

Original Research**Development of a Toddler Anemia Classification Tool Based on Palm Pallor****Nur Djanah^{1*}, Yuliantisari Retnaningsih¹**¹ Department of Midwifery Poltekkes Kemenkes Yogyakarta, Indonesia**ABSTRACT**

Background: Nutritional anemia in toddlers remains a significant public health problem in Indonesia, affecting growth, development, and immunity. Palm pallor assessment has been proposed as a simple screening method in settings with limited laboratory access. This study aimed to develop and evaluate a palm pallor-based classification tool compared with hemoglobin measurement using the cyanmethemoglobin method.

Methods: A cross-sectional study was conducted among 36 toddlers aged 6–57 months at a public health center in Bantul. Data were collected through visual assessment of palm pallor and laboratory hemoglobin measurement. Diagnostic performance was evaluated using sensitivity, specificity, false positive, and false negative rates. Bivariate analysis was performed using Fisher's Exact Test.

Results: The sensitivity value based on the calculation of the results is 68.97%, while the specificity value is 71.43%. False positive values were obtained at 28.57%, while false negative values were at 31.03%. A statistically significant association was found between palm pallor and anemia status ($p = 0.001$).

Conclusion: Palm pallor assessment can be used as a simple and practical screening tool for detecting anemia in toddlers, particularly in low-resource settings. However, due to its moderate diagnostic accuracy, it should be complemented with confirmatory laboratory testing. Further studies are needed to improve its accuracy and validate its use in larger populations.

ARTICLE HISTORY

Received: September 28, 2025

Accepted: April 10, 2026

KEYWORDS

anemia screening; child anemia; pallor of the palms; validity of the anemia classification tool

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Cite this as: Djanah, N., & Retnaningsih, Y. (2026). Development of Toddler Anemia Classification Tool by Seeing Paleness of The Palms. *Interest: Jurnal Ilmu Kesehatan*, 15(1), 11-19. <https://doi.org/10.37341/interest.v15i1.571>

INTRODUCTION

Children represent a critical population group for ensuring optimal growth, development, and future human capital. However, anemia remains one of the most prevalent global public health problems, particularly among infants and young children. It is characterized by a reduced hemoglobin concentration that impairs oxygen transport and affects multiple physiological functions. Anemia in early childhood is associated with impaired cognitive development, decreased immunity, and increased risk of morbidity and mortality (Chaber et al., 2024; Gallagher, 2022; Sant-Rayn Pasricha, 2020).

Globally, anemia affects a substantial proportion of children under five years of age, with higher prevalence in low- and middle-income countries. In Indonesia, anemia continues to be a major public health concern, with uneven distribution across regions and influenced by various socioeconomic, environmental, and nutritional factors (Azmeraw et al., 2023; Mboya et al., 2020; Priliani et al., 2025). Anemia is not a single disease entity but represents a manifestation of various underlying pathological conditions, making early detection and appropriate classification essential for effective intervention (Newhall et al., 2020). These findings highlight the need for effective strategies for early detection and prevention of anemia, particularly in vulnerable populations such as toddlers.

Iron deficiency is recognized as the most common cause of anemia in children, resulting from inadequate dietary intake, poor absorption, or increased physiological requirements. In addition to iron deficiency, anemia may also be associated with inflammation, infections, and other underlying pathological conditions (Kulik-Rechberger & Dubel, 2024). Therefore, early identification and proper classification of anemia are essential for effective intervention and management.

Nutritional factors, particularly dietary patterns, play a significant role in determining hemoglobin levels in children. Previous studies have demonstrated that inadequate dietary intake is strongly associated with lower hemoglobin levels in preschool children (Rosalinna & Sugita, 2020). This underscores the importance of early screening and intervention strategies that not only detect anemia but also address its underlying causes.

The diagnosis of anemia is ideally confirmed through laboratory measurement of hemoglobin levels, with methods such as the cyanmethemoglobin technique considered the gold standard. However, access to laboratory testing remains limited in many primary healthcare and low-resource settings due to constraints in cost, infrastructure, and availability of equipment (Rebecca Brehm et al., 2023). As a result, alternative screening approaches that are simple, rapid, and cost-effective are needed to facilitate early detection.

Clinical examination, particularly the assessment of pallor, is widely used as a practical screening method for anemia in community settings. Pallor can be observed at various anatomical sites, including the conjunctiva, nail beds, tongue, and palms (K. et al., 2020). However, the diagnostic accuracy of pallor assessment varies considerably and is influenced by observer experience, lighting conditions, and skin pigmentation (Divyakrishnan et al., 2020), which may lead to inconsistent classification outcomes. In addition, longitudinal evidence suggests that hemoglobin levels in young children fluctuate over time due to nutritional status, infection, and growth patterns, indicating the need for continuous monitoring and appropriate screening strategies (Alberto Guevaro Tirado, 2026).

Public health approaches such as Integrated Management of Childhood Illness (IMCI/MTBS) also emphasize early recognition of clinical signs, including pallor, as part of routine child health assessments (Kemenkes, 2024). The diagnosis of anemia is ideally confirmed through laboratory measurement of hemoglobin levels. However, access to laboratory facilities remains limited in many primary healthcare and low-resource settings. As a result, clinical examination, particularly the assessment of pallor, is widely used as a practical screening approach. Pallor can be assessed at several anatomical sites, including the conjunctiva, tongue, nail beds, and palms, and remains a key component of physical examination for anemia detection (Nurul Huda et al., 2024).

Recent advancements have explored alternative approaches, including image-based detection and digital tools for anemia screening. For example, studies have demonstrated the potential of facial image analysis in predicting anemia, offering a more objective and technology-assisted approach (Aixian Zhang et al, 2022). However, these methods may not yet be feasible for widespread use in low-resource community settings due to technological and infrastructural limitations.

Despite the growing body of research on anemia detection, most existing studies focus on diagnostic accuracy rather than the development of simple, structured, and standardized classification tools that can be applied in real-world community settings. Furthermore, the integration of clinical assessment with practical implementation strategies remains limited, particularly for toddlers in primary healthcare contexts. To date, there is no standardized classification tool that translates visual assessment of palm pallor into an objective and validated method for diagnosing anemia in toddlers. Existing approaches rely heavily on subjective judgment and have not been consistently validated against laboratory gold standards, limiting their reliability and applicability in public health settings.

This study addresses this gap by developing a palm pallor-based classification tool and validating it against hemoglobin measurement using the cyanmethemoglobin method. The novelty of this research lies in transforming a subjective clinical sign into a structured, practical, and measurable screening tool, which has the potential to improve early detection of anemia among toddlers, particularly in resource-limited settings. Furthermore, this study contributes empirical evidence supporting the integration of simple clinical observations into community-based screening programmes to enhance efforts towards the early detection and prevention of anaemia.

MATERIALS AND METHOD

This study employed a descriptive cross-sectional design combined with laboratory validation. The cross-sectional approach was selected because it allows simultaneous assessment of clinical signs and laboratory measurements to evaluate the diagnostic performance of a screening tool in a specific population at a single point in time. Penelitian ini menggunakan desain deskriptif cross-sectional yang dikombinasikan dengan validasi laboratorium. A cross-sectional approach was chosen because it allows for the simultaneous assessment of clinical symptoms and laboratory results to evaluate the diagnostic performance of a screening tool in a specific population at a specific point in time.

The study was conducted at one of the public health centers in Yogyakarta City Indonesia. The study population consisted of children aged 6–59 months who attended the health center during the study period. A total of 36 children were included in this study. The sample size was determined based on feasibility considerations and the availability of eligible participants during the study period.

A purposive sampling technique was used to select participants. The inclusion criteria were: (1) children aged 6–59 months; and (2) whose parents or guardians provided informed consent. The exclusion criteria included: (1) children with severe illness requiring emergency treatment; (2) children with known hematologic disorders other than nutritional anemia; and (3) incomplete data. This sampling approach ensures that participants are appropriate for the research objectives and are representative of the young children who should undergo anaemia screening at primary healthcare facilities.

Data collection was conducted through direct clinical examination and laboratory testing. The primary data included assessment of palm pallor and measurement of hemoglobin levels. The palm pallor assessment was performed by comparing the color of the child's palm with the examiner's palm under adequate lighting conditions. Hemoglobin levels were measured using the cyanmethemoglobin method, which served as the gold standard for anemia diagnosis.

The research instrument consisted of a classification tool developed to assess anemia based on palm pallor. The feasibility and usability of the tool were evaluated by health professionals. The validity of the tool was assessed by comparing its classification results with hemoglobin measurements. Diagnostic accuracy indicators, including sensitivity, specificity, false positive rate, and false negative rate, were calculated to evaluate the performance of the tool.

Data analysis was performed using both univariate and bivariate approaches. Univariate analysis was used to describe the characteristics of the study population and the distribution of anemia status. Bivariate analysis was performed to assess the association between palm pallor classification and anemia status. Because the data were categorical in a 2×2 table and one expected cell count was less than 5, Fisher's Exact Test was used.

This study was approved by the Bantul Health Office (No. 070/2887, dated 25 April 2022) and received ethical clearance from the Yogyakarta Ministry of Health Polytechnic (No. e-KEPK/POLKESYO/0373/IV/2022, dated 5 April 2022). Written informed consent was obtained from the parents or guardians of all participants prior to data collection. All research procedures were carried out in accordance with the principles of research ethics in human subjects, ensuring data confidentiality, participant safety and voluntary participation.

RESULTS

The age of the toddler, gender, hemoglobin level, anemia status, and the child's pale palm color were among the features of the responders. The frequency distribution of responders is displayed in the following table:

Table 1. Toddler Characteristics Based on Age, Gender, Anemia Incidence, and Pale Palm Color (n = 36)

Characteristics	Frequency (n=36)	Percentage (%)
Age		
Toddler < 12 months (person)	5	14
Toddler > 12 months (person)	31	86
Gender		
male (person)	21	58
female (person)	15	42
Anemia Rate		
Anemia: <11 g/dl	29	80.56
No Anemia: >11 g/dl	7	19.44
Paleness of the Palms		
Pale	22	61.11
Not Pale	14	38.89

Characteristics of the respondents: the majority of toddlers were aged over 12 months, totalling 31 children (86%). By gender, the majority of respondents were male, totalling 21 children (58%). The anaemia status indicated that the majority of toddlers were anaemic (<11 g/dl), totalling 29 children (80.56%). Meanwhile, based on an examination of the paleness of the palms, the majority of toddlers exhibited paleness, totalling 22 children (61.11%).

Table 2. Characteristics of Toddlers Examined Based on Age and Hemoglobin Concentration Levels (n = 36)

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
Age (Month)	29.22	27	15.05	6	57
Rate Concentration Hemoglobin	9.65	9.55	1.71	6.5	14.4

Based on the findings of a study, 36 toddlers, with a minimum age of 6 months and a maximum age of 57 months, shown in Tables 1 and 2. 86% of children under five are older than 12 months. The range of hemoglobin concentrations was 6.5 g/dl at the lowest and 14.4 g/dl at the highest, with an average of 9.65 g/dl and a standard deviation of 1.71. Most toddlers (80.56%) have anemia, which is evident in the majority of the pale palms (61.11%).

Table 3. Validation of the Toddler Palm Paleness Classification Tool

Palm color classification tool	Cyanmethemoglobine HB Examination		Total
	Anemia (Hb <11 g/dl)	Not Anemia (Hgb >11 g/dl)	
Pale	20	2	22
Not pale	9	5	14
Total	29	7	36

Note:

Sensitivity= $a / (a+c) \times 100\% = 20 / (20+9) \times 100\% = 68.97\%$

Specificity= $d / (b+d) \times 100\% = 5 / (2+5) \times 100\% = 71.43\%$

False negative= $c / (a+c) \times 100\% = 9 / (20+9) \times 100\% = 31.03\%$

False positives= $b / (b+d) \times 100\% = 2 / (2+5) \times 100\% = 28.57\%$

Based on Table 3, the diagnostic performance of the tool for classifying pale palms was calculated. The tool's sensitivity was 68.97%, indicating its ability to identify infants with anaemia. Its specificity was 71.43%, indicating its ability to identify infants without anaemia. The false negative rate was 31.03%, whilst the false positive rate was 28.57%.

Table 4. Bivariate Analysis of Palm Pallor and Anemia Status in Toddlers (n = 36)

Palm pallor classification	Anemia (Hb <11 g/dL), n (%)	Not anemia (Hb ≥11 g/dL), n (%)	Total, n (%)	p-value*
Pale	20 (90.9)	2 (9.1)	22 (100)	0.001
Not pale	9 (64.3)	5 (35.7)	14 (100)	

Palm pallor classification	Anemia (Hb <11 g/dL), n (%)	Not anemia (Hb ≥11 g/dL), n (%)	Total, n (%)	p-value*
Total	29 (80.6)	7 (19.4)	36 (100)	

Note: * Fisher's Exact Test

Bivariate analysis using Fisher's Exact Test showed a significant association between palm pallor classification and anemia status in toddlers ($p = 0.001$). Toddlers with pale palms were more frequently classified as anemic than those without pale palms. These findings suggest that the examination of the palmar pallor can be used as an early clinical indicator in the screening for anaemia in young children in primary healthcare settings.

DISCUSSION

The findings of this study indicate that the palm pallor-based classification tool has moderate diagnostic performance, with a sensitivity of 68.97% and specificity of 71.43%. These results suggest that the tool is capable of identifying a substantial proportion of anemia cases, although some degree of misclassification remains inevitable. Furthermore, the significant association between palm pallor and anemia status strengthens the evidence that palm pallor can be used as a reliable initial screening indicator.

The use of clinical pallor as a screening method has been widely discussed in previous studies. Pallor assessment is considered a practical and accessible approach, particularly in low-resource settings where laboratory testing is limited. Therefore, a more structured assessment standard is required to reduce variations in subjectivity between examiners. Furthermore, training healthcare professionals in appropriate clinical observation techniques can improve the consistency and accuracy of early anaemia detection (Divyakrishnan et al., 2020; K. et al., 2020). However, its diagnostic accuracy varies due to subjectivity in visual interpretation, which is consistent with the findings of this study.

From a clinical perspective, anemia particularly iron deficiency anemia affects hemoglobin production and oxygen transport, leading to various adverse health outcomes in children. Early detection is therefore essential to prevent complications and support optimal child development. Early detection enables faster nutritional interventions and treatment, thereby minimising the risk of growth and developmental disorders. Furthermore, simple screening at the primary healthcare level can help to increase the detection rate of anaemia in under-fives more widely (Kulik-Rechberger & Dubel, 2024; Sant-Rayn Pasricha, 2020).

In addition, nutritional factors play a critical role in the occurrence of anemia. Dietary patterns have been shown to significantly influence hemoglobin levels in children, highlighting the importance of combining screening strategies with nutritional interventions (Rosalinna & Sugita, 2020). Variations in anemia prevalence across populations further indicate that contextual factors such as geography, socioeconomic conditions, and healthcare access influence anemia burden. This supports the need for adaptable and context-appropriate screening tools. Therefore, approaches to preventing anaemia must take local community conditions into account to ensure that interventions are more effective and sustainable. It is hoped that integrating simple clinical screening with nutrition education at the community level will optimally reduce the prevalence of anaemia among young children (Priliani et al., 2025).

The presence of false positive (28.57%) and false negative (31.03%) results in this study reflect the limitations of non-invasive screening methods. Similar findings have been reported in studies evaluating simplified anemia detection approaches, where trade-offs between practicality and accuracy are unavoidable. Nevertheless, simple screening methods remain valuable as an initial step in identifying cases within the community. The use of these methods should be followed by further laboratory tests to ensure a more accurate diagnosis of anaemia (Jack Ferguson et al., 2021; Rebecca Brehm et al., 2023).

The results of this study have important implications for public health practice. The palm pallor classification tool offers a simple, low-cost, and non-invasive screening method that can be implemented in primary healthcare and community settings. This tool is particularly useful in areas with limited access to laboratory facilities, where early detection of anemia is often challenging. By enabling early identification of suspected cases, this tool can support timely referral and intervention, contributing to improved child health outcomes.

This study has several limitations that should be considered. First, the small sample size ($n = 36$) limits the generalizability of the findings. Second, the use of purposive sampling may introduce selection bias. Third, reliance on visual assessment of pallor introduces subjectivity, which may affect reliability and interobserver consistency, as also reported in previous pallor studies (Interobserver Agreement of Pallor, 2020). These limitations may influence the interpretation of diagnostic accuracy and should be considered when applying the findings.

Future studies should include larger and more diverse populations to improve generalizability. Longitudinal study designs are recommended to assess the long-term predictive value of pallor-based screening. In addition, the development of objective and technology-assisted approaches, such as image-based anemia detection (Prediction of Anemia Using Facial Images, 2020), may help reduce subjectivity and improve accuracy. Further comparative studies are also needed to evaluate the effectiveness of different screening methods in various healthcare settings.

CONCLUSION

This study demonstrated that the palm pallor-based classification tool has moderate diagnostic performance for detecting anemia in toddlers, with a sensitivity of 68.97% and specificity of 71.43%, as well as false negative and false positive rates of 31.03% and 28.57%, respectively. Bivariate analysis further revealed a statistically significant association between palm pallor and anemia status, reinforcing the validity of palm pallor as an initial screening indicator. From a practical perspective, this tool offers a simple, affordable, non-invasive, and easy-to-use approach that can be implemented in primary healthcare and community settings, particularly in areas with limited access to laboratory facilities. Its application may support early detection and timely referral of anemia cases in children. However, due to its moderate accuracy, this tool should be used as a screening method rather than a definitive diagnostic tool. Therefore, confirmatory laboratory testing remains necessary to ensure accurate diagnosis.

ACKNOWLEDGMENT

Researchers, thank you to the various parties who contributed to this research including material experts, media experts, heads of public health center, midwives, families, research subjects, and those who assisted the research.

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