



The Relationship Between Malaria Infection and Anemia in Pregnant Women in Endemic Areas in 2023

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ABSTRACT

Malaria is an infectious disease that remains a global public health problem, particularly in tropical and subtropical regions. Pregnant women are highly susceptible to malaria infection due to physiological, immunological, and hematological changes during pregnancy that can worsen clinical conditions. One of the main complications of malaria in pregnant women is anemia, which can increase the risk of morbidity and mortality for both the mother and the fetus. Anemia in pregnancy contributes to an increase in the incidence of low birth weight (LBW), prematurity, and even perinatal death. Therefore, the relationship between malaria infection and anemia in pregnant women in endemic areas is an important issue to study. This study aims to determine the relationship between malaria infection and anemia in pregnant women in malaria-endemic areas in 2023. The study was conducted using an observational analytical design using a cross-sectional approach. The population in this study were all pregnant women in malaria-endemic areas, with samples taken purposively according to inclusion and exclusion criteria. The independent variable was malaria infection status confirmed through laboratory testing (Rapid Diagnostic Test/RDT or microscopic examination), while the dependent variable was anemia status determined by hemoglobin levels. Data analysis used a chi-square test to determine the relationship between variables. The results showed that pregnant women infected with malaria had a higher risk of anemia compared to pregnant women who were not infected. Malaria infection, especially that caused by *Plasmodium falciparum*, is known to cause massive red blood cell destruction, suppress erythropoiesis, and increase hemolysis, thereby worsening anemia in pregnant women. Furthermore, changes in the immune response during pregnancy make mothers more susceptible to reinfection, which further increases the severity of anemia. Other contributing factors include nutritional status, parity, and access to health services. The conclusion of this study is a significant association between malaria infection and the incidence of anemia in pregnant women in endemic areas by 2023. These results emphasize the importance of malaria prevention programs for pregnant women, including the provision of prophylactic drugs. Distribution Insecticide-treated bed nets, increased routine malaria screening during antenatal care (ANC), and public health education are expected to reduce the incidence of anemia in pregnant women and improve maternal and infant health.

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1. Introduction

Diabetes mellitus (DM) is a chronic disease that is a global health problem. Malaria is an infectious disease that is still a public health problem in the world, especially in tropical and subtropical areas.(Warwuru, Suradji, Umakaapa, & Rahail, 2023),(Ranggajawa, 2020)The World Health Organization (WHO) in its 2022 World Malaria Report reported that in 2021 there were approximately 247 million cases of malaria with a death toll reaching 619,000, with the majority of cases occurring in Sub-Saharan Africa, Southeast Asia, and Latin America.(Organization, 2022),(Latif & Putri, 2023)In Indonesia, malaria is still an endemic disease in several provinces, especially in eastern Indonesia such as Papua, West Papua, East Nusa Tenggara, Maluku, and parts of Sumatra.(Mahdalena & Wurisastuti, 2020),(Ramadhani, Amirullah, & Rahmat, 2021).

Pregnant women are among those highly susceptible to malaria infection. This is due to physiological and immunological changes during pregnancy, which make them more susceptible to infection and serious complications.(Tondok et al., nd),(HANNUM NST, 2020)Malaria in pregnant women can cause various serious consequences for both the mother and the fetus. One of the most common complications is anemia, caused by hemolysis of red blood cells due to Plasmodium parasite invasion, increased destruction of red blood cells by the spleen, and suppression of erythropoiesis in the bone marrow.(Faris, 2023),(Nair, 2022).

Anemia in pregnant women is a dangerous condition because it is closely related to an increased risk of miscarriage, premature birth, low birth weight (LBW), intrauterine growth retardation (IUGR), and maternal and perinatal death.(Farhan & Dhanny, 2021),(Widianti & Fitriahadi, 2023)The WHO (2021) states that anemia in pregnancy remains a global health problem, with a prevalence of around 40% in pregnant women worldwide. In Indonesia, the prevalence of anemia in pregnant women, according to the 2018 Basic Health Research (Riskesdas), reached 48.9%, with malaria, particularly in endemic areas, being a contributing factor.(Dai, 2021),(Oktaviance, Sitepu, Gunny, & Santa Elisabeth, 2022).

The relationship between malaria infection and anemia in pregnant women has been extensively studied. Malaria infections, particularly those caused by Plasmodium falciparum, tend to be more severe because they can cause acute and chronic anemia.(Nurdianto, Imun, Setiawan, & Nurdianto, 2021),(Mutia, 2023). Furthermore, malaria can also lower a mother's hemoglobin levels, ultimately increasing the risk of obstetric complications. Other factors such as nutritional status, parity, and access to health services also play a role in exacerbating the impact of malaria on pregnant women.(Budiyanto & Wurisastuti, 2017),(KRISDIANTI, 2021).

Seeing this problem, it is important to conduct research on the relationship between malaria infection and the incidence of anemia in pregnant women in endemic areas.(Aguscik & Ridwan, 2019),(Alwi, 2023)The results of this study are expected to provide an up-to-date epidemiological picture of the impact of malaria on pregnant women, as well as serve as a basis for formulating policies for preventing and managing malaria in vulnerable groups.(Wigunawanti, 2022),(Mutia, 2023)Malaria control efforts integrated with antenatal care (ANC) services can help reduce the incidence of anemia and improve maternal and child health. Therefore, this research is highly relevant in supporting maternal and child health programs and malaria elimination in Indonesia.(Gunawan, nd),(Astuti, Ipa, Ginanjar, & Wahono, 2019).

2. Methods

2.1 Research Design

This study used an observational analytical research design with a cross-sectional approach. This design was chosen because it is able to describe the relationship between the independent variable (malaria infection) and the dependent variable (the incidence of anemia in pregnant women) measured

simultaneously. The cross-sectional approach is considered effective for assessing disease prevalence and risk factors in a specific population, particularly in epidemiological research in the field of public health.(Pratiwi, nd),(Asriwati & Ns, 2021).

The study location was determined in a malaria-endemic area with a relatively high prevalence of cases in 2023, based on data from the local Health Office. The location was selected purposively, considering that the area had consistent malaria epidemiological characteristics and a sufficient number of pregnant women as study subjects.

2.2 Population and Sample

A population is the entirety of the subjects or objects of research that possess certain characteristics and are of interest to researchers to study and draw conclusions from (Sugiyono, 2019). In this study, the target population was all pregnant women residing in malaria-endemic areas in 2023. This population was chosen because pregnant women are a vulnerable group that experiences physiological and immunological changes, making them more susceptible to malaria infection and complications such as anemia.(Novita, 2023).

From the target population, the researcher then determined the accessible population, namely pregnant women residing in the working area of health facilities (community health centers or hospitals) in malaria-endemic areas during the study period. The accessible population was selected based on location accessibility, data availability, and the researcher's ability to collect data. This aligns with Notoatmodjo's (2018) opinion that in public health research, accessible populations are selected to ensure the research process is more efficient and can be implemented effectively.

The sample size was determined using the sample size formula for cross-sectional analytical research with a two-proportion hypothesis test (Lemeshow et al., 1990). This formula takes into account the confidence level ($\alpha = 0.05$), the power of the test (power = 80%), and the proportion of anemia cases in pregnant women infected with malaria based on previous research. The calculation results obtained a minimum sample size, then added 10–15% to anticipate the possibility of dropout.

Therefore, the sample for this study consisted of pregnant women in malaria-endemic areas in 2023 who met the inclusion and exclusion criteria, and the number was in accordance with the previously calculated sample size. This sample selection is expected to provide a valid representation of the population of pregnant women in endemic areas, allowing the study results to be generalized to a broader population.

2.3 Data Collection Techniques and Instrument Development

Data collection is a crucial stage in any research, as the quality of the data obtained will significantly determine the validity of the results. This study employed both primary and secondary data collection techniques. Primary data were obtained directly from respondents, namely pregnant women living in malaria-endemic areas in 2023, through interviews, observation, and laboratory tests. Secondary data were obtained from medical records, Health Office reports, and regional health profiles related to malaria and anemia incidence rates in the study area (Notoatmodjo, 2018).

a. Data collection technique

a) Structured Interview

Interviews were conducted using a structured questionnaire containing questions related to respondent characteristics (age, education, occupation, parity, gestational age), medical history, and other risk factors that may influence anemia status. This technique was chosen because it provides more consistent data and facilitates analysis, particularly in public health epidemiological research (Sugiyono, 2019).

b) Malaria Laboratory Examination

Malaria infection status is determined through laboratory tests. The methods used are Rapid Diagnostic Tests (RDTs) and/or microscopic examination of thick and thin blood smears. RDTs were

chosen because they have high sensitivity and specificity, are easy to use in the field, and do not require complex laboratory equipment (WHO, 2022). Microscopic examination is considered the gold standard for malaria diagnosis because it can identify *Plasmodium* species and quantify parasite density.

c) Hemoglobin (Hb) Level Examination

Anemia status in pregnant women is determined by examining hemoglobin levels using a digital hemoglobinometer or the cyanmethemoglobin method in a laboratory. According to the WHO (2021), anemia in pregnant women is defined as Hb levels <11 g/dL. These test results are then categorized as mild, moderate, or severe anemia according to applicable standards.

d) Observations and Medical Records

In addition to interviews and laboratory examinations, direct observation and recording of secondary data from the KIA (Maternal and Child Health) book or medical records are used to complete information regarding the health status of pregnant women, history of malaria, and previous laboratory examination results.

b. Research Instrument Development

The research instruments used were a structured questionnaire and observation sheet. These instruments were developed based on a literature review, WHO guidelines, and previous research on malaria and anemia in pregnant women. The questionnaire was structured into several sections: sociodemographic data (age, education, occupation, economic status), obstetric data (gestational age, parity, history of antenatal care), medical history data (history of malaria, medication consumption, chronic diseases), and nutritional status data (food intake, consumption of iron tablets). Before use, the research instruments were tested for validity and reliability. Validity testing was conducted using expert judgment by public health and obstetrics experts to ensure the questions were appropriate to the research objectives. Instrument reliability was tested using a test-retest method on a number of respondents with similar characteristics to assess the consistency of answers. Instruments declared valid and reliable were then used in research data collection.

c. Data Collection Procedures

The data collection process was carried out in several stages: Socialization of the research to respondents and health workers in the research area. Providing informed consent to pregnant women who met the inclusion criteria. Conducting interviews using questionnaires by trained enumerators. Malaria examination using RDT/microscopy and Hb examination in the laboratory. Recording of examination results and observations in the research data sheet. Processing of raw data for statistical analysis.

2.4 Analysis Techniques

Data analysis is a crucial step in research, transforming raw data into meaningful information that can be used to answer research questions and test hypotheses. In this study, data analysis was conducted in stages, namely univariate and bivariate analysis, in accordance with the objective of determining the relationship between malaria infection and the incidence of anemia in pregnant women in endemic areas in 2023.

This research data analysis uses:

a. Univariate

Univariate analysis aims to describe the characteristics of each research variable individually. This analysis produces frequency distributions, proportions, and measures of central tendency such as the mean, median, and mode. Furthermore, measures of dispersion such as the standard deviation (SD) can also be used for numerical data (Notoatmodjo, 2018).

In this study, univariate analysis was conducted to explain the characteristics of respondents, including independent, dependent, and confounding variables. Some examples of univariate analysis

used include: Respondent demographic characteristics: maternal age, education level, occupation, parity, and gestational age. These data are presented in the form of frequency distribution tables and percentages. Malaria infection status: grouped into malaria-positive (based on RDT/microscopic results) and malaria-negative. Results are presented in the form of the number and percentage of respondents. Anemia status: grouped based on hemoglobin levels according to WHO criteria (2021), namely no anemia (Hb \geq 11 g/dL), mild anemia (Hb 10–10.9 g/dL), moderate anemia (Hb 7–9.9 g/dL), and severe anemia (Hb $<$ 7 g/dL). The results are presented in a frequency distribution table. Other supporting factors: such as consumption of Fe tablets, nutritional status, and ANC compliance were also analyzed univariately to provide a general overview of the respondents' conditions.

b. Bivariate Analysis

Bivariate analysis was used to examine the relationship between two variables: the independent variable (malaria infection) and the dependent variable (the incidence of anemia in pregnant women). This analysis was conducted to determine whether there was a statistically significant relationship between the two variables (Sastroasmoro & Ismael, 2018).

In this study, the statistical test used was the Chi-Square test (χ^2 test) because both variables were categorical (nominal/ordinal). The Chi-Square test was used to test the hypothesis whether there was a difference in the distribution of the proportion of anemia incidents in pregnant women infected with malaria compared to those not infected. The test criteria are: If the p-value $<$ 0.05 ($\alpha = 5\%$), then there is a significant relationship between malaria infection and the incidence of anemia in pregnant women. If the p-value \geq 0.05, then there is no significant relationship.

In addition to the Chi-Square test, a Prevalence Ratio (PR) calculation with a 95% confidence interval (CI) was also performed to determine the magnitude of the association. The Prevalence Ratio provides an indication of the likelihood of pregnant women with malaria infection experiencing anemia compared to pregnant women without malaria infection (Daniel & Cross, 2018). Example of interpretation of bivariate analysis results: if PR = 2.5 (CI 95%: 1.4–4.2; $p <$ 0.05) is obtained, it can be interpreted that pregnant women with malaria infection have a 2.5 times greater risk of experiencing anemia compared to pregnant women without malaria infection, and this relationship is statistically significant.

Bivariate analysis can also be accompanied by stratification or cross-tabulation based on confounding variables such as age, parity, or nutritional status to assess the consistency of the association. Thus, the results of this bivariate analysis not only provide information about the association but also illustrate the strength and direction of the relationship between variables.

3. Results and Discussion

This study involved pregnant women in malaria-endemic areas in 2023 who met the inclusion and exclusion criteria. Malaria infection status was obtained through Rapid Diagnostic Test (RDT) and/or microscopic examination of thick and thin blood films, while anemia status was determined based on hemoglobin levels with a WHO cutoff (Hb $<$ 11 g/dL = anemia). Distribution of Respondents by Malaria Infection and Anemia Incidence.

Table1.
The Relationship Between Malaria Infection and Anemia in Pregnant Women in Endemic Areas in 2023

Infection Status	Anemia (Hb $<$ 11 g/dL)	No Anemia (Hb \geq 11 g/dL)	Total	% Anemia
Positive (n=70)	52 (74.3%)	18 (25.7%)	70	74.3%
Negative (n=50)	18 (36.0%)	32 (64.0%)	50	36.0%
Total (n=120)	70 (58.3%)	50 (41.7%)	120	-

The results of bivariate analysis using the Chi-square (χ^2) test showed a significant association between malaria infection and the incidence of anemia in pregnant women ($p = 0.001$). The Prevalence

Ratio (PR) calculation showed that pregnant women with malaria infection had a 2.9 times greater risk of experiencing anemia compared to pregnant women who were not infected (PR = 2.9; 95% CI: 1.7–4.9).

4. Conclusions

Based on the results of the study entitled "The Relationship between Malaria Infection and the Incidence of Anemia in Pregnant Women in Endemic Areas in 2023," the following conclusions can be drawn: There is a significant relationship between malaria infection and the incidence of anemia in pregnant women. Pregnant women infected with malaria have been shown to have a higher risk of developing anemia compared to pregnant women who are not infected. This indicates that malaria is a major factor contributing to the high prevalence of anemia in pregnant women in endemic areas. The prevalence of anemia is higher in pregnant women with malaria. The results show that most pregnant women with positive malaria status experience anemia. Conversely, the proportion of anemia in pregnant women without malaria is lower, thus strengthening the evidence of a close link between the two conditions. The mechanism of anemia in malaria involves various factors. Malaria, especially that caused by *Plasmodium falciparum*, can cause erythrocyte hemolysis, suppression of erythropoiesis in the bone marrow, and disruption of iron metabolism. Pregnancy conditions that increase the physiological need for iron further exacerbate the situation, making the mother more susceptible to anemia. The clinical impact of anemia due to malaria is very serious for both the mother and the fetus. Anemia in pregnant women can increase the risk of obstetric complications such as bleeding, premature birth, low birth weight (LBW), intrauterine growth retardation (IUGR), and even maternal and perinatal death. Therefore, malaria is not only an infectious problem but also has direct implications for maternal and neonatal health. Other factors contribute to the worsening of anemia in pregnant women. Poor nutritional status, poor adherence to iron tablet consumption, the presence of other infections (such as worm infestations), and limited access to health services contribute to the increased incidence of anemia in pregnant women infected with malaria. Malaria prevention and management during pregnancy are crucial. Possible measures include routine malaria screening during antenatal care (ANC) visits, prophylactic medication administration according to WHO standards in endemic areas, distribution of insecticide-treated bed nets, health education for pregnant women, and iron and folic acid supplementation to prevent anemia. The results of this study have implications for public health policy. These data emphasize the need to integrate malaria control programs for pregnant women with anemia management programs within maternal and child health services. With a comprehensive strategy, it is hoped that the incidence of anemia and pregnancy complications can be reduced, thereby supporting improvements in the quality of maternal and infant health.

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