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Sahli's Method and Reality: Revealing Weaknesses in Determining Hemoglobin Levels in Pregnant Women

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Abstract

Background: Anemia among pregnant women remains a significant health concern, increasing the risk of maternal and perinatal complications. Accurate hemoglobin (Hb) testing is therefore critical in antenatal care. This study analyzed the incidence of anemia and assessed the agreement between Hb measurements obtained using the Sahli Method and those from a Hematology Analyzer among third-trimester pregnant women in Makassar City

Methods: An analytical, observational, cross-sectional design was employed, involving 112 purposively sampled pregnant women. Hb levels were measured using both the Sahli Method and the Hematology Analyzer, the latter serving as the reference standard.

Results: indicated that 70 participants (62.5%) were classified as anemic, while 42 participants (37.5%) exhibited discrepancies in Sahli Method results. The mean Hb level measured by the Sahli Method was 10.8 g/dL, compared to 11.6 g/dL by the Hematology Analyzer, with a mean difference of 0.8 g/dL, which was statistically significant ($p<0.05$). Although a strong correlation was observed between the two methods, the Sahli Method's inaccuracy may result in misdiagnosis.

Conclusion: The findings suggest that the Sahli Method is suboptimal for definitive anemia diagnosis in pregnant women and should be supplemented by more accurate testing to ensure appropriate clinical interventions.

Keywords: Anemia, Hemoglobin, Pregnant

BACKGROUND

Anemia during pregnancy remains a significant health problem both globally and nationally. According to a 2023 World Health Organization report, the prevalence of anemia in pregnant women aged 15–49 years reached over 35.5%. The latest 2024 data from Zhou Y's research (1) show an increase in anemia prevalence to approximately 38.2%. In Indonesia, the prevalence of anemia among pregnant women in 2023 remained at around 27.7%. At the regional level, such as in Makassar City, several healthcare facilities still have a high prevalence of anemia. Initial studies at several community health centers and specialized hospitals in the Makassar area recorded an anemia prevalence of 28.2% in 2023 (2,3).

Anemia in pregnancy is defined as a condition where hemoglobin levels are below normal for gestational age. Hemoglobin functions as an oxygen carrier in the blood, so decreased levels can disrupt oxygen distribution to maternal and fetal tissues. This condition increases the risk of complications such as premature birth, postpartum hemorrhage, and even maternal death. In the fetus, anemia can cause low birth weight, intrauterine growth restriction, asphyxia, and even perinatal death. Therefore, anemia during pregnancy has serious implications for maternal health and the quality of future generations (4,5).

Anemia prevention efforts can be achieved through early detection, with hemoglobin level testing as part of routine antenatal care. In primary healthcare facilities, the Sahli method remains widely used due to its practicality, low cost, lack of electricity requirements, and ease of implementation in resource-limited areas. Furthermore, test results can be obtained quickly, enhancing service efficiency (6).

The Sahli Hb method is still used in several primary health care facilities, including the Antang Community Health Center and the Tamalanrea Community Health Center in Makassar City, especially when automated testing equipment is limited or standard method reagents are unavailable. This method was chosen because it is simple, low-cost, and easy to use in primary care and field screening activities, although it has limitations in classifying anemia based on comparative results due to the subjectivity of color readings. This condition indicates that the use of Sahli Hb is often an adaptation to the limitations of the health care system, which may affect the accuracy of anemia diagnosis and, therefore, warrants further study.

The Sahli method has limitations in classifying anemia based on comparative results. Several studies have shown that results obtained with this method tend to be lower than those from standard methods. This difference may be due to subjectivity in color readings, reagent quality, and lighting conditions during the examination. Inaccurate results can have clinical consequences, including missed anemia detection or misdiagnosis leading to inappropriate therapy (7).

This study specifically evaluates the performance of the Sahli method for assessing hemoglobin levels in pregnant women and analyzes its implications for anemia classification based on comparative anemia detection results in maternal health services. Unlike previous descriptive studies, this study provides scientific contributions in the form of empirical evidence regarding the relevance of using the Sahli method in primary care, particularly in identifying potential measurement bias and its impact on clinical decision-making.

METHODS

Study Design

This study used an observational, analytical design with a cross-sectional approach to assess risk factors for anemia in pregnant women in the third trimester and to compare hemoglobin test results obtained by the Sahli method with those from a hematology analyzer as a standard reference. The study was conducted at several healthcare facilities in Makassar City, including six community health centers and four maternal and children's hospitals.

Sample/Participants

The study population comprised all third-trimester pregnant women undergoing antenatal care during the study period, with a hemoglobin (Hb) level of <11 g/dL as the diagnostic threshold for anemia according to clinical standards. The sample size was calculated using a proportion estimation formula with a 95% confidence level, yielding a minimum sample size of 120 respondents. However, only 112 respondents met the inclusion and exclusion criteria and were included in the analysis. This difference was primarily due to the presence of subjects who did not meet the exclusion criteria: no MCV data were available, or MCV levels were in the range of 80–100 fL and thus were excluded from the analysis.

The sampling technique used was purposive, selecting subjects based on characteristics relevant to the research objectives. Inclusion criteria included pregnant women in their third trimester with anemia (Hb <11 g/dL), both primiparous and multiparous, with an MCV level <80 fL, in good health, and willing to participate in all research procedures. Exclusion criteria included pregnant women with anemia who did not have MCV level data or had an MCV level of 80–100 fL.

Data Collection

Hemoglobin level examinations in this study were conducted by trained and competent laboratory analysts. All examination procedures were carried out at the Wahidin Sudirohusodo General Hospital Laboratory in 2023, in accordance with applicable standard operating procedures (SOPs) to ensure classification as anemia based on the comparison and reliability of test results.

The data used were primary data obtained through interviews and hemoglobin level tests. Hb tests were performed using the Sahli method and then compared with results from a hematology analyzer. Independent variables included maternal risk factors such as parity, pregnancy spacing, age, and history of bleeding. The dependent variables were the incidence of anemia and the level of test result concordance.

Data Analysis

Data analysis was performed using SPSS, with a descriptive approach to characterize the respondents. Bivariate analysis used the chi-square test, while comparisons of mean hemoglobin levels were performed using correlation tests and mean difference tests. A p-value <0.05 was considered statistically significant.

Ethical Considerations

This study has obtained ethical approval, and all respondents provided informed consent. This study has obtained ethical approval from the Health Research Ethics Committee (No. 12457/UN4.6.8/TP/01/02/2021). All respondents provided written consent prior to the study.

RESULT AND DISCUSSION

RESULT

Characteristics of respondents

Table 1 indicates that 62.5% of respondents experienced anemia. The prevalence of anemia was higher among individuals with high-risk parity (66.7%) compared to those with low-risk parity (62.2%), although this difference was not statistically significant (ρ=0.828; OR=0.212). Among those with birth intervals of less than two years, the proportion with anemia was 78.9%, compared to 59.1% in those with intervals of two years or more or in primigravida; this difference was also not statistically significant (ρ=0.104; OR=0.789). In contrast, age demonstrated a significant association, with 90.9%

of individuals in high-risk age groups (<20 and >35 years) experiencing anemia, compared to 50.6% in the 20–35 years group (ρ=0.000; OR=2.749). A history of bleeding was associated with a higher proportion of anemia (100% versus 60.8%), but this difference did not reach statistical significance (ρ=0.076; OR=1.414). Therefore, only age was significantly associated with anemia incidence.

Table 1. Characteristics of respondents

No	Risk Factors		Anemia Incident				Mark	
			Anemia		No Anemia			
			n	%	n	%	*ρ*	OR
1	Parity**	High risk (≥ 4 times)	4	66.7	2	33.3	0.828	0.212
		Low risk (< 4 times)	66	62.2	40	37.8		
2	Birth Interval*	< 2 years	15	78.9	4	21.1	0.104	0.789
		≥ 2 years/ First time pregnant	55	59.1	38	40.8		
3	Age*	High risk (< 20 and > 35 years)	30	90.9	3	9.09	0,000	2,749
		Low risk (20-35 years)	40	50.6	39	49.4		
4	Bleeding History**	Once	5	100	0	0	0.076	1,414
		Never	65	60.8	42	39.2		
Total			70	62.5	42	37.5		

Based on Table 2, the study included 112 respondents across various health facilities, including community health centers and maternal and child hospitals (RSIA/RSKIA). The largest distribution was at ST Hospital with 25 respondents (22.3%). Followed by M Hospital with 18 respondents (16.1%) and Y Community Health Center with 16 respondents (14.3%). D Health Center also contributed 14 respondents (12.5%). A Health Center (8 respondents, 7.1%) and P Health Center (6 respondents, 5.3%) had relatively small sample sizes. F Hospital contributed only 5 respondents (4.5%), while R Health Center had the fewest, with 2 respondents (1.7%).

Table 2. Distribution of pregnant women in the Makassar City area

No	Health Facilities	Sample	
		f	%
1	X Community Health Center	9	8
2	Y Community Health Center	16	14.3
3	A Community Health Center	8	7.1
4	P Community Health Center	6	5.3
5	D Health Center	14	12.5
6	R Community Health Center	2	1.7
7	ST Maternity Hospital	25	22.3
8	M Maternity Hospital	18	16.1
9	P Hospital	9	8
10	F Hospital	5	4.5
Total		112	100

Table 3 presents the distribution of respondents, indicating that most participants were from St. Women's and Children's Hospital, followed by M Women's and Children's Hospital (RSIA) and T Community Health Center (Puskesmas). Method comparison revealed that the Sahli method achieved an accuracy of 62.5%, whereas 37.5% of results did not align with those obtained with the Hematology Analyzer.

Table 3. Distribution Of Anemia Incidence in Pregnant Women in the Third Trimester

No.	Health Facilities	Anemia Incident			
		In accordance (Anemia)		It is not in accordance with (Not Anemic)	
		f	%	f	%
1	M Community Health Center	4	5.7	5	11.9
2	T Community Health Center	9	12.8	7	16.7
3	ACommunity Health Center	2	2.8	6	14.3
4	P Community Health Center	1	1.4	5	11.9
5	D Community Health Center	3	4.3	11	26.2
6	R Community Health Center	0	0	2	4.7
7	St Maternity Hospital	21	30	4	9.5
8	M Maternity Hospital	18	25.7	0	0
9	P Hospital	8	11.4	1	2.4
10	F Maternity Hospital	4	5.7	1	2.4
	Total	70	100	42	100

Table 4. Analysis of Average Hemoglobin (Hb) Levels in Pregnant Women in The Third Trimester

Method	Average Hb (g/dL)	Elementary School	Mean Difference (g/dL)	p-value	r value
Sahli	10.8	1.2		0.001	0.72
Reality	11.6	1.1	0.8		

The analysis in Table 4 shows that two types of statistical tests were used in this study. The first test is a paired t-test, used to compare mean hemoglobin (Hb) levels between the Sahli method and the reference method (Reality) within the same subjects. The variable analyzed in this test is the numerical Hb level from both measurement methods. A p-value of 0.001 indicates a statistically significant difference in the mean.

The Pearson correlation test was used to assess the relationship between Hb test results obtained by the Sahli method and those obtained by the reference method. The variables analyzed were the Hb values from each method. A correlation coefficient (r) of 0.72 indicated a strong positive relationship between the two methods. An increase in Hb values using the Sahli method tended to be followed by an increase in Hb values using the reference method.

DISCUSSION

In a study of 112 pregnant women in the third trimester with anemia (Hb <11 g/dL), 70 respondents (62.5%) were identified as anemic using the Sahli method, while 42 (37.5%) showed inaccurate test results. This study used an analytical observational design with a cross-sectional approach, in which hemoglobin levels were measured simultaneously using the Sahli method and a Hematology Analyzer as a standard of comparison. This design allows direct evaluation of differences in results between methods at the same measurement time in a population of pregnant women in the third trimester.

The study identified age as the only factor significantly associated with anemia in pregnant women, with high-risk age groups (<20 and >35 years) exhibiting a 2.7-fold greater risk compared to those aged 20–35 years. This association may be attributed to increased iron requirements for ongoing maternal growth in women under 20 years, and to decreased iron reserves and physiological function in women over 35 years. Parity, birth interval, and history of bleeding were not significantly associated with anemia, although higher anemia rates were observed in high-risk groups. This lack of statistical significance may result from uneven sample distribution or the influence of other dominant factors, such as nutritional status, adherence to iron supplementation, and maternal health during pregnancy (8,9). In women under 20 years old, competition for iron between maternal growth and fetal development increases the risk of iron-deficiency anemia. In women aged 35 years and above, reduced physiological function, including diminished iron absorption and nutrient reserves, further increases the risk of anemia. Additionally, comorbidities and previous pregnancies may exacerbate this condition (10, 11).

This finding aligns with previous studies that suggest that extremes of reproductive age are a risk factor for anemia in pregnancy. These results are consistent with previous studies indicating that extremes of reproductive age constitute a risk factor for anemia during pregnancy. Pregnant women at both younger and older ages often exhibit suboptimal nutritional status and an increased risk of pregnancy complications, including anemia. The analysis revealed a mean hemoglobin difference of 0.8 g/dL between the Sahli method and the Hematology Analyzer (p-value = 0.001), demonstrating a statistically significant discrepancy. Although the correlation coefficient (r = 0.72) suggests a strong relationship between the two methods, it does not indicate absolute agreement. In this cross-sectional comparative design, the Sahli method yielded hemoglobin values that differed from the standard, potentially affecting anemia classification. A weakness of this method lies in the subjectivity of color readings, which are highly dependent on the examiner's skill. Other factors, such as lighting, reagent quality, and examination technique, also influence results, increasing the risk of variation between measurements. In this study design, these conditions reinforce the finding that differences in examination methods significantly impact Hb measurement results.

Inaccurate hemoglobin test results obtained with the Sahli method can lead to misclassification of anemia, resulting in both false positives and false negatives. Non-anemic pregnant women may be incorrectly diagnosed and receive unnecessary iron supplementation, while anemic individuals may not receive appropriate treatment. Clinical consequences include gastrointestinal disturbances from iron overload and increased risk of pregnancy complications due to undetected anemia (12,13).

Additional factors, including room lighting, reagent quality, and examination technique, also influence test outcomes. These variables reduce the reliability of the Sahli method, particularly at extremely low or high hemoglobin concentrations. Compared to automated methods, the Sahli method presents a higher risk of technical error (14, 16).

These findings align with Kumar's research, which found that the Sahli method is more suitable for initial screening but not accurate enough for a definitive diagnosis. This inaccuracy can lead to errors in therapy, either by administering unnecessary iron supplements or by not administering therapy to women who are actually anemic. Similarly, Kumar stated that the Sahli method should be confirmed using a more accurate method, such as a hematology analyzer. This is crucial for improving diagnostic accuracy and the effectiveness of health interventions for pregnant women (17-20).

Inaccurate hemoglobin testing using the Sahli method can lead to errors in identifying candidates for iron supplementation. A false positive occurs when a non-anemic pregnant woman is incorrectly diagnosed as anemic, leading to unnecessary high-dose iron supplementation. This may cause digestive disturbances, such as nausea, vomiting, and constipation, as well as iron overload, which can ultimately result in liver, pancreatic, and cardiac damage (21-23).

The above descriThis description is consistent with Fekadie's research, which identified limitations of the Sahli method due to its reliance on observer accuracy. This dependence increases the risk of misdiagnosis, leading to either false positives or false negatives and potentially inappropriate iron supplementation. Similarly, a study by Aringazina at a Central Java Community Health Center reported significant discrepancies between hemoglobin levels measured by the Sahli method and those obtained with a hematology analyzer. As a result, some non-anemic pregnant women were misclassified as anemic, potentially receiving excessive iron therapy (24-28).

Summing that the Sahli Method is still used in some primary care facilities because it is inexpensive and easy to perform. However, its weaknesses in classifying anemia based on comparison results, sensitivity, and dependence on the examiner's condition make it less than ideal for precisely determining anemia status, especially in pregnant women. Sahli test results should be validated using gold-standard methods, such as Cyanmethemoglobin or a Hematology Analyzer. Inaccuracy of the Sahli Method in determining anemia in pregnant women can have serious consequences for both the mother and the fetus, ranging from untreated anemia, pregnancy complications, to impaired fetal growth and development, and an increased risk of mortality. The Sahli Method should be used only for initial screening, while a definitive diagnosis should be validated with a more accurate method, such as a Hematology Analyzer. The inaccuracy of the Sahli Method in determining anemia status results in the mistargeting of nutritional and medical interventions, resulting in some pregnant women being harmed due to over-treatment and others being neglected due to under-treatment. This condition ultimately burdens the health system through increased complications, costs, and wasted resources. Thus, the high proportion of pregnant women with anemia, coupled with the inaccurate results from the Sahli method, demonstrates the need to improve the quality of anemia detection in healthcare facilities. The use of more accurate Hb testing methods, such as Hemocue or automated hematology devices, can help healthcare workers obtain a more accurate picture of a pregnant woman's anemia status (29-31).

CONCLUSION

A study of 112 pregnant women in their third trimester found that the Sahli method identified anemia in 62.5% of respondents, with an inaccuracy rate of 37.5% compared to the Hematology Analyzer as the standard. There was a significant difference in mean Hb levels between the two methods ($p = 0.001$), with a strong correlation ($r = 0.72$), but no absolute agreement. The age of the pregnant woman was shown to be significantly associated with the incidence of anemia ($p = 0.000$), where high-risk age groups (<20 years and >35 years) had a greater proportion of anemia. These findings indicate that the Sahli method has limitations in Hb measurement accuracy and the potential to misclassify anemia, so its use is more appropriate as an initial screening and should be confirmed with a more accurate method.

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AUTHOR'S CONTRIBUTION STATEMENT

IJ Conceptualization, Writing the Original Draft, Review & Editing.MILS: Conceptualization, Methodology, Manuscript Review. YS: Supervision. YEDG.: Formal Analysis, Writing the Original Draft, Manuscript Review and AADS: Validation, Manuscript Review.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

AI-assisted technologies were used solely for language refinement/translation support. All text was reviewed and edited by the authors, who remain responsible for accuracy, originality, and appropriate citation.

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