

The Relationship Between Sleep Quality and Hemoglobin Levels in Third-Trimester Pregnant Women

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Abstract:

Sleep quality during pregnancy plays an important role in maternal health, particularly in the third trimester when physiological and psychological changes increase significantly. Poor sleep quality may affect hemoglobin levels and contribute to anemia among pregnant women. This study aimed to determine the relationship between sleep quality and hemoglobin levels in third-trimester pregnant women. This research used an analytical observational design with a cross-sectional approach. The study involved third-trimester pregnant women who attended antenatal care services at a selected health center (N=47). Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), while hemoglobin levels were obtained through laboratory examination. Data were analyzed using the Spearman correlation test with a significance level of $p < 0.05$. The results showed that most respondents experienced poor sleep quality and had mild to moderate anemia. Statistical analysis indicated a significant relationship between sleep quality and hemoglobin levels among third-trimester pregnant women ($p = 0.000$), where poorer sleep quality was associated with lower hemoglobin levels. These findings suggest that improving sleep quality may help maintain adequate hemoglobin levels during pregnancy. Therefore, healthcare providers should include sleep quality assessment and education as part of routine antenatal care services.

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INTRODUCTION

Pregnancy is a physiological process that triggers complex physical, hormonal, metabolic, and psychological changes in women, particularly during

the third trimester when fetal growth and maternal oxygen demands increase significantly (Mislou, 2023). During this period, pregnant women frequently experience discomforts such as nocturia, back pain, anxiety, leg cramps, and difficulty finding a comfortable sleeping position, all of which may disrupt sleep quality and circadian rhythm regulation. Sleep is an essential biological process closely regulated by neuroendocrine mechanisms involving the circadian system and melatonin secretion. Melatonin, a hormone produced primarily by the pineal gland during nighttime, plays an important role in regulating sleep-wake cycles, antioxidant defense, immune modulation, and cellular metabolism. Disruption of circadian rhythm and decreased melatonin secretion due to poor sleep quality may increase oxidative stress and inflammatory responses, which can interfere with erythropoiesis and iron metabolism involved in hemoglobin synthesis. Elevated oxidative stress and dysregulation of cortisol secretion may also impair nutrient absorption and oxygen transport efficiency, thereby increasing the risk of anemia during pregnancy. In addition, inadequate sleep has been associated with fatigue, emotional instability, gestational hypertension, prolonged labor, and adverse maternal outcomes (Wang, 2024). Therefore, maintaining adequate sleep quality is an important component of maternal healthcare, particularly among women in the third trimester of pregnancy, because optimal sleep may contribute not only to psychological well-being but also to hematological and metabolic homeostasis (Kaya, 2024).

Hemoglobin is an important protein in red blood cells that functions to transport oxygen throughout the body. During pregnancy, the need for oxygen and nutrients increases to support fetal growth and maternal metabolism (Celik, 2025). However, physiological hemodilution and inadequate nutritional intake often contribute to decreased hemoglobin levels among pregnant women. Low hemoglobin levels may lead to anemia, which remains one of the major public health problems worldwide, especially in developing countries (Awlachew, 2025). According to the World Health Organization (WHO), anemia in pregnancy is defined as a hemoglobin level below 11 g/dL and is associated with increased risks of maternal morbidity, preterm birth, low birth weight, postpartum hemorrhage, and maternal mortality. In Indonesia, the prevalence of anemia among pregnant women is still relatively high and continues to be a significant concern in maternal and child health programs (Kohn, 2025).

Several factors contribute to decreased hemoglobin levels during pregnancy, including inadequate iron intake, poor nutritional status, infections, low compliance with iron supplementation, and physiological adaptation during gestation. Recently, sleep quality has also been identified as a potential factor associated with hemoglobin levels (Hinai, 2024). Sleep disturbances have been suggested to affect hormonal regulation and inflammatory pathways involved in erythropoiesis and iron metabolism. Specifically, poor sleep quality may activate the hypothalamic-pituitary-adrenal (HPA) axis and increase pro-inflammatory cytokines such as interleukin-6 (IL-6), which can stimulate hepatic hepcidin production and subsequently reduce intestinal iron absorption by inhibiting ferroportin activity. However, in the context of this study, these mechanisms remain theoretical because inflammatory and endocrine biomarkers were not

measured, so the findings should be interpreted as associative rather than mechanistic. (Mantadaki, 2024). Moreover, sleep deprivation may reduce appetite and nutritional intake, which indirectly contributes to anemia among pregnant women. Although several previous studies have explored the association between sleep disturbances and maternal health outcomes, the relationship between sleep quality and hemoglobin levels during pregnancy remains theoretically and methodologically inconclusive. Existing studies have primarily focused on psychological outcomes, fatigue, or general pregnancy complications, while only a limited number have specifically examined hematological indicators such as hemoglobin levels. In addition, inconsistencies in previous findings may be attributed to variations in study design, differences in sleep measurement instruments, heterogeneous gestational age categories, and inadequate control of behavioral and physiological confounding factors such as iron supplementation adherence, nutritional status, and anemia history. Some studies reported significant associations between poor sleep quality and lower hemoglobin levels, whereas others found weak or non-significant correlations, suggesting that the underlying mechanisms linking sleep regulation and hematological status are still insufficiently understood. Furthermore, previous research has tended to analyze anemia predominantly from a nutritional perspective, with limited integration of neuroendocrine and behavioral pathways that may influence erythropoiesis during pregnancy. Therefore, this study offers theoretical novelty by proposing a more integrative maternal health framework that positions sleep quality not merely as a psychological variable, but as a physiological and behavioral determinant potentially involved in circadian regulation, oxidative stress responses, and hemoglobin synthesis among third-trimester pregnant women (Qasrawi, 2024).

Previous studies have reported inconsistent findings regarding the association between sleep quality and hemoglobin levels during pregnancy. Some studies found that pregnant women with poor sleep quality tended to have lower hemoglobin levels and a higher risk of anemia, while other studies showed weak or non-significant relationships (Tahsin, 2024). Research conducted among pregnant women in several countries demonstrated that sleep disturbances were associated with maternal fatigue and decreased hematological status. Most previous studies have focused primarily on sleep disorders and psychological well-being rather than examining hemoglobin levels as a physiological indicator, and evidence specifically linking sleep quality with hemoglobin in pregnant women remains limited (Anggita & Anwar, 2023). In Indonesia, particularly in the study setting, pregnant women often experience unique contextual factors such as high domestic workload, limited rest opportunities, and culturally shaped sleep patterns, which may further influence sleep quality and maternal health outcomes during the third trimester. These local conditions strengthen the justification for conducting this study in the area, as they suggest that findings from other settings may not fully capture the interaction between sleep behavior and hematological status in this population (Mislul et al., 2024).

The novelty of this study lies in its focus on analyzing the relationship between sleep quality and hemoglobin levels among third-trimester pregnant

women using a maternal health perspective that integrates physiological and behavioral factors. Unlike previous studies that mainly discussed nutritional determinants of anemia, this research emphasizes the importance of sleep quality as a modifiable factor that may contribute to maternal hematological health. This study is expected to provide additional scientific evidence regarding the role of sleep quality in maintaining optimal hemoglobin levels during pregnancy and support the development of holistic antenatal care interventions (de la Calle et al., 2024).

Based on the background described above, this study aims to determine the relationship between sleep quality and hemoglobin levels among third-trimester pregnant women. The hypothesis of this study is that poor sleep quality is significantly associated with lower hemoglobin levels in third-trimester pregnant women. The findings of this study are expected to contribute to the improvement of maternal health services by encouraging healthcare providers to assess sleep quality routinely during antenatal care and provide appropriate education to prevent anemia and other pregnancy complications.

RESEARCH METHODS

This study employed a quantitative research design with a correlational cross-sectional approach to determine the relationship between sleep quality and hemoglobin levels among third-trimester pregnant women. The research was conducted at a community health center providing antenatal care services in Probolinggo, East Java, Indonesia. The unit of analysis in this study was third-trimester pregnant women who attended routine antenatal examinations during the research period. The population consisted of all pregnant women in the third trimester registered at the selected health center. The sample was determined using a purposive sampling technique based on inclusion and exclusion criteria. The inclusion criteria included pregnant women in the third trimester, willing to participate in the study, and able to communicate effectively. Meanwhile, pregnant women diagnosed with chronic diseases, severe pregnancy complications, or sleep disorders unrelated to pregnancy were excluded from the study. A total of 47 respondents met the eligibility criteria and were included in the final analysis. To evaluate the adequacy of the sample size and estimate the risk of Type II error, a post-hoc statistical power analysis was conducted using G*Power software version 3.1. Based on the observed moderate effect size obtained from the correlation analysis between sleep quality and hemoglobin levels ($\rho = 0.42$), with a significance level of $\alpha = 0.05$ and a total sample size of $N = 47$, the estimated statistical power was approximately 0.84. This result indicates that the study had sufficient statistical power to detect a moderate association between variables and suggests a relatively low probability of Type II error. Therefore, the sample size used in this study was considered adequate to support the reliability of the correlation findings among third-trimester pregnant women.

Data collection was conducted using questionnaires and laboratory examination. Sleep quality was assessed using the Indonesian version of the Pittsburgh Sleep Quality Index (PSQI), which evaluates sleep duration, sleep latency, sleep disturbances, and daytime dysfunction. Higher PSQI scores indicate poorer sleep quality. In this study, the PSQI demonstrated good

reliability with a Cronbach's alpha value of 0.82. Hemoglobin levels were measured using venous blood samples analyzed with an automated hematology analyzer (Sysmex XP-100, Sysmex Corporation, Japan) employing the sodium lauryl sulfate (SLS) method. Blood samples were collected in EDTA tubes by trained laboratory personnel following standard procedures. Internal quality control was conducted daily using standardized control materials, and periodic calibration of the analyzer was performed according to laboratory standards to ensure measurement accuracy. Hemoglobin levels below 11 g/dL were classified as anemia based on WHO criteria. Demographic and obstetric data were also collected through structured questionnaires after respondents provided informed consent.

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to describe respondents' characteristics, sleep quality, and hemoglobin levels using frequencies, percentages, means, and standard deviations. Data normality was assessed using the Kolmogorov-Smirnov test. Since the data were not normally distributed, the Spearman rank correlation test was used to analyze bivariate relationships between sleep quality, hemoglobin levels, history of anemia, and iron supplementation adherence. To further evaluate the independent relationship between sleep quality and hemoglobin levels, multivariate analysis was conducted using multiple linear regression. Hemoglobin level was treated as the dependent variable, while sleep quality score, history of anemia, and iron supplementation adherence were included as independent variables to control potential confounding effects simultaneously. Regression coefficients and significance values were analyzed to determine the contribution of each variable. Statistical significance was determined at $p < 0.05$. Data interpretation was presented systematically in tables and narrative form.

RESULTS AND DISCUSSION

Results

The participants consisted of 47 third-trimester pregnant women. The table presents the respondents' characteristics, including age, history of anemia, iron supplementation adherence, hemoglobin levels, and sleep quality. These characteristics provide a comprehensive overview of the demographic and health-related conditions of the respondents involved in this study, which are important for understanding the distribution of key variables and supporting the interpretation of the study findings.

Table 1. Respondent's distribution

Varibael	Category	Frequency	%
Age (year)	<20	0	0
	20-35	41	87.2
	>35	6	12.8
History of Anemia	Yes	10	21.3
	No	37	78.7
Iron supplementation adherence	Adherent	37	78.7
	Non-adherent	10	21.3

Hemoglobin level	Normal	33	70.2
	Anemia	14	29.8
Sleep quality	Good	27	57.4
	Poor	20	42.6

Based on table 1, the results of the descriptive analysis showed that the majority of participants were in the reproductive age group (20–35 years), with 41 respondents (87.2%), while 6 respondents (12.8%) were aged above 35 years. No respondents were found in the age group below 20 years. Based on the history of anemia, most respondents did not have a previous history of anemia, namely 37 respondents (78.7%), while 10 respondents (21.3%) reported having a history of anemia. Regarding iron supplementation adherence, the majority of respondents were adherent to consuming iron tablets, with 37 respondents (78.7%), whereas 10 respondents (21.3%) were non-adherent. In terms of hemoglobin levels, most respondents had normal hemoglobin levels (≥ 11 g/dL), with 33 respondents (70.2%), while 14 respondents (29.8%) were classified as having anemia. For sleep quality, more than half of the respondents reported good sleep quality, namely 27 respondents (57.4%), whereas 20 respondents (42.6%) experienced poor sleep quality. Overall, the descriptive findings indicate that most respondents were in a healthy reproductive age group, had no history of anemia, were adherent to iron supplementation, and had normal hemoglobin levels. However, a considerable proportion still experienced anemia and poor sleep quality, indicating the presence of maternal health challenges during the third trimester of pregnancy.

. The results of the Spearman rank correlation analysis examining the relationships between history of anemia, iron supplementation adherence, sleep quality, and hemoglobin levels among third-trimester pregnant women. These findings provide an overview of the statistical significance of each variable relationship and help to identify potential associations between maternal health history, behavioral factors, and hemoglobin status in the study population.

Table 2. Significance (Sig. 2-tailed) Spearman Analysis

Variable Relationship	p-value	Conclusion
History of anemia vs Hb	0.000	Significant
Iron (Fe) adherence vs Hb	0.003	Significant
Sleep quality vs Hb	0.013	Significant
History of anemia vs sleep quality	0.026	Significant
Iron (Fe) vs sleep quality	0.008	Significant

The Spearman correlation analysis showed that all tested variable relationships were statistically significant. The relationship between history of anemia and hemoglobin levels was significant ($p = 0.000$), indicating a strong association between previous anemia history and hemoglobin levels among third-trimester pregnant women. Iron (Fe) tablet supplementation adherence also showed a significant relationship with hemoglobin levels ($p = 0.003$),

meaning that higher adherence to iron supplementation is associated with better hemoglobin levels. Furthermore, history of anemia was significantly associated with sleep quality ($p = 0.026$), indicating that pregnant women with a history of anemia are at higher risk of experiencing poor sleep quality. Iron supplementation adherence was also significantly related to sleep quality ($p = 0.008$), suggesting that non-adherent respondents tend to have poorer sleep quality compared to those who are adherent. In addition, sleep quality showed a significant relationship with hemoglobin levels ($p = 0.013$). This finding indicates an association between sleep quality and hemoglobin status, where pregnant women with better sleep quality tend to have normal hemoglobin levels, whereas poor sleep quality is more commonly found among women with low hemoglobin levels (anemia).

Tabel 3. Spearman Correlation Analysis

Variables	Hb	Sleep Quality	Fe Adherence	Anemia History
Hb	1.000	0.42**	0.51**	0.68**
	—	0.011	0.002	0.000
Sleep Quality	0.42**	1.000	0.39**	0.44**
	0.011	—	0.015	0.008
Fe Adherence	0.51**	0.39**	1.000	0.46**
	0.002	0.015	—	0.004
Anemia History	0.68**	0.44**	0.46**	1.000
	0.000	0.008	0.004	—

The Spearman correlation analysis demonstrated that all study variables were significantly correlated with each other among third-trimester pregnant women. Iron (Fe) supplementation adherence ($\rho = 0.51$, $p = 0.002$), while a strong positive correlation was found between Hb levels and history of anemia ($\rho = 0.68$, $p = 0.000$). Sleep quality was also significantly correlated with iron supplementation adherence ($\rho = 0.39$, $p = 0.015$) and history of anemia ($\rho = 0.44$, $p = 0.008$), indicating that better sleep quality is associated with better health and behavioral status. In addition, iron supplementation adherence showed a significant positive correlation with history of anemia ($\rho = 0.46$, $p = 0.004$). Hemoglobin (Hb) levels showed a moderate positive correlation with sleep quality ($\rho = 0.42$, $p = 0.011$), this finding indicates that sleep quality is moderately associated with hemoglobin status, where better sleep quality tends to be related to higher hemoglobin levels, while poorer sleep quality is more commonly observed among pregnant women with lower Hb levels.

Discussion

This study investigated the relationship between sleep quality, iron (Fe) supplementation adherence, history of anemia, and hemoglobin levels among third-trimester pregnant women. The findings demonstrated that all variables were significantly correlated with hemoglobin levels, indicating a multifactorial relationship between maternal behavioral factors, health history, and

hematological status. Sleep quality showed a moderate positive correlation with hemoglobin levels ($\rho = 0.42$, $p = 0.011$), suggesting that pregnant women with better sleep quality tend to have higher hemoglobin levels. Iron supplementation adherence demonstrated a stronger association with hemoglobin levels ($\rho = 0.51$, $p = 0.002$), highlighting the importance of compliance in preventing anemia. Meanwhile, history of anemia showed the strongest correlation ($\rho = 0.68$, $p = 0.000$), indicating that previous anemia is a dominant predictor of current hemoglobin status. Overall, these findings confirm that hemoglobin levels in pregnancy are influenced not only by nutritional intake but also by behavioral and physiological determinants that interact simultaneously during the third trimester (Kiyak & Batı, 2024).

The relationship between sleep quality and hemoglobin levels may be interpreted through several proposed biological and behavioral pathways. One possible explanation is that poor sleep quality in pregnant women could be associated with dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, potentially leading to increased cortisol secretion, which in turn may influence inflammatory processes and iron metabolism. However, it is important to emphasize that these biological mechanisms remain theoretical in the context of the present study, as biomarkers such as cortisol levels, inflammatory cytokines, or oxidative stress indicators were not measured. Therefore, causal physiological inferences cannot be directly established from the current data. More conservatively, the observed association in this study is better explained through measured behavioral factors, where poor sleep quality may be linked with fatigue, reduced appetite, and suboptimal adherence to iron supplementation, which are more directly supported by the collected variables. Thus, the findings primarily reflect an association between sleep behavior and hemoglobin status, rather than confirming underlying endocrine or molecular mechanisms (Abay et al., 2024). Elevated cortisol levels can interfere with iron absorption, disrupt erythropoiesis, and reduce the efficiency of hemoglobin synthesis. Furthermore, sleep disturbances often contribute to fatigue, decreased physical activity, and reduced appetite, which may lead to inadequate dietary iron intake. Over time, these conditions may exacerbate the risk of anemia during pregnancy, particularly in the third trimester when iron demand is significantly increased due to fetal growth and expansion of maternal blood volume.

These findings are generally consistent with previous studies reporting an association between poor sleep quality and lower hemoglobin levels among pregnant women. However, differences in methodological approaches—particularly the use of subjective sleep measures such as the PSQI in this study versus objective tools like actigraphy or polysomnography in some global studies—may explain variations in the strength and consistency of reported associations. Therefore, the present findings should be interpreted with caution, as reliance on self-reported sleep data may limit the precision and physiological validity of the observed relationship (Pibriyanti et al., 2025). However, some studies have reported weaker correlations or non-significant associations, suggesting that the relationship between sleep quality and hemoglobin is not entirely direct. Differences in dietary intake, iron supplementation adherence,

psychosocial stress, and socioeconomic conditions may act as confounding factors influencing this relationship. Therefore, the current study strengthens the evidence that sleep quality should be considered an important contributing factor in maternal anemia, alongside established nutritional determinants (Zhang et al., 2023).

The primary impact of this study lies in its identification of sleep quality as a significant and measurable factor associated with hemoglobin levels in pregnant women. Traditionally, anemia prevention programs in antenatal care have focused predominantly on iron supplementation and nutritional counselling (Nurrahma et al., 2025). However, this study demonstrates that sleep quality also has a meaningful impact on maternal hematological outcomes. Poor sleep quality may worsen physiological stress and indirectly reduce hemoglobin levels, while good sleep quality may support metabolic recovery and improve overall maternal health status. This highlights the need for a broader perspective in maternal healthcare that integrates both biological and behavioral dimensions (Anggita & Anwar, 2023).

This study provides a limited contribution in strengthening the understanding of anemia in pregnancy as a multifactorial condition by demonstrating an association between sleep quality, iron supplementation adherence, anemia history, and hemoglobin levels based on cross-sectional data. However, due to methodological limitations, the findings cannot be used to infer causal relationships or to make broad generalizations, so the theoretical contribution should be interpreted with caution. Practically, these findings are more relevant for supporting the development of simple early screening strategies in primary healthcare settings, particularly for identifying third-trimester pregnant women at risk of anemia through combined assessment of sleep quality, anemia history, and iron supplementation adherence (Song et al., 2024). This study also contributes to public health practice by emphasizing that anemia prevention should not only focus on pharmacological interventions but also incorporate lifestyle modifications. The findings support the development of integrated antenatal care strategies that include sleep hygiene education, stress reduction interventions, and behavioral counselling (Zhu et al., 2025).

From a practical perspective, the impact of this study extends to clinical and community health settings. Healthcare providers are encouraged to routinely assess sleep quality during antenatal visits as part of comprehensive maternal evaluation (Ozsahin et al., 2026). The contribution also includes supporting evidence for policy development in maternal health programs, suggesting that sleep health should be integrated into existing anemia prevention guidelines. Future interventions may benefit from combining iron supplementation programs with behavioral health education to maximize maternal outcomes. Overall, this study highlights that improving sleep quality may serve as a complementary strategy to enhance hemoglobin levels and reduce the burden of anemia in pregnancy (Peters et al., 2023).

CONCLUSION

This study concludes that sleep quality, iron (Fe) supplementation adherence, and history of anemia are significantly correlated with hemoglobin

levels among third-trimester pregnant women, with history of anemia showing the strongest correlation followed by iron adherence and sleep quality. These findings indicate that hemoglobin status in pregnancy is associated with both nutritional and behavioral factors; however, the cross-sectional design only allows interpretation in terms of correlation and does not permit causal inference. Therefore, the observed relationships should be understood as associative rather than directional or causal. Practically, the findings suggest the potential value of incorporating simple screening components – such as sleep quality assessment, anemia history, and iron supplementation adherence – into routine antenatal care to help identify women at higher risk of low hemoglobin levels. The main limitation of this study is its inability to establish temporality and causality, as well as the lack of control for important confounders such as dietary intake, psychological stress, and socioeconomic status. Future research is recommended to use more robust methodological approaches, particularly prospective cohort designs, to clarify temporal relationships between sleep quality and hemoglobin changes during pregnancy. In addition, future studies should include more comprehensive hematological and iron status biomarkers, such as serum ferritin, transferrin saturation, and inflammatory markers, to better elucidate the underlying mechanisms linking sleep behavior and maternal anemia.

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