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IRON INTAKE, HEMOGLOBIN LEVEL AND ITS ASSOCIATION WITH KARNOFSKY SCORE: A CROSS SECTIONAL STUDY IN PULMONARY TUBERCULOSIS PATIENTS OF RSUP PERSAHABATAN

Asupan Zat Besi, Kadar Hemoglobin, dan Hubungannya dengan Skor Karnofsky: Studi Potong Lintang pada Pasien Tuberkulosis Paru di RSUP Persahabatan

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ABSTRACT

Tuberculosis (TB) is a major public health concern globally, with high prevalence in Indonesia. The functional status of TB patients is commonly assessed using Karnofsky Score. However, the correlations between iron intake, hemoglobin levels, and Karnofsky Score in pulmonary TB patients at RSUP Persahabatan have not been investigated. This study aimed to examine iron intake and hemoglobin levels and their possible correlations with the Karnofsky Score in pulmonary TB patients at RSUP Persahabatan. A total of 108 outpatient TB patients were included in the study. Data on iron intake, hemoglobin levels, and Karnofsky Score were collected through interviews, dietary assessments, and anthropometric measurements. Statistical analyses involved univariate and bivariate correlation tests. The majority of subjects had insufficient iron intake (74.1%), normal hemoglobin levels (56.5%), and Karnofsky Score of 80 percent (30.6%). However, this study did not identify significant relationships between iron intake, hemoglobin levels, and Karnofsky Score in pulmonary TB patients at RSUP Persahabatan. These findings suggest that other factors may influence the functional status of TB patients, highlighting the need for further research. Understanding the characteristics and nutritional requirements of TB patients is crucial for effective management and control strategies.

Keywords: iron intake, hemoglobin, karnofsky score, tuberculosis

ABSTRAK

Tuberkulosis (TB) adalah masalah kesehatan yang mengancam masyarakat secara global, dengan prevalensi yang tinggi di negara Indonesia. Status fungsional pasien TB umum dinilai menggunakan Skor Karnofsky. Namun penelitian mengenai hubungan antara asupan zat besi, kadar hemoglobin, dan Skor Karnofsky pada pasien TB paru di RSUP Persahabatan belum dilakukan. Penelitian ini bertujuan untuk mengkaji asupan zat besi, kadar hemoglobin, dan hubungannya dengan Skor Karnofsky pada pasien TB paru di RSUP Persahabatan. Sebanyak 108 pasien TB rawat jalan menjadi subjek penelitian. Data mengenai asupan zat besi, kadar hemoglobin, dan Skor Karnofsky dikumpulkan melalui wawancara, penilaian pola makan, dan pengukuran antropometri. Analisis statistik meliputi uji korelasi univariat dan bivariat. Sebagian besar subjek memiliki asupan zat besi yang tidak cukup (74,1%), kadar hemoglobin normal (56,5%), dan Skor Karnofsky 80 persen (30,6%). Namun, tidak ditemukan hubungan signifikan antara asupan zat besi dan kadar hemoglobin dengan Skor Karnofsky. Penelitian ini tidak menemukan hubungan signifikan antara asupan zat besi, kadar hemoglobin, dan Skor Karnofsky pada pasien TB paru di RSUP Persahabatan. Temuan ini menunjukkan bahwa faktor lain mungkin memengaruhi status fungsional pasien TB, sehingga diperlukan penelitian lebih lanjut. Memahami karakteristik dan kebutuhan nutrisi pasien TB sangat penting untuk strategi manajemen dan pengendalian yang efektif.

Kata kunci: asupan zat besi, hemoglobin, skor karnofsky, tuberkulosis

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INTRODUCTION

Tuberculosis (TB) is one of the leading infectious causes of death and a global public health threat. In 2020, there were 10 million people who suffered from TB, and 1.5 million deaths were attributed to the disease. Southeast Asia, particularly, is the region that had the highest number of TB cases, accounting for 43 percent of the total cases in 2020. According to the World Health Organization (WHO), Indonesia ranks third among countries with the highest prevalence of TB, following India and China. As of May 2018, Indonesia Ministry of Health had reported 420,994 new cases of TB.[1,2]

The Karnofsky Score is a commonly used clinical prediction rule for TB patients. It is a simple and rapid method to assess the functional status of patients and has been used for over 60 years. The score is widely used as an indicator of disease severity, treatment response, quality of life assessment, mortality prediction, evaluation of different therapeutic approaches, and prognosis assessment for individual patients. The score ranges from 0 to 100 percent, with assessments based on an individual's ability to perform daily activities, work, the need for assistance, and the presence of disease-related symptoms. A lower Karnofsky score indicates poorer functional status.[3–6] Pakasi et al used the Karnofsky score to categorize the severity of TB patients with a score of <80 being severe TB and >80 being mild TB. They found 47 percent of patients with severe TB in East Nusa Tenggara.[7]

In the context of TB patients, decreased appetite and metabolic needs can lead to malnutrition, including iron intake disorders. A study conducted in China in 2019 found that the majority (97.9%) of female TB patients had iron intake below the country's Dietary Reference Intakes (DRI) guidelines.[8] Insufficient iron intake is associated with impaired immune function, but excessive iron intake is also linked to increased active TB and TB-related mortality.[9] World Health Organization has not yet determined iron intake recommendations for active TB patients, and recommendations for iron supplementation are still unclear.[10]

During the diagnosis of TB, low hemoglobin levels are commonly found. Studies have reported a higher prevalence of anemia among TB patients compared to healthy control groups. The prevalence of anemia among TB patients has been reported as 72.7 percent in India[11] and 86 percent in Tanzania [12]. A systematic literature review and meta-analysis of 16,671 TB patients conducted by Barzegari et al. showed a prevalence of anemia of 61.53 percent.[11] In Indonesia, a study conducted in Tanjung Raja Community Health Center found that 81 percent of pulmonary TB patients suffered from anemia.[13]

Study by Mendonca et al. have suggested that anemia can indicate the severity of tuberculosis. Anemia due to iron deficiency has been associated with the Karnofsky score.[14] Isanaka et al found that the hematological status of TB patients with iron deficiency anemia was related to the Karnofsky score (p<0,001).[15] In Indonesia, a study found a significant association between hemoglobin levels and the Karnofsky score, with patients in the severe category (Karnofsky score <80) having lower hemoglobin levels.[7]

Indonesia is the third highest country with the incidence of tuberculosis and RSUP Persahabatan is a national respiratory referral hospital as well as a referral center for lung infection cases including TB. Currently there are no studies linking iron intake and hemoglobin levels with the Karnofsky score in pulmonary tuberculosis patients at RSUP Persahabatan using SQFFQ method. This research is expected to provide an overview of nutritional aspects in TB patients. Thus, the aim of this study was to investigate iron intake and hemoglobin level and to assess for possible correlations with the Karnofsky score in pulmonary TB patients of RSUP Persahabatan.

RESEARCH METHOD

Study Participant

We recruited 108 outpatient TB patients with a Karnofsky score ≥50 percent, diagnosed with pulmonary TB by the attending physician, aged between 18-60 years, and patients with hemoglobin test results. The exclusion criteria are pregnant or breastfeeding, have history of blood transfusion in the past 4 months, diagnosed with kidney failure and liver disease, experiencing moderate to severe bleeding, including menorrhagia, hemoptysis, injury, and moderate to severe surgery, and have

psychiatric disorders. Subjects were patients who were visited RSUP Persahabatan during January-February 2023 and were recruited consecutively. This study has been approved by the Medical Ethics Committee of RSUP Persahabatan No. 03.A.1/KEPK-RSUPP/01/2023.

Data Collection

The study procedures include interviews, assessment of food intake and anthropometric measurements. All procedures are completed while adhering to disease prevention safety protocols. A semi-quantitative Food Frequency Questionnaire (FFQ) was used to collect dietary iron intake. The semi-quantitative FFQ iron database was obtained from the Mutmainnah study in 2016.[16] Subjects were asked to remember the frequency and amount of foods listed in the questionnaire during the last month. Subjects who have problems remembering meal portions or need help eating, the family or caregiver will be asked about the frequency, type and amount of food. Food recording is carried out using household measurements. Body mass index was collected by measuring body weight and body height. The body height measurement was performed with a height measuring board (ShorrBoard, Olney, USA). Weight measurement was performed using SECA 876 for body weight. Measurements were made twice and the average value was taken. An interview regarding the Karnofsky score was conducted using the Karnofsky score form. The researcher inquired about the subject's level of severity. After the subject answers the questions, the researcher record and assign a score based on the subject's responses. The Karnofsky score ranges from 0 percent to 100 percent, with higher scores indicating better patient performance.

Data Analysis

Interviews with research subjects were carried out using a structured questionnaire to obtain characteristic data. Characteristic data includes age, gender, education level, income, treatment phase, bacterial type, comorbidities, and smoking history. The anthropometric examination carried out is measuring height and weight to calculate BMI. Measurements were carried out twice and the average was taken. BMI is obtained from calculating body weight in kilograms divided by height in meters squared. The results of anthropometric measurements are recorded on form. Food recording is carried out using household measurements. The data is then converted into grams using food ingredient analysis data and exchange food ingredient lists. Analysis was carried out using NutriSurvey 2007 (Germany). We used SPSS software (version 25.0, is developed from IBM) to conduct the data analysis). Normality of the distribution was tested using the Kolmogorov-Smirnov test. Mean and standard deviation (SD) were presented in normally distributed data, while median and minimum-maximum were presented in non-parametric data. The Spearman correlation test was applied to evaluate the relationship between correlation between iron intake, hemoglobin levels, and Karnofsky score. If $p< 0.05$, the association was considered significant. Characteristics of subjects were analyzed using the T-test or Mann-Whitney U test for two categories and, ANOVA or Kruskal-Walls test for more than two categories.

RESULTS

The characteristics of subjects are summarized in Table 1. There were 108 subjects aged 19-59 years, most subjects were male, had medium level of education, insufficient income, nutritional status of underweight, on continued treatment phase, drug sensitive bacterial type, no comorbidity, never smoking, normal hemoglobin level, inadequate protein intake, inadequate iron intake and had Karnofsky score of 80 percent. There was no statistical difference between subjects in terms of age, education level, nutritional status, treatment phase, comorbidity, comorbid diseases and hemoglobin level.

Iron intake, hemoglobin level, and Karnofsky score can be seen in Table 2. The median of iron intake was 5.5 mg/day, the median level of hemoglobin level was 12.9 g/dL, and the median of Karnofsky score was 80 percent.

To examine the correlation between iron intake and hemoglobin level with the Karnofsky score, a Spearman test was conducted. Table 3 showed no statistically significant correlations between iron intake and hemoglobin level with the Karnofsky score in pulmonary tuberculosis patients at Persahabatan General Hospital

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Table 1

Sociodemographic Characteristics of Subjects

Characteristics	n (%)	p
Age (years)^	40 (19-59)^	0.44
Gender		
Female	44 (40,7)	0.03*
Male	64 (59,3)	
Education level		
Low	29 (26,9)	
Medium	61 (56,5)	0.07
High	18 (16,7)	
Income		
Insufficient (< Rp4,641,854/month)	84 (77,8)	0.03*
Sufficient (> Rp4,641,854/month)	24 (22,2)	
Nutritional status		
Underweight (<18.5 kg/m^2)	46 (42,6)	
Normal (18.5-22.9 kg/m^2)	43 (39,8)	
Overweight (23-24.9 kg/m^2)	8 (7,4)	0.29
Obese I (25-29.9 kg/m^2)	7 (6,5)	
Obese II (>30 kg/m^2)	4 (3,7)	
Treatment phase		
Intensive	43 (39,8)	0.12
Continued	65 (60,2)	
Bacterial type		
Drug-sensitive	76 (70,4)	0.02*
Drug-resistant	32 (29,6)	
Comorbidity		
No	56 (51,9)	0.21
Yes	52 (48,1)	
Comorbid diseases		
Arthritis	27 (25)	
Cardiovascular	3 (2,8)	0.06
Hypertension	11 (10,2)	
Cancer	4 (3,7)	
Diabetes	25 (23,1)	
Smoking history		
Never (<1 Brinkman index)	62 (57,4)	
Light (1-199 Brinkman index)	18 (16,7)	0.02*
Moderate (200-599 Brinkman index)	24 (22,2)	
Heavy (>600 Brinkman index)	4 (3,7)	
Hemoglobin level		
Normal (>13 g/dL)	61 (56,5)	0.07
Anemia (<13 g/dL)	47 (43,5)	
Protein intake		
Inadequate (<RDA)	81 (75)	0.01*
Adequate (>RDA)	27 (25)	
Iron intake		
Inadequate (<RDA)	80 (74,1)	0.02*
Adequate (>RDA)	28 (25,9)	
Karnofsky score		
50%	2 (1, 9)	
60%	12 (11,1)	
70%	23 (21,3)	0.01*
80%	33 (30,6)	
90%	28 (25,9)	
100%	10 (9,3)	

^Median (min-max) *p<0.05 Significant

Abbreviations used: RDA, Recommended Dietary Allowance.

Table 2

Distribution of Iron Intake, Hemoglobin Level, and Karnofsky Score

Parameter	Median (Min-Max)
Iron intake (mg/day)	5,5 (1,1-68,3)
Hemoglobin level (g/dL)	12,9 (9,4-16,5)
Karnofsky Score (%)	80 (50-100)

Table 1

Correlations Between Iron Intake and Hemoglobin Level With Karnofsky Score

Variable	Karnofsky Score	
	r	p
Iron intake	-0,051	0,601
Hemoglobin level	0,073	0,455

**Spearman test*

DISCUSSION

Our study found no statistical difference between subjects in terms of age, education level, nutritional status, treatment phase, comorbidity, comorbid diseases and hemoglobin level. Majority of the subjects in this study were male (59.3%), which is consistent with global trends showing higher TB prevalence among males.[17] In 2022, Valencia-Aguirre found that the average mortality rate for TB disease is mostly experienced by men with a male-to-female ASMR (Age Related Mortality Rate) ratio of 7.1:2.7.[18] Marçôa in 2018 conducted research in Portugal with the result that men have a higher average prevalence after two decades of life in suffering from TB.[19] Factors contributing to this gender disparity in TB include biological differences, differences in disease presentation, and differential access to healthcare services.[19] The study subjects had an average age of 40 years, reflecting the higher incidence of TB in productive age groups.[1] Meanwhile the Indonesia Ministry of Health in 2021 found that most TB cases are found in the age group 45-54 years with a proportion of 17.5 percent of the total national cases. Based on the 2013 Riskesdas survey, the prevalence of suffering from TB will be higher with increasing age. This is due to the possibility of TB reactivation and the longer duration of TB exposure in the older age group compared to the lower age group.[2]

The majority of the subjects had a moderate level of education (completed high school or equivalent), which can influence TB occurrence due to limited knowledge about transmission and risks.[20] Imam et al in 2021 found that TB patients with higher education suffer fewer TB side effects than those with lower levels of education.[21] Low income was prevalent among the subjects, which is associated with higher TB incidence and poorer treatment outcomes.[22] In 2020 WHO found that there was a strong relationship between the incidence rate of TB and average income as measured in gross domestic product (GDP) per capita.[1] This is in line with Fuady's research in 2020 which found that most subjects (61%) had low incomes.[22] Malnutrition was also common among the subjects, with a significant proportion experiencing underweight. A cross-sectional study conducted in Ethiopia also reported the same thing, namely 57.17% of adult TB patients were malnourished.[23] According to Feleke, the relationship between TB and malnutrition consists of two interactions, namely the effect of malnutrition on clinical manifestations of TB and the effect of TB on nutritional status as a result of immune system disorders.[23] Nutritional support is crucial for individuals with TB. Most of the subjects were in the continued phase of treatment, indicating improvement in symptoms during this phase. A study with similar results

was also obtained by Lee who found that 53 percent of the subjects in his study were in the continuation phase. [24] This could be due to the fact that this study involved pulmonary TB patients with a Karnofsky score >50 percent where symptom improvement mostly occurred in the continuation phase.

The majority of the subjects did not have chronic comorbidities, although some had arthritis, which can be induced by certain TB medications such as pirazinamide and etambutol.[25] Similar results were also obtained by Widowati in 2021 in Surakarta who found that the majority of TB patients did not have comorbid chronic diseases.[26] However, Salihi in 2020, who conducted a study on 1160 TB patients of productive age, obtained different results, namely the majority of TB patients had comorbid chronic diseases.[27] According to Padrão, this can be attributed to a reverse causality bias, namely by considering that the individual adopts a healthy lifestyle because the individual has a chronic disease.[28] Smoking was not prevalent among the subjects, but it is a strong individual-level risk factor for TB.[29] Research with similar results was also obtained by Lee who found that 77.5 percent of the subjects in his study did not smoke.[24] The role of cigarette smoke in the pathogenesis of tuberculosis is associated with ciliary dysfunction, decreased immune response, and defects in macrophage immune responses, with or without a decrease in CD4 cell count thereby increasing susceptibility to Mycobacterium tuberculosis infection.[29]

Inadequate protein intake was common among the subjects, which is important to address as recommended protein intake is higher for individuals with TB. The same results were also obtained by Ren in China in 2019 who found that 90.8 percent of male subjects and 58.4 percent of female subjects consumed insufficient protein.[8] In Indonesia, a study conducted by Pakasi et al found that outpatients pulmonary TB patients in NTT consume an average of 26.4 g of protein, which is a value below Indonesia recommendation dietary allowance.[7] Recall bias and overestimation or underestimation of food intake are potential limitations of assessing protein intake through food recall. Overall, understanding the characteristics of TB patients, such as gender, age, education, income, nutritional status, comorbidities, smoking, and protein intake, is crucial for effective TB management and control strategies.

The majority of subjects in the study (74.1%) had iron intake below Indonesia recommendation dietary allowance. The median intake of iron among the subjects was 5.5 mg/day. Previous research by in China has shown that the majority (97.9%) of female TB patients consumed iron below the recommended levels. Iron is essential for the growth of MTB within macrophages.[8] Excessive iron consumption is associated with increased active TB and TB-related deaths, while iron deficiency is associated with impaired immune function.[15,30] Low iron intake in TB patients is linked to decreased appetite due to inflammation process, which can worsen the disease or slow down the healing process through immune suppression. The mechanism behind the decreased appetite is based on the increased production of Tumor Necrosis Factor-alpha (TNF-α). TNF-α not only helps fight infections in the body but also affects homeostasis and has an anorexigenic effect in the hypothalamus. TNF-α impacts appetite within the arcuate nucleus of the hypothalamus, which serves as the central hub for regulating energy homeostasis.It triggers the synthesis of α-melanocyte-stimulating hormone (α-MSH) and cocaine and amphetamine-regulated transcript (CART) in proopiomelanocortin (POMC) neurons.This stimulation results in a 35-42 percent decrease in the production of orexigenic signals originating from agouti-related protein (AgRP) and NPY-expressing AgRP neurons.The aforementioned signaling molecules are then transported to the lateral hypothalamus and paraventricular nucleus. Ultimately, this process leads to a reduction in appetite and body weight.[30,31]

The majority of subjects in the study (56.5%) had normal hemoglobin levels. The median hemoglobin level among the subjects was 12.9 g/dL. Similar results were found in a study in China in 2022, which reported that the majority of pulmonary TB patients did not have anemia (78.8%).[32] However, different results were observed in studies conducted in India and Tanzania, reporting anemia prevalence rates of 72.7 percent[11] and 86 percent[12], respectively. Although there is a strong association between tuberculosis and anemia, the exact mechanisms

underlying this association are not yet fully understood[11]. Three main mechanisms have been proposed: pathological dysregulation of iron homeostasis, erythropoiesis abnormalities, and decreased response to erythropoietin. In pathological dysregulation of iron homeostasis, there is increased iron retention in the reticuloendothelial system. This process involves inflammation caused by TB bacteria and their ligands, leading to increased production of the cytokine TNF-alpha, which stimulates macrophages for erythrophagocytosis. This results in accelerated aging and destruction of old red blood cells. Additionally, IL-6 produced by monocytes and lipopolysaccharides from TB bacteria increases hepcidin production in hepatic cells, thereby reducing iron absorption in the duodenum and increasing iron retention in macrophages. Another mechanism is erythropoiesis abnormalities, where there is a decrease in the proliferation and differentiation of erythroid progenitor cells. There is also a decrease in the expression of erythropoietin receptors on CFU. The response of erythroid progenitor cells to erythropoiesis is inversely related to the severity and duration of TB infection, resulting in a lower erythroid response with prolonged TB progression.[33,34]

The biggest proportion of patients in the study had a Karnofsky score of 80 percent, with a minimum score of 50 percent and a maximum score of 100 percent. Patients with Karnofsky score of 80 percent has can do normal activity with effort which means the patient restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature, e.g., light house work, office work. Similar findings have been reported in studies conducted in various countries, where most pulmonary TB patients had Karnofsky scores of 90 or 100. Karyadi et al. used the Karnofsky Score as an outcome measure in a clinical trial to assess the health status of TB patients.[35] The Karnofsky Performance Status (KPS) is also commonly used to assess the quality of life of patients, particularly those with tumors. In TB patients, the Karnofsky score is often used as a clinical prediction rule, helping doctors make decisions in conditions of uncertainty and improving diagnostic, prognostic, and therapeutic accuracy to enhance the quality of patient care.

This study found no correlation between iron intake and Karnofsky score in pulmonary tuberculosis (TB) patients at RSUP Persahabatan. Previous research has not directly linked iron intake with the Karnofsky score in pulmonary TB patients. A study conducted in Africa showed an increase in iron consumption due to high iron intake from traditional fermented food. The study included 98 TB patients and 98 control subjects in Zimbabwe. Iron intake, hemoglobin, ferritin, and transferrin saturation were examined at the beginning of the study and after 9 months. The results showed that iron consumption increased in the population due to high iron intake from traditional fermented beer. Laboratory results showed low mean hemoglobin (9.4+2.1), high ferritin, and transferrin saturation in TB patients at the beginning of the study. Over time, there was a decrease in serum ferritin and an increase in hemoglobin levels. The analysis showed that increased iron intake was associated with a 3.5 times higher risk of TB and a 1.3 times higher risk of mortality.[36] In a published case study, intravenous iron administration was found to promote the activation of tuberculosis. Iron overload, as indicated by splenic iron levels, has been previously correlated with tuberculosis mortality, as discussed earlier.[37] The authors concluded that excessive iron intake led to iron overload, resulting in iron deposition in macrophages and parenchymal cells. This impairs the ability of macrophages to suppress microbial invasion and leads to increased growth of *Mycobacterium tuberculosis* (MTB). Increased MTB growth prolongs the duration of TB infection and worsens symptoms in patients, resulting in decreased activity and performance as reflected by the Karnofsky score.

The bivariate analysis using Spearman's test in this study showed no correlation between hemoglobin levels and Karnofsky score in pulmonary TB patients at RSUP Persahabatan. However, different results were found in other studies. Isanaka et al., in a randomized controlled trial (RCT) with 887 pulmonary TB patients, found that most patients with low Karnofsky scores (<70%) had iron-deficiency anemia.[15] Bivariate analysis showed a significant association between anemia status and Karnofsky score ($p<0.001$). Another study by Pakasi et al. in outpatient pulmonary TB

patients in East Nusa Tenggara Province found a significant correlation between hemoglobin levels and Karnofsky score. Patients with severe TB (Karnofsky score <80) had lower hemoglobin levels.[7] Low hemoglobin levels in TB patients are associated with the severity of the disease. It is suggested that hemoglobin levels examination is important to do in tuberculosis cases and it can serve as a biomarker for TB severity.[7] The exact mechanisms underlying the decrease in hemoglobin levels in TB patients are not fully understood, but it is believed to involve excessive cytokine production, disturbances in iron metabolism, increased erythrocyte destruction, and shortened erythrocyte lifespan. As the duration of TB increases, the symptoms worsen, leading to a longer period of hemoglobin decrease in TB patients.

This study has several limitations. First, this research utilized interview data obtained from subjective sources, which inherently carries the risk of reducing the objectivity of the study outcomes. However, we took proactive steps to mitigate this risk by conducting interviews administered by trained healthcare professionals. Second, the collection of hemoglobin data relied on secondary sources, potentially failing to accurately capture the current hemoglobin status. Third, we did not have data on several predictors of iron status, factors associated with its bioavailability, or genetic polymorphisms. Thus, we cannot rule out the contribution of confounding to the observed associations. This limitation in data collection methodology could have contributed to the absence of a significant relationship in the findings.

CONCLUSION

The majority of subjects had iron intake below Indonesia recommendation dietary allowance, normal hemoglobin levels and a Karnofsky score of 80 percent. In conclusion, iron intake and hemoglobin level appear not to be associated with Karnofsky score among pulmonary TB patients at RSUP Persahabatan.

RECOMMENDATION

A further study through a prospective cohort analysis is necessary to evaluate the iron requirements in TB patients as well as the significant impact of iron intake and hemoglobin levels linked to the severity of pulmonary TB patients. Moreover, it is essential to enhance socialization and education among individuals diagnosed with pulmonary TB regarding the intake of iron and protein-rich food items, while also meeting the necessary criteria for other vital nutrients, including both macronutrients and micronutrients.

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