildren who aged 8 to 10 years old in Kudat district, Sabah. Out of 82 anaemic children, 36 were suffering from iron deficiency anaemia. Household income, body mass index status, knowledge and practice regarding IDA, soil-transmitted helminthes exposures, and limited intake of iron were found to be associated significantly with the prevalence of iron deficiency anaemia. By improving the quality of life including improved household economy, education, sanitation and personal hygiene status and promoting consistent nutritional education among the population may help to reduce prevalence of IDA.

ABSTRAK

PREVALENS DAN FAKTOR RISIKO ANEMIA AKIBAT KEKURANGAN ZAT BESI DI KALANGAN KANAK-KANAK PEDALAMAN KUDAT, SABAH.

Anemia akibat kekurangan zat besi adalah penyakit yang sering berlaku di kalangan individu di negara membangun dan sedang membangun termasuk Malaysia. Beberapa kajian terdahulu menyatakan bahawa terdapat hubungan jelas antara anemia akibat kekurangan zat besi dengan beberapa faktor termasuk demografi, sosio-ekonomi, status nutrisi, dan pendedahan kepada jangkitan cacing. Data di kalangan kanak-kanak adalah penting untuk mengetahui status zat besi kanak-kanak dan faktor risiko yang berhubungan kerana penyakit ini mampu mengganggu perkembangan mental dan prestasi akademik. Oleh itu, matlamat utama kajian ini adalah untuk menentukan kadar prevalens dan faktor risiko anemia akibat kekurangan zat besi termasuk demografi, sosio-ekonomi, status nutrisi dan pendedahan kepada jangkitan cacing di kalangan kanak-kanak sekolah. Kajian keratan rentas telah dijalankan dari Ogos 2017 sehingga Februari 2018 di kalangan 261 orang kanak-kanak berumur 8 hingga 10 tahun di daerah Kudat, Sabah. Daripada 82 orang kanak-kanak anemia, 36 orang kanak-kanak di kesan mendapat anemia akibat kekurangan zat besi. Pendapatan keluarga, indeks jisim tubuh, pengetahuan dan amalan terhadap anemia akibat kekurangan zat besi, jangkitan cacing dan kekurangan dalam pengambilan zat besi ternyata mempunyai hubungan dengan prevalens anemia akibat kekurangan zat besi. Oleh itu, menaik taraf kualiti kehidupan termasuk memperbaiki ekonomi, pendidikan, sanitasi dan status kebersihan diri serta menyarankan pendidikan nutrisi secara berterusan di kalangan populasi boleh membantu untuk mengurangkan kadar prevalens.

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LIST OF ABBREVIATIONS

<	Less than
>	More than
µ/ ml	Micro per milliliter
BMI	Body mass index
FBC	Full blood count
Fe 2+	Ferrous iron
Fe 3+	Ferric iron form
FFQ	Food frequency questionnaires
g/dl	Gram per deciliter
g/L	Gram per liter
Hb	Haemoglobin
ID	Iron deficiency
IDA	Iron deficiency anemia
KAP	Knowledge, attitude and practice
MCH	Mean corpuscular haemoglobin
MCHC	Mean corpuscular haemoglobin concentration
MCV	Mean corpuscular volume
Mg	Milligram
RBC	Red blood cells
RNI	Recommended nutrient intake
SD	Standard deviation
SF	Serum ferritin
SI	Serum iron
STH	Soil-transmitted helminthes
TIBC	Total iron binding capacity
WHO	World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Iron is an essential micronutrient which plays important roles in human metabolic processes. Iron equilibrium is maintained to make sure that sufficient iron is absorbed to compensate iron losses during metabolic process in the body (WHO, 2005). Consistent errors on maintaining iron equilibrium lead to either iron deficiency or iron overload (Conrad & Umbreit, 2000). In Global Burden of Disease (GBD) 2000 project, iron deficiency is considered as the most prevalent forms of malnutrition and in the rank number 9 among 26 selected risk factors (Ezzati, Lopez, Rodgers A , Vander HS , & CJ., 2002). Along with the previous study, it has been stated that anaemia burden estimation remains unchanged in the Global Burden of Disease (GBD) 2010 project. A follow up study has been conducted on Global Burden of Disease (GBD), injuries and risk factors 2013 to determine the trend and level of anaemia-related issues. The study estimated the prevalence of anaemia (Kassebaum, 2016).

Anaemia is a medical condition that continues to be a major public health concern until today. Therefore, it deserves a sustained public health intervention in many developing countries, especially in rural communities. Anaemia is defined by WHO (2008) as a reduced haemoglobin (Hb) level which leads to impairment of oxygen delivery to body tissues. According toWHO (2001), half of anaemia cases are due to deficiency of iron, which is one of the most common micronutrient deficiencies in both developing and developed countries.

Iron deficiency anaemia (IDA) occurs when there is overlap exists between anaemia and iron deficiency (Al-Zabedi, 2014). Iron deficiency (ID) is the outcome of long term of depleted iron imbalance. Further depletion causes severe stage of iron deficiency which leads to development of IDA (WHO, 2001). The severity of IDA may vary from mild to severe. Due to the progression of iron deficiency stage, people with mild or moderate IDA may not experience signs and symptoms. The most common symptoms of IDA are fatigue, dizziness, headache, shortness of breath, chest pain, difficulty of concentrating and irregular heartbeat (severe IDA). The signs of IDA may include pallor, koilonychias (spoon nails), glossitis or dysphagia. Symptoms become worsen when anaemia becomes more severe.

IDA causes severe health consequences which may lead to increased risk of high maternal and child mortality, incidence of low birth weight infants as well as decreased work productivity, increased risk of infectious diseases and death due to severe anaemia(WHO, 2008). The main concerns in children due to negative effects of IDA are cognitive impairment and physical development of children. This includes inadequate growth and mental development in which contribute to poor school performance among schoolchildren (Grantham-McGregor S & C, 2001; Robertson LJ, Crompton DW, Sanjur D, & MC., 1992).

The concentrations of haemoglobin may vary with multiple factors including age, gender and physiological status. Iron deficiency is more likely to occur when requirements are increased such as during rapid growth period in children and adolescent, but the iron body stores is too low to compensate the red blood cell production. Iron stores are progressively reduced and no longer able to meet the demands of normal iron turnover (Fonseca et al., 2016; WHO, 2005). Of relevance to this research project, the defining criteria for anaemia for children 5 to11 years old haemoglobin cut-off value of lower than 11.5 g/dl has been used (WHO, 2001).

In Malaysia, malnourishment is often associated with IDA because of the low consumption of iron haem from animal food sources. This condition is may be due to economic challenge that leads to financial constraint towards underprivileged

population, hence, poor diet because of poverty (Ngui, Lim, Chong Kin, Sek Chuen, & Jaffar, 2012). Determinants including demographic factors such as age, gender and larger family size; Socio-economic factors such as parents' education level, occupation and low household income may contribute to IDA (Al-Mekhlafi et al., 2008; Ngui et al., 2012). For instance, nutritional deficiency disease are associated with soil-transmitted helminths (STH) infections which give impact on nutrition, growth and development especially in children (Robertson LJ et al., 1992). Given that the nutritional deficiency, poor socio-economic status and STH infections are closely associated, we conducted a comprehensive study to provide current information on the prevalence of IDA and to determine the possible associated risk factors among 300 schoolchildren living in remote areas in Kudat, Sabah.

Globally, iron deficiency is one of the most prevalent nutritional deficiencies that affect over two billion people across the world in both developed countries and developing countries. According to Saloojee and Pettifor (2001), the prevalence of IDA in the world's population suffering from iron deficiency is 20 percent to 50 percent. Studies of the prevalence of IDA have been conducted across the world, it has been reported in Africa and some part of Asia regions, whereas, North America contributes about 1.4% of global burden (Stoltzfus, 2003). It has been estimated that about 5.9% and 48.1% in children between the ages 5 to 14 years old had iron deficiency anaemia. There have been significant differences in prevalence of iron deficiency anaemia between developed and developing countries in each age group (WHO, 2001).

1.2 RESEARCH BACKGROUND

Sabah is divided into 5 divisions; the interior, the west coast, Kudat, Sandakan and Tawau. This study was carried out in Kudat district from August 2017 to February 2018. Kudat is located 190 KM north of Kota Kinabalu, Sabah, East Malaysia. The areas are purposely chosen due to their similar nature of populations in these villages with respect to their socio-cultural and daily economic activities which was considered

appropriate for this study. In addition, the areas are considered as remote with poor socio-economic conditions with a high potential of malnutrition and possible parasitic infections. Most people residing in the areas are working as farmers, fishermen, labor workers and self-employed. One of the reasons Kudat was chosen for this study because the location is accessible by road transport for rapid transfer of samples to the laboratory.

In this current study, a cross sectional study has been conducted in six different rural schools in Kudat involving 300 schoolchildren. Prior to that, letters of permission to schools' principals were distributed to each school after approval by Ministry of Education and Kudat District Education Office. A short briefing and distribution of consent letters attached with the questionnaires were given to class teachers and parents / guardians involved. The participants were chosen according to the consent form returned to researcher. As a result, only participants who agreed to participate were included in the study.

The sampling technique used in the study is simple random sampling among schoolchildren aged from 8 to 10 years old. Demographic, socio-economic, nutritional status and knowledge, attitude and practice towards IDA data were collected using validated questionnaires. The questionnaires have been modified to fit the population. To determine IDA status, haemoglobin concentrations, full blood count, serum iron (SI), serum ferritin (SF) and total iron binding capacity (TIBC) were measured. Stools were taken and analysed using direct smear stool techniques to detect the presence of helminths egg.

1.3 PROBLEM STATEMENTS

According to Saloojee and Pettifor (2001) in their studies, 20 percent to 50 percent of the world's population is suffering from iron deficiency. The World Health Organization (WHO) estimates that over two billion people across the world including Malaysia are affected with anaemia. On average, fifty percent of the anaemia cases globally

occurred due to IDA. Globally, 841,000 deaths and 35,057,000 disability-adjusted life year (DALY) are attributable to IDA (Stoltzfus RJ, Mullany L, & RE., 2004). However, even there are many studies regarding iron deficiency anaemia, the health consequences of the disease remain as a subject of research and debate to many experts. This is due to a lack of agreement about the nature and magnitude of the health consequences of iron deficiency in populations.

It has been highlighted that the group most affected to IDA include infants, children, women of childbearing age, pregnant and lactating women (WHO, 2008). Several studies of IDA have been shown to be an important cause for decreased attention span, reduced alertness and learning difficulties in both children and adolescent (Gordon, 2003; Pollitt, 1997; Saloojee & Pettifor, 2001). There is vast evidence on negative effects of iron deficiency to a child's developing brain from studies that have been conducted across the world (Igbal et al., 2015). However, data on this subject in Malaysia especially children in Sabah is limited to certain extent.

Nutritional deficiency is often associated with underprivileged communities with poor socio-economic status and soil-transmitted helminths infestation. Prior studies revealed that STH infestation was a strong predictor of anaemia and IDA among children especially in rural communities.

The prevalence of IDA recorded as high as 50% among east Asian schoolchildren age and 60% among children less than 5 years old (Stoltzfus, 2003). Several previous local studies by Al-Mekhlafi et al. (2008) and Ngui et al. (2012), demonstrated findings on prevalence of IDA with 34.0% and 16.9% respectively. In a most recent similar study conducted in Peninsular Malaysia has shown that the prevalence of children with IDA was reported with 7.7% (Halib, Muda, Dam, & Mohamed, 2017).

1.4 JUSTIFICATION OF STUDY

From the above-mentioned statistics of prevalence of IDA, it has been shown that there has been a progressive decline in prevalence from year 2008 to 2017 in peninsular Malaysia. However, since there is evidence of anaemia and IDA is highly associated with poor communities and low socio-economic conditions, this study intended to find out if the current level of prevalence of IDA among rural schoolchildren in Sabah is still concerning. Moreover, early detection of IDA may help to decrease a large burden of neurodevelopment and cognitive function among affected children. Hence, findings of this study may contribute to improve the wellbeing of children according to the associated risk factors and benefit as a future reference of Ministry of Health, Ministry of Education and Ministry of Rural and Regional Development, Malaysia.

1.5 PURPOSE OF THE STUDY

The purpose of this study was to determine the prevalence and risk factors of iron deficiency anaemia among schoolchildren in rural areas of Kudat, Sabah.

1.6 RESEARCH QUESTION

1) What is the prevalence of iron deficiency anaemia among primary schoolchildren in rural area of Kudat, Sabah?
2) What are the risk factors of iron deficiency anaemia among primary schoolchildren in rural area of Kudat, Sabah?

1.7 HYPOTHESES

H_{a1}: IDA is associated with demography, socio-economic condition, nutritional status and soil transmitted helminthes exposure.

H_{a2}: IDA is related to the level of knowledge, attitude and practice towards iron among parents/guardians

1.8 OBJECTIVES OF THE STUDY

The objectives of the study were to:

1) To investigate the current prevalence of anaemia due to iron deficiency among primary school children.
2) To determine the possible risk factors that may contribute to IDA among schoolchildren population in rural areas of Kudat.
3) To determine the association between IDA and the level of knowledge, attitude and practice towards IDA among the parents/ guardian.

Overall, socio-economic and demographic status plays significant roles in influencing a healthy environment of a population. These factors affect the access and quality of food to be served for the family due to the knowledge and education of the parents or guardians concerning iron source foods (Soekarjo et al., 2001). Public health services and facilities such as proper sanitation and clean water supply with decent housing are important to increase the quality of life among rural communities. Hence, this may decrease the risk of exposure to intestinal parasitic infections that are prone in low hygiene and poor sanitation conditions.

As IDA is a common treatable condition, it is important to strengthen primary healthcare especially in rural areas to determine and treat IDA. This is to prevent its further consequences on cognitive abilities among the school children as well as to

enhance the quality of life in this population. Findings of this study exposed that more attention in rural development especially in community health, education and infrastructure are needed. By improving the quality of life includes a betterment of family economy, education, sanitation and personal hygiene status and promoting consistent nutritional education among the population may help to reduce poverty and control IDA.

CHAPTER 2

LITERATURE REVIEW

2.1 BIOLOGY AND PHYSIOLOGY OF IRON

The role of iron is vital for cellular processes, including cellular respiration, synthesis of DNA, RNA and proteins, cell proliferation and differentiation and electron transport (WHO, 2005).

In the body, most iron present in the form of haemoglobin (65.0%), myoglobin (10.0%) and other tissues such as iron-containing enzymes called Cytochromes (FAO & WHO, 2004). The remaining body iron is stored in the liver, reticuloendothelial system and bone marrow. Iron is reversibly stored within liver as ferritin and hemosiderin which responsible in iron uptake, transport and storage in the body. Iron equilibrium is carefully maintained and regulated to ensure that sufficient iron is absorbed to compensate iron losses during metabolic process in the body. Consistent errors on maintaining iron equilibrium leads to either iron deficiency or iron overload, which may cause siderosis and damage on organs (Conrad & Umbreit, 2000)

REFERENCES

Aini, U. N., Al-Mekhlafi, M. H., Azlin, M., Shaik, A., Sa, A., Fatmah, M., Rozlida, A. (2007). Serum iron status in Orang Asli children living in endemic areas of soil-transmitted helminths. Asia Pacific journal of clinical nutrition, 16(4), 724-730.

Alaimo, K., Olson, C. M., Frongillo Jr, E. A., & Briefel, R. R. (2001). Food insufficiency, family income, and health in US preschool and school-aged children. American Journal of Public Health, 91(5), 781.

Almeida, C. A. N. d., Ricco, R. G., Del Ciampo, L. A., Souza, A. M., Pinho, A. P., & Oliveira, J. E. D. d. (2004). Fatores associados a anemia por deficiência de ferro em crianças pré-escolares brasileiras. Jornal de Pediatria, 80, 229-234.

Al-Mekhlafi, M. H., Surin, J., Atiya, A. S., Ariffin, W. A., Mahdy, A. K., & Abdullah, H. C. (2008). Anaemia and iron deficiency anaemia among aboriginal schoolchildren in rural Peninsular Malaysia: an update on a continuing problem. Trans R Soc Trop Med Hyg, 102(10), 1046-1052. doi: 10.1016/j.trstmh.2008.05.012

Al-Zabedi, E. M. (2014). Prevalence and Risk Factors of Iron Deficiency Anemia among Children in Yemen. American Journal of Health Research, 2(5), 319. doi: 10.11648/j.ajhr.20140205.26

Aslam, M., & Rasool, S. (2014). Investigating the impact of major variables influencing food security in Lahore, Pakistan. International Journal on Advanced Science, Engineering and Information Technology, 4(3), 143-147.

Balarajan, Y., Ramakrishnan, U., Özaltin, E., Shankar, A. H., & Subramanian, S. V. (2011). Anaemia in low-income and middle-income countries. The Lancet, 378(9809), 2123-2135. doi: 10.1016/s0140-6736(10)62304-5

Best, C., Neufingerl, N., van Geel, L., van den Briel, T., & Osendarp, S. (2010). The nutritional status of school-aged children: why should we care? Food Nutr Bull, 31(3), 400-417. doi: 10.1177/156482651003100303

Bingham, S. A., Gill, C., Welch, A., Day, K., Cassidy, A., Khaw, K. T., Day, N. E. (2007). Comparison of dietary assessment methods in nutritional epidemiology: weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records. British Journal of Nutrition, 72(04), 619. doi: 10.1079/bjn19940064

Block, G. (1982). A review of validations of diaetary assesment method. american journal of epidemiology, 115(4).

Block, G. (1989). Human dietary assesment : methods and issues. preventive medicine, 18, 653-660.

Fonseca, C., Marques, F., Robalo Nunes, A., Belo, A., Brilhante, D., & Cortez, J. (2016). Prevalence of anaemia and iron deficiency in Portugal: the EMPIRE study. Intern Med J, 46(4), 470-478. doi: 10.1111/imj.13020

Foo, L. H., Khor, G. L., Tee, E.-S., & Prabakaran, D. (2004). Iron status and dietary iron intake of adolescents from a rural community in Sabah, Malaysia. Asia Pacific J Clin Nutr 2004;13 (1), 13(1), 48-55.

Głąbska, D., Guzek, D., Ślązak, J., & Włodarek, D. (2017). Assessing the Validity and Reproducibility of an Iron Dietary Intake Questionnaire Conducted in a Group of Young Polish Women. Nutrients, 9(3). doi: 10.3390/nu9030199

Gordon, N. (2003). Iron deficiency and the intellect. Brain and Development, 25(1), 3-8. doi: 10.1016/s0387-7604(02)00148-1

Grantham-McGregor S, & C, A. (2001). A review of studies on the effectof iron deficiency on cognitive developmental in children. J Nutr, 131, 649S-666S.

Haas, J. D., & Brownlie, T. (2001). Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research to Determine a Causal Relationship. American Society for Nutritional Sciences., 676-690.

Halib, H., Muda, W., Dam, P., & Mohamed, H. (2017). Prevalence of iron deficiency and its associated risk factors among primary school children in Kelantan. Journal of Fundamental and Applied Sciences, 9(2S), 397-412.

Harris, R. J. (2007). Iron deficiency anaemia: does it really matter? Paediatrics and Child Health, 17(4), 143-146.

Hashizume, M., Kunii, O., Sasaki, S., Shimoda, T., Wakai, S., Mazhitova, Z., Farmer, A. (2003). Anemia and iron deficiency among schoolchildren in the Aral Sea region, Kazakhstan. Journal of tropical pediatrics, 49(3), 172-177.

Heshmat, R., Azemati, B., Keshtkar, A., Salehi, F., Abdollahi, Z., Kolahdouz, F., Nadim, A. (2009). Comparison_of_knowledge attitude and practice of Urban. Iranian J Public Health, 38(4), 83-90.

Hurrell, R. F. (1997). Preventing iron deficiency through food fortification. Nutrition Reviews, 55(6), 210-222.

Igbal, K., Zafar, T., Igbal, Z., Usman, M., Bibi, H., Afreen, M. S., & Igbal, J. (2015). Effect of iron deficiency anemia on intellectual performance of primary school children in Islamabad, Pakistan. Tropical Journal of Pharmaceutical Research, 14(2), 287-291.

JL, B. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning. J Nutr, 131, 568-580.

JM, H. J., Mitra, A. K., Hasmiza, H., Pim, C., LOr, N., WM, W. M., & Prcgnmme, I. N. (2011). Effect of gender and nutritional status on academic achievement and cognitive function among

primary school children in a rural district in Malaysia. Malaysian journal of nutrition, 17(2), 189-200.

Kassebaum, N. J. (2016). The Global Burden of Anemia. *Hematol Oncol Clin North Am, 30*(2), 247-308. doi: 10.1016/j.hoc.2015.11.002

Khor, G. L. (1998). Nutritional status of children in Malaysia : persistence of old problems. Malaysian Journal of Child health

9(2).

Kordas, K., Lopez, P., Rosado, J. L., García Vargas, G., Alatorre Rico, J., Ronquillo, D., R. J. (2004). Blood lead, anemia, and short stature are independently associated with cognitive performance in Mexican school children. The Journal of nutrition, 134(2), 363-371.

Kuczmarski, R. J. (2000). CDC growth charts; United States.

Levi, M., Rosselli, M., Simonetti, M., Brignoli, O., Cancian, M., Masotti, A., Lapi, F. (2016). Epidemiology of iron deficiency anaemia in four European countries: a population-based study in primary care. Eur J Haematol. doi: 10.1111/ejh.12776

Lim, Y., Romano, N., Colin, N., Chow, S., & Smith, H. (2009). Intestinal parasitic infections amongst Orang Asli (indigenous) in Malaysia: has socioeconomic development alleviated the problem? Tropical Biomedicine, 26(2), 110-122.

Liu, J., Ai, Y.-X., Hanlon, A., Shi, Z., Dickerman, B., & Compher, C. (2011). Micronutrients deficiency and associated sociodemographic factors in Chinese children. World Journal of Pediatrics, 7(3), 217.

Loh, S., & Khor, G. (2010). Iron Intake and Iron Deficiency Anaemia among Young Women in Kuala Lumpur. Malaysian Journal of Medicine and Health Sciences, 6(1), 63–70.

Lönnerdal, B., & Kelleher, S. L. (2007). Iron metabolism in infants and children. Food and nutrition bulletin, 28(4), S491-s499.

Makhoul, Z., Taren, D., Duncan, B., Pandey, P., Thomson, C., Winzerling, J., Shrestha, R. (2012). Risk factors associated with anemia, iron deficiency and iron deficiency anemia in rural Nepali pregnant women. Southeast Asian Journal of Tropical Medicineand Public Health, 43(3), 735.

MOE. (2018). Sekolah Kekurangan Murid. Retrieved 27 September 2018, from www.moe.gov.my

Munoz, M., Garcia-Erce, J. A., & Remacha, A. F. (2011). Disorders of iron metabolism. Part 1: molecular basis of iron homoeostasis. J Clin Pathol, 64(4), 281-286. doi: 10.1136/jcp.2010.079046

Munoz, M., García-Erce, J. A., & Remacha, Á. F. (2010). Disorders of iron metabolism. Part 1: molecular basis of iron homoeostasis. J Clin Pathol, jcp. 2010.079046.

Nasr, N. A., Al-Mekhlafi, H. M., Ahmed, A., Roslan, M. A., & Bulgiba, A. (2013). Towards an effective control programme of soil-transmitted helminth infections among Orang Asli in rural Malaysia. Part 2: Knowledge, attitude, and practices. Parasites & vectors, 6(1), 28.

Nemeth, E., Tuttle, M. S., Powelson, J., Vaughn, M. B., Donovan, A., Ward, D. M., Kaplan, J. (2004). Hepcidin regulates cellular iron efflux by binding to ferroportin and inducing its internalization. Science, 306(5704), 2090-2093. doi: 10.1126/science.1104742

Ngui, R., Lim, Y. A., Chong Kin, L., Sek Chuen, C., & Jaffar, S. (2012). Association between anaemia, iron deficiency anaemia, neglected parasitic infections and socioeconomic factors in rural children of West Malaysia. PLoS Negl Trop Dis, 6(3), e1550. doi: 10.1371/journal.pntd.0001550

Nik Shanita, S., Siti Hanisa, A., Noor Afifah, A. R., Lee, S. T., Chong, K. H., George, P., Poh, B. K. (2018). Prevalence of Anaemia and Iron Deficiency among Primary Schoolchildren in Malaysia. Int J Environ Res Public Health, 15(11). doi: 10.3390/ijerph15112332

Osazuwa, F., Ayo, O. M., & Imade, P. (2011). A significant association between intestinal helminth infection and anaemia burden in children in rural communities of Edo state, Nigeria. North American journal of medical sciences, 3(1), 30.

Park, K., Kersey, M., Geppert, J., Story, M., Cutts, D., & Himes, J. H. (2009). Household food insecurity is a risk factor for iron-deficiency anaemia in a multi-ethnic, low-income sample of infants and toddlers. Public health nutrition, 12(11), 2120-2128.

Patel, S., M.Shah, J.Patel, & N.Kumar. (2009). iron deficiency anemia in moderate to severely anaemic patients. Gujerat medical journal, 64(no.2).

Pippard, M. J. (2011). Iron deficiency anemia, anemia of chronic disorders and iron overload. 173-195. doi: 10.1016/b978-0-7020-3147-2.00011-0

Pollitt, E. (1997). Iron Deficiency and Educational Deficiency. Nutrition Reviews, 55(4), 133-140. doi: 10.1111/j.1753-4887.1997.tb06464.x

Pourghassem, B., Kimiagar, G., Abolfathi, A., Vallaii, N., & Ghaffarpour, M. (2000). Prevalence of iron deficiency, anaemia, and iron-deficiency anaemia in high-school students in Jolfa, East Azerbaijan. Food and nutrition bulletin, 21(3), 301-304.

Rajoo, Y., Ambu, S., Lim, Y. A. L., Rajoo, K., Tey, S. C., Lu, C. W., & Ngui, R. (2017). Neglected intestinal parasites, malnutrition and associated key factors: a population based cross-sectional study among indigenous communities in Sarawak, Malaysia. PloS one, 12(1), e0170174.

Robertson LJ, Crompton DW, Sanjur D, & MC., N. (1992). haemoglobin concentrations and concomitant infections of hookworm and Trichuris trichiura in Panamanian primary schoolchildren. Trans R Soc Trop Med Hyg, 86, 654-656.

Rushton, D. H., Dover, R., Sainsbury, A. W., Norris, M. J., Gilkes, J. J., & Ramsay, I. D. (2001). Why should women have lower reference limits for haemoglobin and ferritin concentrations than men? BMJ: British Medical Journal, 322(7298), 1355.

Saloojee, H., & Pettifor, J. M. (2001). Iron deficiency and impaired child development. British Medical Journal, 323, 1377-1378.

Siti-Noor A S, Wan-Maziah W M, Narazah M Y, & S, Q. B. (2006). Prevalence and risk factors for iron deficiency in Kelantanese pre-school children. Singapore Med J 2006; 47(11) : 935.

Soekarjo, D., Pee, S. d., Bloem, M., Tjiong, R., R Yip, Schreurs, W., & Muhilal. (2001). Socio-economic status and puberty are the main factors determining anaemia in adolescent girls and boys in East Java, Indonesia. European Journal of Clinical Nutrition, 55, 932-939.

Stoltzfus, R. J. (2003). Iron deficiency: global prevalence and consequences. Food and nutrition bulletin, 24(4 suppl2), S99-S103.

Stoltzfus RJ, Mullany L, & RE., B. (2004). Iron deficiency anaemia. Comparative quantification of health risks : the global and regional burden of disease due to 25 selected major risk factors. (M. Ezzati, A. D. Lopez, A. Rodgers & C. J. L. Murray Eds. Vol. 1). Geneva: WHO.

Stoltzfus, R. J., Chwaya, H. M., Tielsch, J. M., Schulze, K. J., Albonico, M., & Savioli, L. (1997). Epidemiology of iron deficiency anemia in Zanzibari schoolchildren: the importance of hookworms. The American journal of clinical nutrition, 65(1), 153-159.

Tesfaye, M., Yemane, T., Adisu, W., Asres, Y., & Gedefaw, L. (2015). Anemia and iron deficiency among school adolescents: burden, severity, and determinant factors in southwest Ethiopia. Adolescent health, medicine and therapeutics, 6, 189-196. doi: 10.2147/AHMT.S94865

Thurlow, R. A., Winichagoon, P., Green, T., Wasantwisut, E., Pongcharoen, T., Bailey, K. B., & Gibson, R. S. (2005). Only a small proportion of anemia in northeast Thai schoolchildren is associated with iron deficiency–. The American journal of clinical nutrition, 82(2), 380-387.

WHO. (2001). Iron Deficiency Anaemia : Assessment, Prevention, and Control. A guide for programme managers.

WHO, F. (2004). vitamin and mineral requirements in human nutrition. (Second edition), p.341.

WHO. (2005). Iron. Worldwide prevalence of anemia 1993-2005. Geneva World Health Organization. P.154-156.

WHO. (2008). Worldwide prevalence of anemia 1993-2005 (de Benoist B, McLean E, Eglie I & C. M Eds. Vol. WHO global database on anaemia). Geneva World Health Organization.

WHO. (2011). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. (Vol. (WHO/NMH/NHD/MNM/11.1)). Geneva World Health Organization.

WHO. (2014). Global nutrition targets 2025: Policy brief series: World Health Organization.