Body Mass Index, Hemoglobin levels and Grade-Point Average for Public Health Students: Cross Sectional Study

Syamsul Alam[1]*, Sukfitrianty Syahrir[2], Maesarah Yasin[3], Aswadi Aswadi[4]

[1]Department of Public Health, Universitas Islam Negeri Alauddin Makassar, Indonesia
[2]Department of Public Health, Universitas Islam Negeri Alauddin Makassar, Indonesia
[3]Department of Science Nutrition, Faculty of Public Health, Universitas Gorontalo, Indonesia
[4]Department of Public Health, Universitas Islam Negeri Alauddin Makassar, Indonesia

*Corresponding Author: E-mail: syamsul.alam@uin-alauddin.ac.id

ARTICLE INFO

ABSTRACT

Introduction: Poor nutrition can disrupt a child's motivation, ability to train, and his ability to learn. This will affect children's learning achievement. The first-year students following the lecture process with the block system have an average GPA lower than students who use the lecture system block two to three years. The aim to find out the nutritional status and the college student's achievement index who take the block system learning method in the learning environment of the public health department UIN Alauddin Makassar.

Methods: The participants were 88 students from the public health department of UIN Alauddin Makassar with the Cross-Sectional approach method. The research data was obtained by measuring anthropometry based on BW / TB, measurement of hemoglobin, and student achievement index. Data were analyzed by the chi-square test at p-value <0.05.

Results: The results showed that the analysis of BMI based on indicators of weight and height measurements obtained the normal nutritional status of students only 40.9%, nutritional status underweight category as much as 35.2% and overweight or overweight as much as 23.9%. The results of hemoglobin examination (g / dl) showed that respondents had anemia which was as much as 71.6%, which was not anemic 28.4%. The results showed that there was no relationship between the BMI with the learning achievement of students who took classes with the block system in health study programs, P-value = 0.902. P-value = 0.001, which shows that there is a significant relationship between anemia status and achievement index obtained during the 2 semesters of lectures that have been followed.

Conclusion: Anemia is one of the nutritional problems that can affect student learning achievement, so students can improve consumption patterns that affect hemoglobin.

INTRODUCTION

The World Health Organization (WHO) emphasizes that nutrition is a fundamental basis of human life, crucial for health and well-being at every stage of life (1). Nutrition status is said to be good if there are a balance and harmony between physical growth and mental development (2). Poor nutrition occurs due to lack of learning or more than important nutrients that cause learning disabilities, inability to work, morbidity to death (3).

Currently, Iron Deficiency Anemia (IDA) is the most prevalent micronutrient deficiency worldwide, leading to significant economic impacts and hindering national development (3). The The prevalence of anemia is disproportionately higher in developing countries due to low socioeconomic conditions and limited access to healthcare services (4). In these regions such as Indonesia, adolescents face greater nutritional challenges, with adolescent girls being particularly vulnerable. Research has shown that anemia among adolescents remains one of the most pressing nutritional issues in developing nations (5).

According to the World Health Organization (WHO), the global prevalence of anemia ranges from 40% to 88%. In Indonesia, adolescents aged 10-19 years make up 26.2% of the total population, with 50.9% being male and 49.1% female (6). Based on the 2013 Basic Health Research data, the prevalence of anemia in Indonesia is 21.7%, with 26.4% of cases occurring in children aged 5-14 years and 18.4% in individuals aged 15-24 years (7), In 2018, the prevalence of anemia reached 49.9%, with the highest proportion found in the 15-24 and 25-34 age groups (8). A literature review of 20 articles meeting the inclusion criteria indicated that anemia incidence is significantly high among adolescents (9).

Anemia is a blood disorder that is common in children and is known to cause complications such as lethargy and stress. Iron deficiency anemia is often associated with fatigue, stress, reduced concentration, and impaired memory (10). This iron deficiency affects the condition of impaired function of hemoglobin which is an oxygen transport device. Oxygen is much needed in the body's metabolic reactions (11). Children have shown a correlation between hemoglobin levels and the ability of children to learn (11).

A person's cognitive intelligence is closely related to one's nutritional status. Poor nutrition can disrupt a child's motivation, ability to concentrate, and his ability to learn. This certainly affects children's learning achievement (12). Factors that influence learning achievement include health, namely nutritional status. Abnormal levels of hemoglobin can cause anemia (2).

Students suffering from iron deficiency are more susceptible to infections due to weakened immunity. Their intelligence quotient (IQ) tends to be lower, leading to reduced learning abilities and academic performance (11). Studies have shown a significant positive correlation between six blood factors (ferritin, serum iron, MCV, MCH, HCT, and hemoglobin) and academic achievement (13). Furthermore, T-test results indicate that students with anemia score significantly lower in academic performance compared to their healthy peers (14).

A comparative study on body mass index indicates that the prevalence of overweight is higher among health students compared to non-health students (15). Research findings suggest that students with obesity have a greater need for academic achievement than their peers with normal weight (16).

Several studies have revealed that cognitive abilities are influenced by obesity, while the risk of obesity itself is closely linked to dietary quality. As nutritional quality declines, the risk of obesity increases, making poor nutrition often associated with lower academic performance (17). Furthermore, this study highlights a positive correlation between dietary patterns and higher academic achievement (18). However, other research findings suggest that the relationship between healthier food intake and better academic performance is relatively small, and vice versa (19).

Preliminary studies indicate that research on the relationship between nutritional status and academic achievement in higher education remains limited, particularly in the context of the block system curriculum implementation. This limitation underscores the need for further research, especially among students in the Public Health Study Program at UIN Alauddin Makassar, who have adopted the block system in their learning process.

Data obtained from the academic section of the Public Health Study Program UIN Alauddin Makassar for the distribution of student GPAs that follow the lecture process with the block system is the average semester III GPA of students: 3.48; semester V: 3.54; and semester VII, namely 3.61; This data shows that the first-year students taking part in the lecture process with the block system had an average GPA lower than students who took the two-year system block to three years. 12.42% of students get a GPA of less than 3.25 (GPA, <3.25) and as much as 3.3% with a GPA of less than 2.75 (GPA, <2.75). The data obtained means that there are still students who get less GPA and need to be examined the causes.

Based on the above data, the author is interested in research on the analysis of the nutritional status and the student cumulative restoration index in the learning system block of the UIN Alauddin Makassar public health study program. However, there is still a lack of research exploring the direct relationship between nutritional status and academic achievement among university students, particularly those following the block system learning method. Most existing studies focus on younger populations, such as school-aged children and adolescents, leaving a gap in understanding how nutritional deficiencies, particularly iron deficiency anemia, impact cognitive function and academic performance at the university level. Given the increasing academic demands of higher education, especially in structured learning environments like the block system, it is crucial to examine how students' nutritional status influences their ability to adapt and excel in such a rigorous academic framework. This research aims to assess the nutritional status and academic achievement index of college students who follow the block system learning method in the Public Health Department at UIN Alauddin Makassar.

METHOD

This research was conducted at Campus II UIN Alauddin Makassar. This research is a type of analytic survey research with a cross-sectional study approach. Primary data in the form of height, body weight, and Hb examination of students are used to determine nutritional status while secondary data in the form of a temporary cumulative achievement index is obtained from the card of the study results of public health study program students. The sample in this study was 2018 active students, with the sampling technique in this study was total sampling.

This study only involved students from the 2018 cohort to ensure data validity and consistency. They have undergone the block learning system for a sufficient period to evaluate its impact on academic performance. Including other cohorts could introduce uncontrolled variations in the study results. The sample consists of 88 students from the 2018 cohort, selected through total sampling. Measurements include body mass index using anthropometric methods, hemoglobin levels using spectrophotometry, and academic performance data obtained from the university's academic information system. This approach ensures accurate data for analyzing the relationship between nutritional status and academic performance.

The instruments to be used in this study are: Informed consent forms and forms to assess the nutritional status and GPA of students. To determine weight and height, anthropometric measuring tools including a digital weight scale and a multifunctional height measuring device used in the 2018 RISKESDAS by the Ministry of Health of the Republic of Indonesia will be utilized. Hemoglobin level assessment will be conducted using a hemoglobinometer with the Family Dr. brand Hb check tool. The procedure involves taking a small blood sample from the fingertip using a lancet, placing it on a reagent strip, and then inserting it into the hemoglobinometer. The device will analyze the sample and display the hemoglobin level. Data will be analyzed using univariate analysis to determine sample and variable characteristics. Bivariate analysis will be used to ascertain relationships between variables using the Chi-square method.

In this study, calibration procedures and quality control were implemented to ensure measurement accuracy. Measuring instruments were calibrated periodically according to laboratory standards, particularly for spectrophotometry in hemoglobin level measurement. Additionally, examinations were conducted by trained personnel to minimize anthropometric measurement errors. Regarding the use of GPA as an indicator of academic performance, we selected GPA because it is a commonly used standard for evaluating students' academic achievements in higher education. GPA reflects cumulative academic performance across various courses, as recorded in the Academic Transcript (KHS) verified by academic advisors and the university portal. Therefore, it serves as a representative parameter for analyzing the relationship between nutritional status and academic performance.

In this study, potential confounding variables include dietary patterns, physical activity, academic stress, medical history, and socio-economic factors. These factors can influence BMI, hemoglobin levels, and students' GPA. Therefore, controlling for these variables is essential to ensure the validity of the analysis and accurately reflect the true causal relationship.

RESULTS
Univariate Analys

The study results regarding the distribution of respondent characteristics by gender, Body Mass Index (BMI), hemoglobin levels, and grade-point average (GPA) are presented in Table 1.

Table 1. Distribution of Respondent Characteristics by Gender, Body Mass Index (BMI), Hemoglobin levels and Grade-Point Average

Respondent Characteristics	n (88)	%
Gender		
Male	17	10,2
Girl	71	89,8
Student Nutritional Status (IMT=BB/TB^2)		
Underweight (IMT: < 18,5)	31	35,2
Normal (IMT: 18,5 – 22,9)	36	40,9
Overweight (IMT: > 18,5)	21	23,9
Hemoglobin levels		
Normal (Hb: > 12 g/dl)	25	28,4
Anemia (Hb: < 12 g/dl)	63	71,6
Grade-Point Average		
Very satisfy (IPK: > 3,50)	58	65,9
Satisfy (IPK: < 3,50)	30	34,1

Table 1 shows that of 88 respondents there were 89.7% who were female and 10.2% who were male. The results of body mass index analysis based on indicators of body weight and height measurements showed that the normal nutritional status of students was only 40.9%, the nutritional status of the underweight category was 35.2%, and overweight or overweight was 23.9%. The results of hemoglobin examination (g / dl) showed that the majority of respondents experienced anemia, as many as 71.6% with a hemoglobin (Hb) value of less than 12 g / dl while only 28.4% were normal or not anemic. Grade-Point Average that has completed the study process for 2 semesters or the first year shows 65.9% with a very satisfactory performance index category while 34.1% satisfactory achievement index.

Table 2. Distribution of Statistical Characteristics of Respondents

Statistics	BB (Kg)	TB (m)	BMI	HB	GPA
n	88	88	88	88	88
Mean	50.79	1.54	21.23	11.31	3.57
Median	46.60	1.54	19.67	11.30	3.60
Std. Deviation	12.02	0.05	4.80	1.315	0.22
Minimum	35.00	1.44	15.76	8.6	2.93
Maximum	96.50	1.75	40.90	14.8	3.95

Table 2 shows that the average weight of a student is 50.79 kg, the lightest weight is 35.0 kg, and the heaviest is 96.5 kg with a median value of 46.60 and a standard deviation of 12.02. The average body height of respondents was 1.54 meters, the highest 1.75 meters and the shortest was 1.44 meters with a median value of 1.54 and a standard deviation of 4.80. The mean body mass index value that indicates the nutritional status of respondents is 21.23 or the average BMI value is in the normal category. The lowest BMI value is 15.76 and the highest is 40.90 with a median value of 19.67 and a standard deviation of 4.80. The results of hemoglobin examination using the MHD-1 Test Meter obtained mean respondent's Hb value of 11.31g / dl which illustrates that the average of respondents experienced anemia, where the lowest Hb value is 8.6 g / dl and the highest is 14.8 g / dl with a median value 11.30 g / dl and 1,315 standard deviations. the results of the interim study of respondents obtained an average achievement index value of 3.57 with a predicate while very satisfying, where the highest achievement index is 3.95 and the lowest is 2.93 with a median value of 3.60 and a standard deviation of 0.22.

Bivariate Analys

Table 3. Relationship of Bodu Mass Index and Hemoglobin Levels with Grade-Point Average

Variabel	Grade-Point Average (n=88)				Total		P Value (95% Cl)
	Very Satisfying		Satisfying				
	n	%	n	%	n	%	
Body Mass Index							
Underweight	21	67,7	10	32,3	31	100,0	
Normal	24	61,9	12	33,9	36	100,0	P = 0,902
Overweight	13	65,9	8	38,1	21	100,0	(CI = 0,911-0,921)
Hemoglobin Levels							
Normal	10	40,0	15	60,0	25	100,0	P=0,001
Anemia	48	76,2	15	23,8	63	100,0	(CI = 0,002-0,004)

Table 3 shows that the analysis of the relationship between nutritional status by Body Mass Index with the 2018 student achievement index joining the lecture with the block system for 2 semesters in public health study program there were 36 respondents with normal nutritional status with a very satisfying Grade-Point Average of 24 respondents or 67, 7% and satisfying as many as 12 respondents or 33.3%. Respondents who are underweight or malnourished are 31 respondents consisting of 21 respondents or 67.7.2% with a very satisfying student achievement index and 10 respondents or 32.3% with a satisfactory predicate. While respondents with overweight or over nutrition status were 21 respondents consisting of 13 respondents or 61.9% with a very satisfactory student achievement index and 8 respondents or 38.1% with a satisfactory predicate. The statistical analysis using the chi-square test yielded a p-value of 0.902, indicating no significant relationship between the respondents' nutritional status and their academic performance over two semesters of lectures.

The results of the analysis of the relationship of anemia status with the 2018 student achievement index following the lecture with the block system for 2 semesters in public health study program there were 63 respondents who experienced anemia based on the results of the hemoglobin examination, anemia respondents with a very satisfactory student achievement index as many as 76.2% and satisfying only 23.8%. Respondents with normal hemoglobin examination results were 25 respondents with a very satisfying Grade-Point Average of 40.0% and satisfying 23.8%. The statistical analysis using the chi-square test resulted in a p-value of 0.001, indicating a significant relationship between anemia status and the academic achievement index over two semesters of lectures.

DISCUSSION
The Relationship between Body Mass Index (BMI) and the Student Achievement Index

The results of body mass index measurements according to age obtained that the nutritional status of third-semester students or class of 2018 students of the public health study program is classified as underweight, normal, and overweight. From 88 respondents, the normal nutritional status of students is only 40.9%, the nutritional status of the underweight/malnutrition category is 35.2%, and overweight or overweight is 23.9%. Optimal health and nutrition factors are very important to human resources which are the basic national assets and determinants of successful development outcomes.

The findings indicated no correlation between body mass index and the academic performance of students enrolled in block system classes within health study programs. Statistical analysis using the chi-square test yielded a p-value of 0.902 (p > 0.05). These results align with research by N. Rani (2017), which also found no significant relationship between nutritional status and academic achievement, with a p-value of 0.882 (p > 0.04) (20). However, this study is not in line with research conducted by Seyoum, D et al (2019) in Nekemte West Ethiopia who said that underweight children were 43% lower in academic performance than those who were of normal weight (21).

Other studies have found no evidence that iron status and anemia influence or are associated with attention, intelligence, or memory in adolescents. Furthermore, iron supplementation does not improve memory, recall, or cognitive abilities (22).

The basic theory explains that nutritional status is related to one's achievement, but there are still many other factors that are also related to student achievement, which is not used as variables in this study and is not measured against these other variables. This states that nutritional status is based on body weight / TB not the only influencing factor student achievement index because there are many other factors not examined in the study such as psychological aspects, learning factors, lecturer factors, family factors, and the environment.

In this research, there is still some nutritional status of students whose nutritional status is less likely due to the pattern and food intake not in accordance with the nutritional needs, where the majority of students live in contracting so that the choice of food is of poor quality and fulfills good nutritional elements and is preoccupied with academic routines and non-academic so that they can forget or be late eating and not enough rest time. In addition, this study also shows that there are students with overweight or overweight nutritional status categories that need to be aware of future health risks such as the risk of degenerative diseases in the productive age and old age.

Relationship of Hemoglobin Levels with Student Achievement Index

The analysis of the relationship between anemia and student achievement found that students with abnormal hemoglobin (HB) levels tended to have satisfactory performance, while those with normal HB levels achieved very satisfactory results. This indicates a significant relationship between HB levels and academic performance, supporting the theory that anemia can lead to fatigue and reduced concentration, ultimately lowering learning achievement and productivity.

Stoltzfus RJ et al. investigated the link between hemoglobin levels and IQ, finding that a 1 g/dL reduction in hemoglobin was associated with a 1.73-point drop in IQ. Numerous studies have also identified correlations between iron deficiency anemia and impaired cognitive function, delayed motor skills, and behavioral difficulties (23). These findings are consistent with research indicating a significant relationship ($P = 0.001$) between hemoglobin levels (anemia) and the academic achievement index of public health students enrolled in block system courses. The results showed the strength of a strong relationship between Hb levels with the student learning achievement index.

This study aligns with research by Husjaind Ningrat (2014), which found a significant relationship between hemoglobin (Hb) levels and students' academic achievement at the Polytechnic Board of Health, Ministry of Health Jakarta III ($p = 0.003$) (24). Research on the effect of Fe supplementation on learning achievement, and the effect of Fe-folate supplementation, zinc, and vitamin A on learning achievement, both show a significant relationship. While others say anemia can affect a person's level of physical fitness. This situation affects concentration and learning achievement and affects work productivity among adolescents (13).

This study aligns with several research findings that indicate a significant relationship between low hemoglobin levels, anemia, and academic achievement in students and adolescents. Studies by Mosiño et al. (2020) in Mexico and Hu et al. (2024) in China show that anemia is associated with academic performance and affects it both directly and indirectly (25) (26). A systematic review by Samson KLI et al. (2022) reported similar findings, highlighting a link between iron status, anemia, and academic performance across various settings. The study also emphasized that iron supplementation during adolescence can improve school performance, attention, and concentration (27).

Several studies have shown results that do not support a relationship between anemia and academic performance. One study concluded that iron status and anemia do not affect attention, intelligence, or memory in adolescents. Furthermore, iron supplementation does not improve memory, recall, or intelligence (22). Another study conducted at a university also found no significant correlation between anemia and students' academic performance (28). Similarly, research has shown that anemia incidence does not significantly impact students' cumulative grade point average (29).

On the other hand, some studies support the link between anemia and academic performance. Prolonged anemia, low body weight, and short stature during adolescence are associated with learning difficulties (30). Students with anemia tend to have lower APT scores, reduced learning concentration, and poorer academic performance than their non-anemic peers ($p<0.001$). However, the relationship between anemia and IQ was not statistically significant ($p<0.05$) (Agus Santosa, 2025) (31). Other findings highlight that anemia can directly and indirectly affect learning performance. Anemia in adolescents can lead to decreased physical endurance, fatigue, excessive hunger, concentration disorders, and a decline in academic achievement (32).

Furthermore, the research highlights a significant relationship between the prevalence of anemia and academic achievement, emphasizing the importance of addressing anemia among students to improve their learning outcomes (33). Other studies emphasize that hemoglobin levels affect cognitive function in school children (34). Anemia is associated with impaired fine motor skills and children's cognitive scores (35). Evidence from these various studies reinforces the relationship between low hemoglobin levels and decreased academic performance. Therefore, it is essential to maintain normal hemoglobin levels to support optimal cognitive function and academic achievement.

Implications for Public Health

The research findings underscore the importance of awareness regarding physical health and nutrition in supporting academic achievement. While there is no direct relationship between Body Mass Index (BMI) and academic performance, variations in nutritional status highlight the need for a holistic approach considering factors such as psychological aspects, learning environment, and dietary habits. On the other hand, the significant correlation between hemoglobin levels (HB) and academic performance emphasizes the importance of adequate nutrient intake, particularly iron, in supporting learning concentration and academic achievement. These implications underline the necessity for comprehensive interventions in public health education to enhance student well-being and promote optimal academic performance.

Limitations and Cautions

This study mainly investigates the correlation between Body Mass Index (BMI) and hemoglobin (HB) levels with students' academic performance. However, it overlooks several other factors that could potentially influence academic achievement, such as psychological factors, learning environment, family support, and dietary patterns in greater depth. Moreover, the limited sample size might not encompass the entire student population and could fail to represent the existing variability within it. Consequently, the generalizability of the research findings to a broader population may be restricted.

Recommendations for Future Research

Future research should include longitudinal studies with comprehensive variables such as psychological factors, learning environments, family support, and dietary patterns to gain a deeper understanding of their relationship with academic performance. Expanding the sample to diverse backgrounds is also crucial to enhance the validity of findings. Policymakers should develop anemia screening programs and nutrition education, while educators can implement inclusive learning strategies. Healthcare professionals play a role in routine examinations and nutritional interventions. This interdisciplinary collaboration is expected to improve students' overall health and academic performance.

CONCLUSION

This study indicates that nutritional status based on Body Mass Index (BMI) does not have a significant impact on students' academic performance (p=0.902). While nutrition contributes to learning performance, other factors such as psychological conditions and environmental influences also play a crucial role in academic success. However, anemia status has a significant relationship with students' academic performance (p=0.001), where anemic students tend to have a higher-Grade Point Average (GPA) compared to those with normal hemoglobin levels. These findings suggest that while general nutritional status does not directly affect academic performance, anemia remains a nutritional challenge that requires greater attention. Therefore, more specific interventions, such as anemia prevention programs and nutrition education, are needed to support students' academic achievement.

AUTHOR'S CONTRIBUTION STATEMENT

The authors have contributed significantly to this work, including drafting, revising, and critically reviewing the manuscript to ensure its quality and accuracy. They have collectively approved the final version for publication, agreed on the chosen journal, and accepted responsibility for all study aspects. Their contributions span various stages of the research process, including conceptualization, study design, execution, data collection, analysis, and interpretation.

CONFLICTS OF INTEREST

SOURCE OF FUNDING STATEMENTS

ACKNOWLEDGMENTS

BIBLIOGRAPHY

1. A. Khan, S. U. Khan, S. Khan, S. zia-ul-islam, K. B. Naimatullah, and M. Khan, "Nutritional complications and its effects on human health.," J. Food Sci. Nutr., 2018. Available from: https://www.academia.edu/download/86915299/nutritional-complications-and-its-effects-on-human-health.pdf

2. "School-Based Nutrition Education in Improving Dietary Diversity Among Adolescent Girls," Case Med. Res., 2019.

3. T. G. DeLoughery, "Iron Deficiency Anemia," Medical Clinics of North America. 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28189173/

4. K. A. Gonete, A. Tariku, S. D. Wami, and T. Derso, "Prevalence and associated factors of anemia among adolescent girls attending high schools in Dembia District, Northwest Ethiopia, 2017," Arch. Public Heal., 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/30598822/

5. J. K. Das et al., "Nutrition in adolescents: physiology, metabolism, and nutritional needs," Annals of the New York Academy of Sciences. 2017. Available from: https://pubmed.ncbi.nlm.nih.gov/28436102/

6. Depkes RI, Kementerian Kesehatan Republik Indonesia. 2018.

7. Kementerian Kesehatan Republik Indonesia, "Hasil Riset Kesehatan Dasar Kementerian RI 2013," Proceedings, Annu. Meet. - Air Pollut. Control Assoc., 2013.

8. Badan Penelitian dan Pengembangan Kesehatan (Balitbangkes), Kementerian Kesehatan Republik Indonesia. Laporan Nasional Riset Kesehatan Dasar (Riskesdas) 2018. Jakarta: Kementerian Kesehatan RI; 2018.

9. Deivita Y, Syafruddin S, Nilawati UA, Aminuddin A, Burhanuddin B, Zahir Z. Overview of anemia; risk factors and solution offering. Gac Sanit. 2021;35(S2):S235-S241. https://doi.org/10.1016/j.gaceta.2021.07.034

10. T. P. Gwetu, M. Taylor, M. Chhagan, M. Craib, and S. Kauchali, "Health and educational achievement of school-aged children: The impact of anaemia and iron status on learning," Heal. SA Gesondheid, 2019. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6917415/

11. C. D. Karakochuk et al., "Measurement and interpretation of hemoglobin concentration in clinical and field settings: a narrative review," Ann. N. Y. Acad. Sci., 2019. Available from: https://pubmed.ncbi.nlm.nih.gov/30652320/

12. S. J. Schwarzenberg and M. K. Georgieff, "Advocacy for improving nutrition in the first 1000 days to support childhood development and adult health," Pediatrics, 2018. Available from: https://pubmed.ncbi.nlm.nih.gov/29358479/

13. N. Soleimani and N. Abbaszadeh, "Relationship between Anaemia, caused from the iron deficiency, and academic achievement among third grade high school female students," in Procedia - Social and Behavioral Sciences, 2011. Available from: https://www.sciencedirect.com/science/article/pii/S1877042811029041

14. F. J. Rosales, J. S. Reznick, and S. H. Zeisel, "Understanding the role of nutrition in the brain and behavioral development of toddlers and preschool children: Identifying and addressing methodological barriers," Nutritional Neuroscience. 2009. Available from: https://pubmed.ncbi.nlm.nih.gov/19761650/

15. Jha Reena, Yadav AK, Shrestha S, Shrestha PR, Shrestha S, Jha M, et al. Study of body mass index among

medical students of a medical college in Nepal: A descriptive cross-sectional study. J Nepal Med Assoc. 2021;59(235):280-3. https://doi.org/10.31729/jnma.6282

16. Alswat KA, Al-shehri AD, Aljuaid TA, Alzaidi BA, Alasmari HD. The association between body mass index and academic performance. Saudi Med J. 2017;38(2):186-191. https://doi.org/10.15537/smj.2017.2.16320

17. Bradley BJ, Greene AC. Do health and education agencies in the United States share responsibility for academic achievement and health? A review of 25 years of evidence. J Adolesc Health. 2013;52(5):523-532. https://doi.org/10.1016/j.jadohealth.2013.01.008

18. Neuman J, Ina EA, Huq SO, Blanca A, Petrosky SN. Cross-sectional analysis of the effect of physical activity, nutrition, and lifestyle factors on medical students' academic achievement. Cureus. 2024;16(3):e56343. https://doi.org/10.7759/cureus.56343

19. Whatnall M.C., Patterson A.J., Burrows T.L., Hutchesson M.J. (2019) Higher diet quality in university students is associated with higher academic achievement: a cross-sectional study. J Hum Nutr Diet. 32, 321–328 https://doi.org/10.1111/jhn.12632

20. N. A. Rani, R. Arasegowda, P. Mukherjee, and S. Y. Dhananjay, "Prevalence of nutritional deficiency anaemia and its impact on scholastic performance among undergraduate medical students," J. Clin. Diagnostic Res., 2017. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5427299/

21. D. Seyoum, R. Tsegaye, and A. Tesfaye, "Under nutrition as a predictor of poor academic performance; The case of Nekemte primary schools students, Western Ethiopia," BMC Res. Notes, 2019. Available from: https://bmcresnotes.biomedcentral.com/articles/10.1186/s13104-019-4771-5

22. Samson KLI, Fischer JAJ, Roche ML. Iron status, anemia, and iron interventions and their associations with cognitive and academic performance in adolescents: a systematic review. Nutrients. 2022;14(1):224. https://doi.org/10.3390/nu14010224

23. M. Ezzati, A. D. Lopez, A. Rodgers, and C. J. Murray, "Comparative Quantification of Health Risks Global and Regional Burden of Disease," 2004. Available from: https://iris.who.int/handle/10665/42770

24. M. Djajaningrat, Husjain., Chairlan., "Analisis hubungan kadar hemoglobin dengan prestasi belajar mahasiswa penghuni asrama poltekkes jakarta III," J. Ilmu dan Teknol. Kesehtan, 2014. Available from: https://journal.ummat.ac.id/journals/5/articles/7883/attachment/7883-26942-1-AT.docx

25. Mosiño, Alejandro, Karen P. Villagómez-Estrada, and Alberto Prieto-Patrón. "Association between school performance and anemia in adolescents in Mexico." International Journal of Environmental Research and Public Health 17.5 (2020): 1466. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7084426/

26. Hu, Yisong, Yanxin Mao, and Weidong Wang. "Relationship between anemia and academic performance in Chinese primary school students: Evidence from a large national survey." Health & Social Care in the Community 2024.1 (2024): 1150608. Available from: https://www.researchgate.net/publication/377802365_Relationship_between_Anemia_and_Academic_Performance_in_Chinese_Primary_School_Students_Evidence_from_a_Large_National_Survey

27. Samson KLI, Fischer JAJ, Roche ML. Iron Status, Anemia, and Iron Interventions and Their Associations with Cognitive and Academic Performance in Adolescents: A Systematic Review. Nutrients. 2022 Jan 5;14(1):224. doi: 10.3390/nu14010224. PMID: 35011099; PMCID: PMC8746955. Available from: https://pubmed.ncbi.nlm.nih.gov/35011099/

28. Essawi K, Hakami S, Abdullah A, Badr D, Madkhali AA, Hakami W, dkk. Impact of iron deficiency anemia on academic achievement among female university students in Saudi Arabia. Afr J Reprod Health. 2024;28(9):85-97. https://doi.org/10.29063/ajrh2024/v28i9.8

29. Syahrun, Metungku F, Sholichin, Wahyuni AP, Nopriyanto D. Overview of the incidence of anemia on the student achievement index of the Nursing Study Program, Faculty of Medicine, Mulawarman University. Mulawarman Nurs Indones J. 2023;1(1):14-16. https://e-journals2.unmul.ac.id/index.php/mnij/article/view/1008

30. Nguyen PH, Walia M, Pant A, Menon P, Scott S. Changes in anemia and anthropometry during adolescence predict learning outcomes: findings from a 3-year longitudinal study in India. Am J Clin Nutr. 2022;115(6):1549-58. https://doi.org/10.1093/ajcn/nqac028

31. Santosa A, Fajri RN, Ramadani KN, Azzahra A. The impact of anemia on academic indicators in nursing students: intelligence quotient, academic potential, study concentration and academic performance. Proceedings Series on Health & Medical Sciences. 2025;6:81

32. Suryati Y, Yuniarti S, Anggiyani IR. Correlation of anemia with achievement index in female adolescents in junior high school. KnE Med. 2022;4:367-372. https://doi.org/10.18502/kme.v2i2.11099

33. Anindya, Mar'atus, Sholikhah., Yetty, Septiani, Mustar., Agus, Hariyanto. "Anemia di kalangan mahasiswi: prevalensi dan kaitannya dengan prestasi akademik." undefined (2021). Available from: https://journal2.unusa.ac.id/index.php/MTPHJ/article/view/1907

34. Rassamee, Sungthong., Ladda, Mo-suwan., Virasakdi, Chongsuvivatwong. "Effects of haemoglobin and serum ferritin on cognitive function in school children.." Asia Pacific Journal of Clinical Nutrition, undefined (2002). Available from: https://pubmed.ncbi.nlm.nih.gov/12074177/

35. Thando, P., Gwetu., Myra, Taylor., Meera, Chhagan., Murray, H., Craib., Shuaib, Kauchali. "Health and educational achievement of school-aged children: The impact of anaemia and iron status on learning.." Health Sa Gesondheid, undefined (2019). Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC6917415/