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DIFFERENCES IN HEMOGLOBIN AND HEMATOCRITE LEVELS IN ACTIVE SMOKERS AND NON-SMOKERS

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ABSTRACT

Hemoglobin (Hb) and hematocrit (Hct) are two important parameters in clinical hematology that reflect the body's ability to carry oxygen. Smoking is known to affect these parameters due to the exposure to carbon monoxide, which causes hypoxia and stimulates the production of more red blood cells. This phenomenon represents a significant health issue globally, including among employees in Indonesia, where smoking is common. The aim of this study is to investigate the difference in hemoglobin and hematocrit levels between active smokers and non-smokers among non-medical employees at RS Bhayangkara Tulungagung. This observational study used a cross-sectional design. A total of 30 respondents, consisting of 15 active smokers and 15 non-smokers, were selected using purposive sampling based on inclusion criteria. Data were collected through smoking behavior questionnaires and laboratory blood tests using a hematology analyzer. Statistical analysis was performed using the Shapiro-Wilk normality test and Mann-Whitney U test to examine differences between the two groups. The average hemoglobin level in active smokers was 15.98 g/dl, which was higher compared to non-smokers at 15.03 g/dl. Similarly, the average hematocrit level in smokers was 50.40%, higher than in non-smokers at 44.91%. Mann-Whitney test results indicated significant differences between the two groups for both hemoglobin ($p = 0.020$) and hematocrit ($p = 0.004$). There are significant differences in hemoglobin and hematocrit levels between active smokers and non-smokers. Active smokers tend to have higher levels of Hb and Hct as a response to the hypoxia caused by carbon monoxide exposure from cigarette smoke.

Keywords: active smokers; hematocrit; hemoglobin; non-smokers

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INTRODUCTION

Hemoglobin and hematocrit are two main parameters in clinical hematology evaluations that reflect the physiological condition of the body. Hemoglobin functions as an oxygen carrier from the lungs to all body tissues, while hematocrit indicates the percentage of red blood cell volume in the blood, representing the density of erythrocytes (Haiti & Tominik, 2018). Both parameters play an important role in determining maximal oxygen consumption capacity and overall physical fitness (Yuniarty et al., 2024). According to (Panawala, 2017), hemoglobin not only serves in oxygen transport but also contributes to acid-base balance and physiological stability. High levels of hemoglobin and hematocrit are closely associated with an increased risk of cardiovascular disease. (Fajar et al., 2018) stated that elevated hemoglobin levels raise the risk of coronary heart disease (CHD). Meanwhile, (Hultcrantz et al., 2020) found that high hemoglobin concentrations may increase the risk of myocardial infarction and ischemic stroke in both men and women. This condition occurs due to increased blood viscosity, which can slow circulation and impair oxygen supply to vital tissues.

Active smokers are individuals who directly inhale cigarette smoke, which contains various toxic substances such as nicotine and carbon monoxide. Based on the classification adapted from (Prabowo et al., 2020), smokers are divided into three categories: light smokers (1–4 cigarettes per day), moderate smokers (5–14 cigarettes per day), and heavy smokers (more than

15 cigarettes per day). Conversely, non-smokers are divided into two categories: never smokers—individuals who have never smoked—and ex-smokers—those who have completely quit smoking for at least six months (He et al., 2020).

Smoking remains a serious global health concern. It not only affects the respiratory system but also impacts hematological functions. According to (Acik et al., 2020), carbon monoxide exposure in smokers causes tissue hypoxia, prompting the body to increase erythrocyte production as a compensatory mechanism. This condition results in elevated hemoglobin and hematocrit levels. Similar findings were reported by (Makawekes et al., 2016), showing that smokers generally have higher hemoglobin levels than non-smokers. However, (An et al., 2023) discovered that long-term cigarette exposure can disrupt blood homeostasis by decreasing hemoglobin levels and increasing leukocyte counts, which may contribute to hematological and cardiovascular disorders..

Nutritional intake also plays an important role in maintaining hemoglobin stability among smokers. The study by Setia (Restuti & Suryana, 2018) showed that adequate protein intake can help balance changes in hematological parameters caused by smoking habits. Furthermore, (Restuti & Suryana, 2018) added that adolescent smokers with poor nutrition exhibit higher but unstable hemoglobin levels, indicating oxidative stress and metabolic imbalance in the blood. According to data from the (BPS Provinsi Jawa Timur, 2022), the average cigarette consumption in Tulungagung Regency reached 64 cigarettes per week, or approximately nine cigarettes per day. This figure illustrates the high level of tobacco exposure among the population, especially among active workers. Such conditions highlight the urgency of studying the effects of smoking on blood health, particularly hemoglobin and hematocrit levels.

In hospital environments, cigarette exposure is still commonly found among non-medical employees. Internal data from Bhayangkara Hospital Tulungagung show that the hospital employs 286 workers, consisting of 191 medical and 90 non-medical staff, with smoking habits more prevalent among the non-medical group (Holipah et al., 2020). Based on this background, the present study focuses on examining the differences in hemoglobin and hematocrit levels between active smokers and non-smokers among non-medical employees at Bhayangkara Hospital Tulungagung. This research is expected to provide a deeper understanding of how smoking habits affect blood health and serve as a foundation for more effective occupational health policies. Through routine monitoring of hematological parameters such as hemoglobin and hematocrit, the findings of this study are expected to support preventive efforts aimed at reducing smoking-related disease risks in hospital workplace settings.

METHOD

The research was conducted from May 2025 to August 2025. This study used an observational design with a cross-sectional approach. Hemoglobin (Hb) and Hematocrit (Hct) measurements were carried out at the RS Bhayangkara Tulungagung laboratory. The study population consisted of 30 non-medical employees from RS Bhayangkara Tulungagung, aged between 20 and 50 years, who met the criteria of being either active smokers or non-smokers for at least 6 months. All participants signed an informed consent form prior to participating in the study.
The tools used for sample collection included vacutainers with EDTA (Ethylene Diamine Tetraacetic Acid), syringes, alcohol swabs, sterile cotton, gloves, tourniquets, and a hematology analyzer. The research process involved obtaining research permission (ethical clearance), distributing informed consent forms, administering questionnaires regarding smoking habits and demographic information, and conducting blood sampling for laboratory analysis.

RESULT

The research results are presented in the tables below, which describe the characteristics of the subjects based on smoking status. While demographic information, including age and other

relevant factors, were considered in the analysis, the primary focus of this study is on the comparison of Hemoglobin (Hb) and Hematocrit (Hct) levels between active smokers and non-smokers. These hematological parameters were measured using an automated hematology analyzer at the RS Bhayangkara Tulungagung laboratory. Data collected through questionnaires provided additional insights into smoking habits and other factors that might influence the results

Table 1.
Respondent Hematology characteristics (n=15)

No	Hemoglobin (Hb) (g/dl)	Hematokrit (Hct) (%)	Keterangan
1	14.9	44.3	Normal
2	16.7	49.1	High Hb
3	14.3	41.8	Normal
4	15.1	43.7	Normal
5	14.7	43.0	Normal
6	16.7	47.2	High Hb
7	14.2	42.3	Normal
8	15.0	44.0	Normal
9	14.7	43.4	Normal
10	14.6	49.4	Normal
11	14.4	42.8	Normal
12	13.3	39.5	Low Hct
13	15.4	45.2	Normal
14	16.8	48.5	High Hb
15	14.6	49.4	Normal
Mean	15.03	44.91	

This table represents the Hemoglobin (Hb) and Hematocrit (Hct) levels for non-smoker subjects. The data shows the average Hemoglobin (Hb) value as 15.03 g/dl and the average Hematocrit (Hct) value as 44.91%.

Table 2.
Hemoglobin (Hb) and Hematocrit (Hct) Levels in Smoking Subjects

No	Hemoglobin (Hb) (g/dl)	Hematocrit (Hct) (%)	Remarks
1	14.7	45.9	Normal
2	14.7	42.7	Normal
3	15.4	45.3	Normal
4	15.0	44.2	Normal
5	15.7	45.9	Normal
6	15.7	45.6	Normal
7	15.7	45.0	Normal
8	12.8	39.4	Low Hb+Hct
9	16.0	48.7	High Hb
10	13.4	39.2	Low Hb+Hct
11	12.4	39.9	Low Hb+Hct
12	15.6	44.7	Normal
13	14.9	44.3	Normal
14	14.9	49.6	Normal
15	15.3	45.0	Normal
Mean	15.98	50.40	

This table shows the Hemoglobin (Hb) and Hematocrit (Hct) levels for the smoker subjects. The average Hemoglobin (Hb) level is 15.98 g/dl and the average Hematocrit (Hct) level is 50.40%.

Table 3.

Hemoglobin and Hematocrit Levels Based on Smoker and Non Smoker Groups

Group	Hemoglobin (Hb) Level	Standard Deviation (Hb)	Hematocrit (Hct) Level	Standard Deviation (Hct)
Smokers	15.98 g/dl	0.9973 g/dl	50.40%	5.3090%
Non- Smokers	15.03 g/dl	1.0025 g/dl	44.91%	3.1040%

Table 3 shows that the smokers group has a higher average Hemoglobin (Hb) level (15.98 g/dl) compared to the non-smokers group (15.03 g/dl). Additionally, the Hematocrit (Hct) level in the smokers group is also higher (50.40%) compared to the non-smokers group (44.91%). The standard deviation for Hemoglobin (Hb) in the smokers group is 0.9973 g/dl, while in the non- smokers group it is 1.0025 g/dl, indicating that the variation in Hb levels is slightly lower in the smokers group compared to the non-smokers group. For Hematocrit (Hct), the standard deviation in the smokers group is higher (5.3090%) compared to the non-smokers group (3.1040%), suggesting greater variation in Hct levels among smokers.

Table 4.

Mann-Whitney Test Results for Hemoglobin (Hb) and Hematocrit (Hct) Levels

Variable	Mann-Whitney U	Wilcoxon W	Z	p-value (Asymp. Sig.)
Hemoglobin (Hb)	56,500	176,500	-2.330	0.020
Hematocrit (Hct)	43,000	163,000	-2.883	0.004

Based on the results of the Mann-Whitney test, there is a significant difference between the smokers and non-smokers groups for both variables:

a. Hemoglobin (Hb): The p-value = 0.020 indicates a significant difference in Hb levels between the two groups.
b. Hematocrit (Hct): The p-value = 0.004 indicates a significant difference in Hct levels between the two groups.

This suggests that smoking affects Hemoglobin and Hematocrit levels, with the smokers group tending to have higher levels compared to the non-smokers group.

DISCUSSION

Normal Hemoglobin (Hb) levels generally range between 11–16 g/dl, while Hematocrit (Hct) levels typically fall within 40–54%. Based on the measurements of hemoglobin and hematocrit levels among smokers and non-smokers, significant differences were observed in these hematological parameters.

The average Hb level in the smoker group was 15.98 g/dl, higher than the non-smoker group, which had an average of 15.03 g/dl. This finding indicates that smoking habits influence the increase of hemoglobin concentration in the blood. Some smoker participants, such as subjects No. 9 (16.0 g/dl) and No. 6 (15.7 g/dl), showed Hb values above the normal range. This increase can be explained as a physiological response to hypoxia induced by carbon monoxide in cigarette smoke. Carbon monoxide has a higher affinity for hemoglobin than oxygen, leading the body to compensate for oxygen deficiency by increasing erythrocyte production and hemoglobin levels (Makawekes et al., 2016).

This phenomenon aligns with (Acik et al., 2020), who explained that the rise in hemoglobin levels among smokers is a compensatory mechanism in response to oxygen deprivation caused by carbon monoxide exposure. A similar finding was reported by (Wu et al., 2022), who demonstrated that chronic exposure to cigarette smoke increases oxidative stress and stimulates erythropoiesis, leading to elevated hemoglobin levels. Their study also highlighted that inadequate nutritional intake can exacerbate oxidative damage, potentially increasing the risk of hematological disorders such as anemia and reduced erythrocyte survival. (Schmitt et al., 2024) found that cigarette smoke extract or CO can cause eryptosis in erythrocytes, which potentially reduces the quality and number of red blood cells.

The study (Hultcrantz et al., 2020) demonstrated that higher hemoglobin levels do not always indicate a healthy physiological condition, as increased blood viscosity may raise the risk of cardiovascular diseases such as myocardial infarction and ischemic stroke. Similarly, (Fajar et al., 2018) explained that elevated hemoglobin due to chronic hypoxia in smokers can burden cardiac workload and increase blood pressure, thus heightening the risk of cardiovascular complications.

In the context of occupational health, (Yuniarty et al., 2024) highlighted that hematological examinations, particularly hemoglobin and hematocrit measurements, serve as essential indicators for monitoring physiological conditions in individuals exposed to toxic substances such as cigarette smoke. These assessments can provide early insights into the body's adaptive responses to oxidative stress and respiratory function disturbances caused by smoking habits. Physiologically, the increase in Hb levels among smokers represents an adaptive response to oxygen deficiency; however, over the long term, this condition can serve as an early indicator of serious health problems. Therefore, high hemoglobin levels in smokers must be interpreted with caution, as they may signify alterations in body homeostasis that could lead to hematological or cardiovascular disorders. Thus, regular monitoring of Hb and Hct levels is crucial, particularly among workers who smoke, to prevent more severe health complications.

Nevertheless, although smokers generally tend to have higher Hb levels, some individuals in the smoker group such as subjects No. 8 (12.8 g/dl), No. 10 (13.4 g/dl), and No. 11 (12.4 g/dl)—exhibited lower Hb levels. This variation may be attributed to oxidative stress resulting from exposure to harmful chemicals in cigarette smoke, including nicotine and carbon monoxide, which can damage red blood cell membranes and accelerate hemolysis. As red blood cell destruction increases, the number of functional erythrocytes decreases, preventing Hb levels from rising optimally even under hypoxic conditions. This explanation aligns with the findings of (Hultcrantz et al., 2020), who reported that unstable hemoglobin levels are associated with the vulnerability of red blood cells to damage. Their large- scale study emphasized that high hemoglobin levels do not always reflect a healthy physiological condition; instead, increased blood viscosity and erythrocyte fragility may worsen health outcomes by elevating the risk of both arterial and venous thrombosis.

Furthermore, (Holipah et al., 2020) found that chronic exposure to cigarette smoke increases inflammation and oxidative stress throughout the body. These conditions can inhibit the production of healthy erythrocytes and accelerate red blood cell degradation, which may explain why some smokers exhibit lower Hb levels rather than elevated ones. From a physiological standpoint, (Panawala, 2017) emphasized that hemoglobin plays a fundamental role in oxygen transport. Oxidative damage to erythrocytes caused by exposure to toxic substances reduces hemoglobin's ability to bind and transport oxygen efficiently. Consequently, even though the body attempts to increase erythrocyte production in response to hypoxia, the quality of hemoglobin may decline due to continuous oxidative damage.

In addition, (Nugraha et al., 2021) found that exposure to certain chemicals can affect the stability of hematological parameters, including hemoglobin. Although their study did not specifically examine smokers, the findings support the notion that environmental factors and exposure to toxic agents such as cigarette smoke can alter blood quality and influence Hb levels in some individuals. Moreover, (Rahadatul et al., 2024) highlighted that the accuracy of hematological testing particularly in hemoglobin measurement largely depends on laboratory quality control and proper testing procedures. This is important because inaccurate results may lead to misinterpretation of low Hb values, especially when influenced by pre-analytical factors or individual physiological conditions.

Overall, the findings of this study indicate that although smoking generally induces an increase in Hb as a compensatory mechanism for carbon monoxide–induced hypoxia, conditions such as oxidative stress, inflammation, erythrocyte damage, technical measurement factors, and individual physiological variability may cause some smokers to experience reduced Hb levels. Therefore, the

evaluation of Hb levels in smokers should consider additional factors such as smoking intensity, duration of exposure, antioxidant capacity, erythrocyte condition, and laboratory testing accuracy to provide a more comprehensive assessment of blood health.

The average hematocrit (Hct) level in the smoker group was 50.40%, higher than that of the non-smoker group, which had an average of 44.91%. This increase in Hct serves to enhance the blood's oxygen-carrying capacity throughout the body and represents a physiological response to chronic hypoxia caused by carbon monoxide exposure from cigarette smoke. Such hypoxic conditions stimulate the bone marrow to increase erythrocyte production as a compensatory mechanism. This result is consistent with the findings of (Hultcrantz et al., 2020), who reported that elevated hemoglobin and hematocrit levels can increase the risk of arterial and venous thrombosis due to heightened blood viscosity and reduced oxygen transport efficiency to tissues. A significant rise in Hct levels among smokers was also observed by (Makawekes et al., 2016), who stated that an increase in hematocrit represents the body's adaptive response to reduced oxygen levels resulting from carbon monoxide exposure. This gas has a much higher affinity for hemoglobin than oxygen, thereby reducing the blood's oxygen-carrying capacity. In response, the body increases the number of red blood cells to maintain oxygen balance within tissues. However, excessive Hct elevation may increase the risk of high blood viscosity, clot formation, and thrombosis, which can impair systemic circulation. Aliviameita and Puspitasari (2024) also emphasized that routine hematology examinations, including hematocrit measurements, are essential for disease screening and general health monitoring. Regular testing can help identify blood abnormalities such as secondary polycythemia caused by toxic exposure, including cigarette smoke, before progressing to more serious complications.

Furthermore, the findings of this study align with (Aminuddin et al., 2024) in Clinical Hematology Reference, which states that hematocrit analysis is a key parameter in assessing blood oxygenation and homeostasis. Accuracy in measuring this parameter is crucial because even small errors in laboratory analysis may result in misinterpretation of an individual's hematological health status. Some individuals in the smoker group actually exhibited lower Hct levels, such as subjects No. 8 (39.4%), No. 10 (39.2%), and No. 11 (39.9%). This decrease may be attributed to oxidative stress and erythrocyte damage resulting from exposure to harmful chemicals in cigarette smoke(Restuti & Suryana, 2018) explained that chronic exposure to nicotine and carbon monoxide can cause oxidative damage to red blood cells, reducing the number of healthy erythrocytes and consequently lowering hematocrit levels. Dehydration, which frequently occurs among smokers, may further aggravate this condition by altering plasma volume and body fluid balance.

From a laboratory management perspective, (Ramadani Fitri et al., 2023) highlighted the importance of quality control in hematological examinations to ensure accurate and reliable hematocrit measurements. Proper maintenance of hematology analyzers, calibration, and laboratory quality assurance is essential to prevent bias, especially in studies comparing hematocrit levels among individuals exposed to toxic substances such as active smokers.
Overall, the increase in hematocrit levels among smokers reflects the body's adaptation to hypoxic conditions but also carries a potential risk for cardiovascular complications. Meanwhile, variations in decreased Hct levels among some smokers indicate that the effects of smoking on blood are not linear and are influenced by multiple factors, including nutritional status, hydration, oxidative stress levels, and laboratory measurement quality.Therefore, regular monitoring of hematocrit and strict laboratory quality control are essential steps to achieve accurate interpretation of hematological status in smokers.

CONCLUSION

Based on the study findings, active smokers tend to have higher Hemoglobin (Hb) and Hematocrit (Hct) levels compared to non-smokers. A significant difference was observed

between the Hb and Hct levels of active smokers and non-smokers. Active smokers generally exhibit higher Hb and Hct levels as a response to hypoxia caused by carbon monoxide in cigarette smoke. Additionally, the variation in Hb and Hct levels among smokers is greater than that of non-smokers, indicating that factors such as smoking intensity and individual health conditions also play a role in influencing hematological outcomes.

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