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Associations of Nutritional Status and Soil-Transmitted Helminth Infection with Anemia Among Vegetable Farmers in Gowa District, South Sulawesi

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ABSTRACT

Introduction: Anemia is a major public health concern that may reduce health, well-being, and work productivity. Vegetable farmers are potentially vulnerable to anemia because of nutritional inadequacy and frequent occupational exposure to soil, which may increase the risk of Soil-Transmitted Helminth (STH) infection. This study aimed to examine the associations of nutritional status and STH infection with anemia among vegetable farmers in Kanreapia Village, Gowa District, Indonesia.

Methods: This cross-sectional study involved 90 vegetable farmers selected proportionally from a population of 1,437 farmers. Nutritional status was assessed using body mass index (BMI), STH infection was identified through stool examination using the Kato–Katz technique, and hemoglobin concentration was measured using a portable hemoglobin meter. Anemia was classified using sex-specific hemoglobin thresholds. Associations between the study variables and anemia were assessed using appropriate exact tests, with statistical significance defined as $p < 0.05$.

Results: Among the 90 participants, 21 (23.3%) had anemia, 6 (6.7%) tested positive for STH infection, and 14 (15.6%) were underweight. No statistically significant association was observed between STH infection and anemia ($p = 1.000$). However, the small number of STH-positive participants limited the statistical power to detect a potentially meaningful association. Nutritional status was significantly associated with anemia ($p = 0.016$).

Conclusion: Nutritional status was significantly associated with anemia among vegetable farmers. In contrast, the evidence regarding the association between STH infection and anemia remains inconclusive because of the small number of infected participants and limited statistical power. Nutritional assessment and anemia screening should be integrated into occupational health programs for agricultural workers, while preventive measures against STH infection should remain part of comprehensive health promotion strategies.

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INTRODUCTION

Anemia remains one of the most prevalent public health problems worldwide, affecting more than 1.9 billion people and imposing substantial health, social, and economic burdens. Despite considerable progress in nutrition and disease control, anemia continues to disproportionately affect populations in low- and middle-income countries, where nutritional deficiencies, infectious diseases, and adverse environmental conditions frequently coexist. Iron deficiency remains the leading cause of anemia globally; however, anemia is increasingly recognized as a multifactorial condition influenced by micronutrient deficiencies, chronic inflammation, parasitic infections, chronic diseases, and socioeconomic inequalities. Beyond its clinical consequences, anemia reduces physical work capacity, cognitive performance, immune function, and overall productivity, thereby limiting individual well-being and national economic development (World Health Organization [WHO], 2025; Lee et al., 2025; Garcia-Casal et al., 2023; Hess et al., 2023).

Among working-age adults, anemia represents an important occupational health concern because adequate hemoglobin concentration is essential for oxygen transport, aerobic metabolism, and sustained physical performance. Agricultural workers are particularly vulnerable because their occupations involve prolonged physical labor accompanied by high energy expenditure, while access to nutritionally adequate diets is often limited. Persistent anemia among agricultural workers may reduce work efficiency, increase fatigue, impair concentration, and ultimately decrease agricultural productivity. Consequently, preventing anemia is not only a nutritional priority but also an essential component of occupational health and rural economic development (Christian, 2021; Pasricha et al., 2021; WHO, 2025).

Nutritional status is one of the strongest determinants of anemia because erythropoiesis requires adequate availability of iron, protein, folate, vitamin B12, vitamin A, and other micronutrients. Individuals with poor nutritional status frequently experience deficiencies in these nutrients, resulting in impaired hemoglobin synthesis and reduced red blood cell production. Nevertheless, recent evidence indicates that nutritional status should not be interpreted solely through anthropometric measurements, because individuals with normal body mass index may still suffer from micronutrient deficiencies or functional iron deficiency. Current evidence therefore considers anemia as the result of complex interactions among nutritional inadequacy, inflammatory processes, metabolic conditions, and environmental exposures rather than a single nutritional disorder (Pasricha et al., 2021; Garcia-Casal et al., 2023; Hess et al., 2023; Young et al., 2023).

Infectious diseases remain another important contributor to anemia, particularly in tropical and subtropical regions. Among these, soil-transmitted helminth (STH) infection continues to affect more than one billion people worldwide and remains one of the most neglected tropical diseases. The principal STH species, including *Ascaris lumbricoides*, *Trichuris trichiura*, *Necator americanus*, and *Ancylostoma duodenale*, contribute to anemia through multiple biological pathways. Hookworm infection may cause chronic intestinal blood loss leading directly to iron deficiency, whereas *Ascaris* and *Trichuris* infections impair nutrient absorption, reduce appetite, alter intestinal integrity, and induce chronic inflammatory responses that further compromise erythropoiesis. The magnitude of these effects depends on parasite species, infection intensity, duration of infection, and the nutritional status of the host (Jourdan et al., 2018; Caldrer et al., 2022; Ellwanger et al., 2022; WHO, 2023).

Indonesia remains an endemic country for both anemia and STH infection because of its tropical climate, environmental characteristics, and unequal access to sanitation and health services. Individuals engaged in agricultural occupations, particularly vegetable farming, experience repeated occupational exposure to soil that may facilitate helminth transmission through direct skin contact, contaminated hands, or inadequate personal hygiene practices. In addition, vegetable farming requires sustained physical activity, making adequate nutritional status essential for maintaining work capacity. Previous studies conducted in Indonesia have reported inconsistent findings regarding the relationship between STH infection, nutritional status, and anemia. Some investigations identified poor nutritional status as the dominant determinant of

anemia, whereas others suggested that STH infection contributes indirectly through nutritional impairment. These inconsistencies may reflect differences in environmental conditions, sanitation, infection intensity, dietary patterns, and study populations (Djuardi et al., 2021; Husniar et al., 2022; Nasution et al., 2022; Lubis et al., 2025).

Recent international evidence further suggests that the contribution of STH infection to anemia varies substantially according to transmission intensity and concurrent nutritional deficiencies. In communities where deworming programs, sanitation improvements, and hygiene practices have reduced parasite transmission, nutritional inadequacy may become the predominant determinant of anemia. Conversely, in highly endemic settings, persistent helminth infection may continue to substantially increase anemia risk through chronic blood loss and impaired nutrient utilization. These findings highlight the importance of evaluating nutritional status and STH infection simultaneously rather than considering either factor independently when designing anemia prevention strategies among agricultural workers (Ellwanger et al., 2022; Lubis et al., 2025; Young et al., 2023).

Although numerous studies have investigated anemia among children, pregnant women, and school-aged populations, evidence focusing on adult agricultural workers remains limited. In particular, few studies have simultaneously examined nutritional status and STH infection within the same analytical framework among vegetable farmers, despite their continuous occupational exposure to contaminated soil. Furthermore, evidence from eastern Indonesia remains scarce, limiting the development of context-specific occupational health interventions for farming communities. Understanding the relative contributions of nutritional status and STH infection is therefore essential for developing integrated prevention strategies that combine nutritional improvement, occupational health protection, environmental sanitation, and parasite control.

Kanreapia Village in Gowa District is one of the major vegetable-producing areas in South Sulawesi, where intensive farming activities create frequent opportunities for occupational contact with soil. However, evidence regarding the combined influence of nutritional status and STH infection on anemia among vegetable farmers in this setting remains limited. Addressing this knowledge gap will provide evidence to support integrated nutritional and occupational health programs tailored to agricultural communities. Therefore, this study aimed to examine the associations of nutritional status and soil-transmitted helminth infection with anemia among vegetable farmers in Gowa District, Indonesia.

METHODS

Study Design

This study employed an analytical cross-sectional design to examine the association between Soil-Transmitted Helminth (STH) infection, nutritional status, and anemia among vegetable farmers in Kanreapia Village, Tombolo Pao District, Gowa Regency, South Sulawesi, Indonesia. The study was conducted in September 2024. Kanreapia Village was selected because of its intensive vegetable farming activities, where frequent occupational exposure to soil may increase the risk of STH infection and its potential nutritional and hematological consequences.

Participants

The study population consisted of all registered vegetable farmers residing in Kanreapia Village, totaling 1,437 individuals. Eligible participants were adults aged 18 years or older who had been actively engaged in vegetable farming for at least six months before the study and who provided written informed consent. Individuals were excluded if they were pregnant, had a known hematological disorder or chronic disease that could influence hemoglobin concentration (e.g., chronic kidney disease, malignancy, or inherited blood disorders), had received anthelmintic treatment within the previous three months, or were unable to provide stool or blood samples.

The minimum sample size was calculated using the formula for cross-sectional studies with a 95%

confidence level and a 10% margin of error, yielding a required sample of 90 participants. Participants were selected using proportional sampling according to the number of vegetable farmers in each hamlet to ensure representative distribution across the study area. Recruitment was facilitated through collaboration with village authorities and local agricultural extension officers. All eligible participants received an explanation of the study objectives and procedures before voluntarily agreeing to participate.

Assessment of Nutritional Status, STH Infection, and Anemia

Data collection was performed by trained research personnel using standardized procedures. Nutritional status was assessed using body mass index (BMI), calculated as body weight in kilograms divided by the square of height in meters (kg/m²). Body weight was measured using a calibrated digital scale to the nearest 0.1 kg, while height was measured using a portable stadiometer to the nearest 0.1 cm. Participants were categorized according to the World Health Organization BMI classification as underweight (<18.5 kg/m²), normal weight (18.5–24.9 kg/m²), or overweight (≥25.0 kg/m²).

STH infection was determined through microscopic examination of fresh stool specimens using the Kato–Katz thick smear technique following standard WHO laboratory procedures. Participants were classified as positive if at least one STH egg (including *Ascaris lumbricoides, Trichuris trichiura,* or hookworm species) was identified during examination.

Hemoglobin concentration was measured using the EasyTouch GCHb system (Model ET-321, EasyTouch®, Taiwan) with disposable EasyTouch Hemoglobin Test Strips according to the manufacturer's instructions. Anemia was defined based on the World Health Organization criteria as hemoglobin concentration <13.0 g/dL for adult men and <12.0 g/dL for non-pregnant adult women.

Statistical Analysis

Data were entered, cleaned, and analyzed using IBM SPSS Statistics version XX (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize participant characteristics. Categorical variables were presented as frequencies and percentages.

Associations between independent variables and anemia status were examined using exact statistical tests because of sparse cell counts. Fisher's exact test was used to evaluate the association between STH infection and anemia because of the limited number of STH-positive participants. The association between nutritional status and anemia was analyzed using the Fisher–Freeman–Halton exact test for the 3 × 2 contingency table because several expected cell counts were less than five, including one zero-frequency cell among overweight participants with anemia. Statistical significance was defined as a two-sided p-value <0.05. Given the limited number of STH-positive cases, non-significant findings were interpreted cautiously and were not considered evidence of the absence of a biological association.

Ethical Considerations

The study protocol was reviewed and approved by the Health Research Ethics Committee, Faculty of Medicine and Health Sciences, Universitas Islam Negeri Alauddin Makassar, Indonesia in 2025. Written informed consent was obtained from all participants prior to data collection.

RESULTS

Sample Characteristics

As shown in Table 1, the study included 90 vegetable farmers, equally distributed by sex (45 males and 45 females). Participants aged 41–50 years constituted the largest age group (27.8%). Overall, 21 participants (23.3%) were classified as anemic, 6 (6.7%) tested positive for Soil-Transmitted Helminth (STH) infection, and 14 (15.6%) were underweight, while the majority had normal nutritional status (77.8%).

Tabel 1. Characteristics of the study participants (n = 90)

Characteristics	(n)	(%)
Sex		
Male	45	50.0
Female	45	50.0
Age (years)		
20–30	23	25.6
31–40	18	20.0
41–50	25	27.8
51–60	17	18.9
61–70	7	7.8
Anemia Status		
Anemia	21	23.3
Non-anemia	69	76.7
STH Infection Status		
Positive	6	6.7
Negative	84	93.3
Nutritional Status		
Underweight	14	15.6
Normal	70	77.8
Overweight	6	6.7

Association Between Soil-Transmitted Helminth (STH) Infection and Anemia

Table 2. Association between *soil-transmitted helminth* infection and anemia among vegetable farmers

STH Infection Status	Anemia n (%)	Non-anemia n (%)	Total n (%)	p-value
Positive	1 (4.8)	5 (7.2)	6 (6.7)	1.000
Negative	20 (95.2)	64 (92.8)	84 (93.3)	
Total	21 (23.33)	69 (76.67)	90 (100.0)	

Among the 90 participants, six (6.7%) tested positive for STH infection. One participant with STH infection had anemia, whereas five infected participants were non-anemic. Fisher's exact test showed no statistically significant association between STH infection and anemia (p = 1.000). Given the small number of STH-positive participants, this finding should be interpreted cautiously because the statistical power to detect a meaningful association was limited

Association Between Nutritional Status and Anemia

Table 3. Association between nutritional status and anemia among vegetable farmers

Nutritional Status	Anemia *n (%)*	Non-anemia *n (%)*	Total *n (%)*	p-value
Underweight	7 (33.3)	7 (10.1)	14 (15.6)	0.016
Normal	14 (66.7)	56 (81.2)	70 (77.8)	
Overweight	0 (0.0)	6 (8.7)	6 (6.7)	
Total	21 (23.33)	69 (76.67)	90 (100.0)	

Most participants had normal nutritional status (77.8%), whereas 15.6% were underweight and 6.7% were overweight. Among participants with anemia, one-third (33.3%) were underweight, while none of the overweight participants were classified as anemic. Statistical analysis using the Fisher–Freeman–Halton exact test demonstrated a statistically significant association between nutritional status and anemia (p = 0.016).

DISCUSSION

The present study demonstrated that nutritional status was significantly associated with anemia among vegetable farmers, whereas no statistically significant association was observed between Soil-Transmitted Helminth (STH) infection and anemia. These findings suggest that nutritional status may represent a more important determinant of anemia than STH infection in this agricultural population. However, the absence of a statistically significant association between STH infection and anemia should be interpreted with caution because only six participants (6.7%) were infected, substantially limiting the statistical power to detect meaningful differences. Therefore, the present findings should not be interpreted as evidence that STH infection has no biological relationship with anemia but rather that the available data were insufficient to demonstrate such an association within this study population.

The significant relationship between nutritional status and anemia observed in this study is biologically plausible and consistent with the current understanding of erythropoiesis. Adequate production of red blood cells requires sufficient intake and metabolism of iron, protein, folate, vitamin B12, vitamin A, and other essential micronutrients. Individuals with poor nutritional status often experience chronic deficiencies in these nutrients, reducing hemoglobin synthesis and impairing erythrocyte production. Furthermore, chronic energy deficiency may weaken immune function and increase susceptibility to infections that indirectly exacerbate anemia. Recent evidence emphasizes that anemia should be viewed as a multifactorial disorder in which nutritional inadequacy interacts with inflammation, infection, and metabolic disturbances rather than as a consequence of iron deficiency alone (Pasricha et al., 2021; Garcia-Casal et al., 2023; Hess et al., 2023; Young et al., 2023).

Our findings are consistent with previous studies conducted in Indonesia and other low- and middle-income countries reporting that undernutrition remains an important determinant of anemia among adults. Although body mass index (BMI) is not a direct indicator of micronutrient status, underweight individuals generally have lower dietary intake, reduced nutrient reserves, and poorer overall nutritional health, increasing their susceptibility to anemia. Conversely, participants with normal nutritional status are more likely to maintain adequate erythropoietic function through sufficient intake of essential nutrients. Nevertheless, normal BMI should not automatically be interpreted as evidence of adequate iron status because individuals with apparently normal nutritional status may still experience subclinical micronutrient deficiencies that are undetectable using anthropometric assessment alone (Garcia-Casal et al., 2023; Pasricha et al., 2021).

In contrast, STH infection was not significantly associated with anemia in the present study. Similar findings have been reported among Indonesian adult populations exposed to contaminated environments, where low infection prevalence or light infection intensity reduced the likelihood of detecting statistically significant associations. These observations suggest that the contribution of STH infection to anemia may vary considerably according to epidemiological context, parasite species, infection intensity, environmental sanitation, and host nutritional status rather than representing a uniform risk across all populations (Djuardi et al., 2021; Husniar et al., 2022; Nasution et al., 2022).

Despite the absence of statistical significance, the biological relationship between STH infection and anemia remains well established. Hookworm infection contributes directly to chronic intestinal blood loss and progressive iron depletion, whereas *Ascaris lumbricoides* and *Trichuris trichiura* primarily impair nutrient absorption, reduce appetite, damage intestinal mucosa, and promote chronic inflammation that interferes with erythropoiesis. The severity of these mechanisms depends largely on parasite burden and duration of infection. Because this study did not identify parasite species or quantify infection intensity, it is possible that most infected participants harbored light infections with limited hematological consequences. Consequently, the present findings should not be interpreted as contradicting established biological evidence but rather as reflecting the relatively low prevalence of infection within the study population (Jourdan et al., 2018; Caldrer et al., 2022; Ellwanger et al., 2022).

The low prevalence of STH infection observed among vegetable farmers may indicate gradual improvements in environmental sanitation, access to clean water, personal hygiene practices, and the adoption of preventive behaviors such as wearing protective footwear during agricultural activities. Previous studies in Indonesia have demonstrated that improved sanitation and consistent personal hygiene substantially reduce the transmission of soil-transmitted helminths. Although these factors were not directly measured in the present study, they may partly explain the relatively small number of infected participants and the absence of a detectable association with anemia. Continued investment in sanitation and hygiene promotion therefore remains essential to sustain low transmission levels in agricultural communities (Kurniawan et al., 2023; Syamsul et al., 2021; WHO, 2023).

An important implication of the present findings is that nutritional interventions should receive greater attention within occupational health programs for agricultural workers. Nearly one-quarter of participants were classified as anemic despite the relatively low prevalence of STH infection, suggesting that nutritional deficiencies may currently represent the dominant modifiable risk factor in this population. Routine nutritional assessment, dietary counselling, promotion of iron-rich foods, and early anemia screening should therefore be integrated into occupational health services for farmers. At the same time, preventive measures against STH infection—including health education, personal hygiene promotion, environmental sanitation improvement, and periodic deworming where epidemiologically appropriate should continue because these interventions provide broader health benefits beyond anemia prevention (WHO, 2025; Lubis et al., 2025).

The findings also support the concept that anemia among agricultural workers is multifactorial and cannot be adequately explained by a single exposure. In addition to nutritional status and parasitic infection, other determinants such as dietary diversity, iron bioavailability, inflammatory conditions, chronic diseases, menstrual blood loss among women, pesticide exposure, socioeconomic status, and access to healthcare may influence hemoglobin concentration. The interaction among these factors highlights the importance of comprehensive public health strategies that simultaneously address nutrition, occupational safety, environmental health, and primary healthcare services. Such integrated approaches are likely to produce greater and more sustainable reductions in anemia than interventions focusing exclusively on a single determinant (Christian, 2021; Garcia-Casal et al., 2023; Hess et al., 2023).

Several limitations should be considered when interpreting these findings. First, the cross-sectional design precludes causal inference because exposure and outcome were measured simultaneously. Second, the small number of STH-positive participants limited statistical power and increased the possibility of a type II error. Third, infection intensity and parasite species were not assessed, although both strongly influence the relationship between STH infection and anemia. Fourth, nutritional status was evaluated using BMI rather than biochemical indicators such as serum ferritin, transferrin saturation, vitamin B12, folate, or inflammatory biomarkers, limiting interpretation of the underlying causes of anemia. Finally, several potential confounding factors, including dietary intake, socioeconomic status, chronic diseases, pesticide exposure, and altitude-related hemoglobin adjustment, were not evaluated and may have influenced the observed associations.

Overall, this study contributes new evidence regarding anemia among adult vegetable farmers, a population that has received relatively limited attention compared with children and pregnant women. By simultaneously evaluating nutritional status and STH infection within the same analytical framework, the study provides evidence that nutritional status remains a more prominent determinant of anemia than detectable STH infection in this agricultural setting. These findings support the development of integrated occupational health policies that combine nutritional improvement, routine anemia screening, environmental sanitation, and parasite control to reduce the burden of anemia among agricultural workers.

CONCLUSION

This study demonstrated that nutritional status was significantly associated with anemia among

vegetable farmers in Gowa District, whereas no statistically significant association was found between soil-transmitted helminth (STH) infection and anemia. However, the low number of STH-positive participants limited the statistical power, and the observed non-significant association should therefore be interpreted with caution. These findings highlight the importance of integrating nutritional assessment, anemia screening, and health promotion into occupational health programs for agricultural workers while maintaining preventive measures against STH infection. Future studies with larger sample sizes and comprehensive assessments of dietary intake, infection intensity, and micronutrient status are needed to better clarify the determinants of anemia in agricultural populations.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ARTIFICIAL INTELLIGENCE (AI) STATEMENT

AI-assisted tools were used only to improve English grammar and readability and to assist in identifying relevant literature. All content, interpretation, and reference verification were reviewed by the authors, who take full responsibility for the manuscript.

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