Determinants of nutritional status, students' learning achievement and physical activity: a cross sectional study in Jayapura City, Papua, Indonesia
Determinantes del estado nutricional, rendimiento de aprendizaje de los estudiantes y actividad física: un estudio transversal en la ciudad de Jayapura, Papúa, Indonesia

Semuel Piter Irab, Marlina Flassy, Agus Zainuri, Evi Sinaga, Rodhi Rusdianto Hidayat, Yos Wandik, Miftah Fariz Prima Putra
Universitas Cenderawasih (Indonesia)

Abstract. Optimal learning achievement is often obtained through the consumption of nutritious and balanced food, which prevents poor nutritional statuses. This is particularly relevant to Junior High School students aged 12-15 years, who are more prone to experience malnutrition. Therefore, this study aimed to investigate determinants of students' learning achievement according to nutritional status, nutritional knowledge, students' diet, physical activity, and learning interest. This was a descriptive correlation cross-sectional study. Three hundred and fifty Junior High School students in Jayapura Municipality, Papua Province, Indonesia was involved as sample in this study. The study sample were taken by accidental sampling method. The primary data (knowledge of nutrition, diet, physical activity, interest in learning, nutritional status, and learning achievement) and secondary data were obtained from relevant sources and analyzed using frequency distribution analysis and statistical path analysis tests. The results showed the indirect effect of exogenous variables on the endogenous, where nutritional knowledge and students diet influenced nutritional status (p-value = 0.001), but physical activity had no impact (p-value = 0.167). Meanwhile, the direct effect of exogenous variables on the endogenous showed that nutritional knowledge, interest in learning, and nutritional status influenced students' achievement (p-value = 0.001). Thus, nutritional status plays a significant role in determining students' learning achievement. Nutrition knowledge and students diet indirectly affect learning achievement through nutritional status. Nutritional status, nutritional knowledge, and interest in learning directly affect the learning achievement of junior high school students. It is important to improve nutritional status through nutritional knowledge as well as students' diet, therefore this would eventually improve learning achievement.
Keywords: nutrition status, students, achievement, physical activity, interest in learning

Resumen. El logro óptimo del aprendizaje se obtiene a menudo mediante el consumo de alimentos nutritivos y equilibrados, que previenen estados nutricionales deficientes. Esto es particularmente relevante para los estudiantes de secundaria de entre 12 y 15 años, que son más propensos a la desnutrición. Por lo tanto, este estudio tuvo como objetivo investigar los determinantes del logro de aprendizaje de los estudiantes según el estado nutricional, el conocimiento nutricional, la dieta de los estudiantes, la actividad física y el interés por aprender. Se trata de un estudio descriptivo transversal de correlación. En este estudio participaron como muestra trescientos cincuenta estudiantes de secundaria del municipio de Jayapura, provincia de Papúa, Indonesia. La muestra del estudio se tomó mediante el método de muestreo accidental. Los datos primarios (conocimientos sobre nutrición, dieta, actividad física, interés en el aprendizaje, estado nutricional y logros de aprendizaje) y los datos secundarios se obtuvieron de fuentes relevantes y se analizaron mediante análisis de distribución de frecuencia y pruebas de análisis de ruta estadística. Los resultados mostraron el efecto indirecto de las variables exógenas sobre las endógenas, donde el conocimiento nutricional y la dieta de los estudiantes influyeron en el estado nutricional (valor p = 0,001), pero la actividad física no tuvo impacto (valor p = 0,167). Mientras tanto, el efecto directo de las variables exógenas sobre las endógenas mostró que el conocimiento nutricional, el interés por aprender y el estado nutricional influyeron en el rendimiento de los estudiantes (valor p = 0,001). Por lo tanto, el estado nutricional juega un papel importante en la determinación del logro de aprendizaje de los estudiantes. El conocimiento sobre nutrición y la dieta de los estudiantes afectan indirectamente el logro de aprendizaje a través del estado nutricional. El estado nutricional, el conocimiento nutricional y el interés por aprender afectan directamente el logro de aprendizaje de los estudiantes de secundaria. Es importante mejorar el estado nutricional a través del conocimiento nutricional así como de la dieta de los estudiantes, por lo que eventualmente esto mejoraría el rendimiento del aprendizaje.
Palabras clave: estado nutricional, estudiantes, rendimiento, actividad física, interés por aprender.

Introduction

The learning method is often employed in education to enhance knowledge and skills during the teaching and learning process between teachers and students. This approach has been reported to have the ability to increase intelligence levels and improve the quality of human resources for the nation and state (Mustafa, Haque, & Baksi, 2021). The education of children by teachers aligns with Law 20 of 2003, which pertains to the Indonesian National Education System. Furthermore, the primary objective is to cultivate abilities and foster a sense of honorable national character and civilization, fear of God Almighty, noble character, health, knowledge, creativity, and independence, to produce democratic and responsible citizens (Bollwein et al., 2013).

Junior High School is an educational stage designed for male and female adolescents aged 12-15 years old. At this stage, adolescents were very vulnerable during their growth and development. The teaching and learning methods employed in this stage differ from those utilized in tertiary institutions, high schools, elementary schools, and kindergartens. Furthermore, the distinction in educational levels is largely determined by age, and this influences the diverse learning approaches at each level (Al Ghwass, Halawa, Sabry, & Ahmed, 2015). The learning method is a

teaching model developed by the teacher to facilitate the acquisition of new knowledge and skills among junior high school students. This approach plays a crucial role in nurturing human resources through comprehensive education across various fields of human life. Furthermore, it involves the introduction of students to the realm of science, socialization, mental and moral development, as well as character building, within a broad environment (Webb & Beckford, 2014; Asmare, Taddele, Berihun, & Wagnew, 2018).

Although diligent teaching is undoubtedly important, it cannot solely guarantee an increase in students' learning achievement. Adequate nutrition also plays a crucial role, as it provides the body with the necessary physical and mental resilience to support the learning process. The age, weight gain, and height of Junior High School students can be determined using Body Mass Index (BMI) which represents their nutritional status. During adolescence, students tend to be prone to experience malnutrition due to related factors. For example, anemia among female students, eating disorders, and increase energy requirement (Dumilah & Sumarmi, 2017). Body requires more energy to catch up growth and the increase of physical activity (Yurisna, Sattu, Lanyumba, & Otoluwa, 2023). Finally, inadequate nutrition intake may lead to malnutrition and eventually disturb learning process and achievement.

A study on junior high school students in Ghana (2019) showed that nutritious food consumption improved learning achievement (Dumilah & Sumarmi, 2017). Based on observations, the problems found in Papua Province included low academic achievement due to the lack of access to nutritious food, which caused difficulty in concentrating at school and poor examination performance. This was exemplified by the high rate of anemia (57.1%) among young females aged 10-14 years at Kelila Public Junior High School in Central Mamberamo Regency in 2018 (Nugraheni, Latifah, & Wijayatri, 2023). Low students' achievement in Jayapura City was also observed among families who could not afford nutritious food and school fees, leading to poor nutritional status due to the low intake of vegetables and fruits (Dumilah & Sumarmi, 2017).

Jayapura, the capital of Papua Province with an area of 940 km2, is widely recognized as the City of Education, hosting a wide range of educational institutions. These include Kindergarten, Junior High School, Public/Private High School, Vocational High School, and Higher. In Jayapura, there are 38 Junior High Schools, which are distributed across different districts, with 7, 10, 9, 9, and 3 of them being located in Abepura, North Jayapura, South Jayapura, Heram, and Muara Tami, respectively. Out of the total 38 existing junior high schools, they then are divided into two types, namely state and private schools. There are 25 public schools and 13 private schools. More educational institutions can be found in Jayapura city compared to other cities in Papua. Previous studies have been conducted questioned about athletes (Guntoro & Putra, 2022; Sinaga, Padang, Womsiwor, Ita, & Sinaga, 2023; Guntoro et al.,

2023), sports students (Wandik et al., 2024; Guntoro et al., 2024), sports psychology (Putra et al., 2021; Putra & Guntoro, 2022; Sutoro, Guntoro, & Putra, 2023; Putra, Kurdi, et al., 2024; Putra, Sutoro, et al., 2024), and theme of sporting events (Kogoya, Hijjang, Ahmad, Guntoro, Amali, Ita, Flassy, Sokoy, Numberi, Putra, et al., 2024; Kogoya, Guntoro, & Putra, 2022; Kogoya, Hijjang, Ahmad, Guntoro, Amali, Ita, Flassy, Sokoy, Numberi, Sinaga, et al., 2024). Though these topics are intriguing and significant considering the gaps in the field of study, there hasn't been much research conducted on diet, physical activity, and learning performance.

Based on the above explanation, nutrition plays a vital role in the overall development of intellectual abilities and growth, however, malnutrition still become main health problem in Papua. Besides, study related to nutritional status and learning achievement especially among Junior High School in Papua are limited. If nutritional problems among Papua students cannot be overcome, it will have an impact on the development of Papuan human resources. Therefore, this study aims to investigate determinants of students' learning achievement according to nutritional status, nutritional knowledge, diet, physical activity, and students learning achievement in Jayapura City.

Materials and Methods

Participants

In the initial stage, we used a total sampling method in to include all junior high schools in Jayapura city after that we used accidental sampling in selecting research subjects. The inclusion criteria of students were aged 12-15 years old, male, and female, strata VII-IX, parents living in Jayapura City, parents' occupations were civil servants and non-civil servants, healthy, and agree to join the study. Students those parents living outside Jayapura City were excluded. We also considered if the student is unhealthy and suffering from chronic diseases were excluded from our study.

The study population consisted of Junior High School students in Jayapura City. The sample size was determined based on the difference in proportion test formula (n) (Panel & Products, 2021):

$$n = \frac{\left\{Z_{1-\frac{a}{2}}\sqrt{(P_a(1-P_a))} + Z_{1-\beta}\sqrt{(P_a(1-P_a))}\right\}^2}{(P_a - P_o)^2}$$

Where:
N = sample size
Z (1-α/2)= degree of significance at α=0.05; Zα=1.96
Z (1-β) = test strength at β=0.10; Zβ=1.28
Po = the proportion of students who have learning achievement (P1=0.35)
Pa = the proportion of students who do not have learning achievement (P2=0.05)
The sample was 350 junior high school students in Jayapura City.

Procedur

This was a descriptive correlation cross-sectional study, which was carried out to measure the contribution of nutritional status, nutritional knowledge, students' diet, physical activity on affecting the learning achievement of students. The study locations included 38 junior high schools in Jayapura City, Papua Province, Indonesia.

This study used both primary and secondary data, where the secondary data contained demographics and the population of Jayapura City, which were collected from the Central Bureau of Statistics in 2022. Meanwhile, the primary data included knowledge of nutrition, students' diet, physical activity, interest in learning, nutritional status (Body Mass Index), and learning achievement, which were obtained from direct measurement of sample and questionnaires.

Knowledge of nutrition, students' diet, physical activity, interest in learning and academic achievement were measure by a questionnaire that has been tested the validity and reliability. The questionnaire consists of 12 questions to collect data of nutrition knowledge, including the topic of healthy food, unhealthy food, and the impact of food consumption on body and health. Nutrition knowledge is classified to 4 classes, including very low, lack, moderate and good knowledge. Fifteen questions provided about pattern of students' dietary intake. Diet was divided into 3 categories (imbalanced, moderate, and balanced). Physical activity was measure by 10 questions regarding involvement of student in physical activity and the impact of physical activity on students' body. Physical activity was categorized into 3 categories: inactive, moderate and active. Interest in learning is measured by 11 questions regarding how students enjoy learning in school and their interest in learning, it then divided into 4 categories.

Body Mass Index (BMI) obtained from weight and height measurement and calculated by BMI formula (kg/m2). BMI were classified into 5 categories to represent their body fatness based on the cut off points for Asian population: < 16.5 for severely underweight; < 18.5 for underweight; 18.5 to 22.9 for healthy weight; 23 to 24.9 for overweight and ≥ 25 for obesity.

Learning achievement was measured based on students' achievement on their mean value of students' study report. The results were then categories into five. If the result of students' achievement < 71 indicated very low. If the achievement is between 71 to 76 indicated low category. If the value is between 77 to 81, the category is moderate. If the value is between 82 and 86, the category is excellent. Finally, if the value is between 87 and 100, the category is excellent.

This study was conducted through Ethics Review and was granted approval by the Ethics Committee of Cenderawasih University, the registry number of 114/KEPK-FKM UC/2022 on 9th May 2022.

Statistical Analysis

The data obtained on this study were analyzed using descriptive and path analyses. The descriptive analysis was carried out to assess students' BMI, gender, class VII-IX, and Junior High School within the districts of Jayapura City (ordinal data form). Prior to conducting the path analysis, we performed a normality test on the data. The path analysis was used to evaluate multivariate data sets to form a causal model of student achievement in Jayapura City in 2022 (Interval data form). We used IBM SPSS version 26 for all of our analyses.

Results

Body Mass Index (BMI)

BMI obtained from the weight and height of Junior High School students was divided into five categories, namely severely underweight (BMI <16.5), underweight (BMI 16.5-18.4), healthy weight (BMI 18.5-22.9), overweight (BMI 23–24.9), and obesity (BMI >= 25.0). The nutritional status of junior high school students in Jayapura City shows considerable variation between sub-regions. It is striking that areas like North Jayapura and Heram have a relatively high percentage of students classified as overweight (BMI 23 - 24.9), at 16 and 9 respectively, in stark contrast to areas like Abepura, South Jayapura and Muara Tami. A high number of underweight students were found in Abepura (38), Heram (35), South Jayapura (22), North Jayapura and Muara Tami, respectively 18 (figure 1). Severely underweight was found in all areas, with the highest number was in Abepura (9) and Muara Tama (9) (figure 1). Thus, these suggests a major malnutrition challenge in these areas.
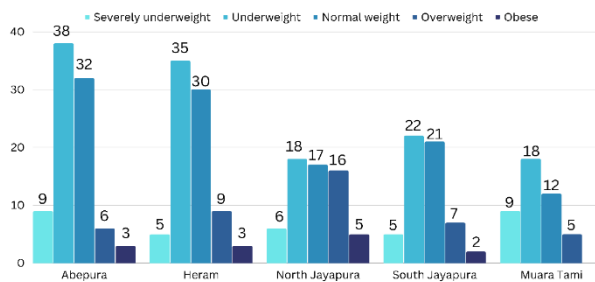

Figure 1. Students' BMI in Jayapura City in 2022 (n = 350)

Univariate Analysis

Junior High School was typically established for male and female students aged 12-15 years. At this stage, adolescents were very vulnerable during their growth and development, which had a relationship with nutritional knowledge, students' diet, physical activity, interest in learning, nutritional status, and academic achievement. The average of the data obtained as well as the normality test were presented in Table 2.

Table 1.
Data Normality Test and Mean (n=350)

Variables	Means	Standard Deviations	Minimum-Maximum	Skewness

NutritionKnowledge	2.22	1.14	1.00–4.00	2.08
Students Diet	1.96	0.88	1.00–3.00	0.60
Physical Activity	17.61	2.31	11.60–9.00 p.m	0.73
Interest in learning	2.22	1.14	1.00–4.00	2.08
Nutritionalstatus	20.33	3.95	16:10–29:40	7.97
Student achievements	68.94	17.75	30.00–98.00	1.9

Note: Nutritional Status value of 7.97 is not ≤ 2 normal standard error skewness values. However, the QQ Plot graph shows that the nutritional status variable is normal, leading to its inclusion in the next statistical test.

Univariate mean and normality tests of Junior High School students were conducted in Jayapura City in 2022. The results showed that the mean nutritional knowledge was 2.22%, meanwhile the minimum value was 1.00 and maximum value was 4.00. Furthermore, the standard deviation was 1.14, and the nutritional knowledge variable was normally distributed, as indicated by the skewness value (*p-value* 2.08 ≤ 2). The mean value of students diet was 1.96% of the minimum and maximum daily consumption values of students, with a standard deviation of 0.88. The skewness value (*p-value* 0.60 ≤ 2) indicated that data on diet variables were normally distributed.

The average number of students engaging in physical activity (sports) at school or home was 17.61% of the minimum and maximum value. Furthermore, the standard deviation was 2.31 and the skewness value (*p-value* 0.73 ≤ 2) indicated normally distributed data. The mean of the variable interest in learning was 2.22% of the minimum and maximum values, with a standard deviation of 1.14. The data on interest in learning were normally distributed based on the skewness value (*p-value* 2.08 ≤ 2).

The mean nutritional status was 20.33% of BMI obtained from the threshold value for the minimum and maximum. The standard deviation was 3.95 and the variable data measured by the QQ Plot graph were normal, but not shown by the skewness value. The mean students' achievement was 68.94% of the minimum and maximum scores recorded, with a standard deviation of 17.75. The skewness value (*p-value* was 1.9 ≤ 2) obtained indicated normal data distribution.

Path Analysis Diagrams

Path analysis could be elucidated through the theory of planned behavior developed by Ingram, etc concerning school students (de Leeuw, Valois, Ajzen, & Schmidt, 2015). The results of nutritional status effect on the students' learning achievement investigated in Jayapura City could be explained as follows:
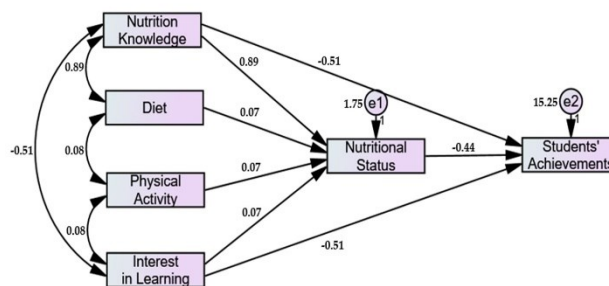

Figure 2. Path analysis diagram.

The path correlation coefficients of students' achievement were summarized in the following model: Correlation coefficients of cause and effect (knowledge of nutrition and diet = 0.89, diet and physical activity = 0.08, physical activity and interest in learning = 0.08, as well as nutrition knowledge and interest in learning = -0.51). The total effect on students was 0.003 from the formed path analysis. Indirect effect correlation coefficients (nutrition knowledge and nutritional status = 0.89, diet and nutritional status = 0.07, and physical activity and nutritional status = 0.07). The total effect was 0.06, indicating an indirect effect on the students' learning achievement. Direct effect correlation coefficients (nutrition knowledge and students' achievement=-0.51, nutritional status and students' achievement=-0.44, and interest in learning and students' achievement = 0.51). The total effect was -0.11, which had a direct effect on students' learning achievement.

The indirect residual variable ($\varepsilon 1$=1.75) was a combination of nutrition knowledge, diet, physical activity, and other variables outside the measured analysis model, as well as measurement errors. Meanwhile, the direct residual variable ($\varepsilon 2$ = 15.25) was a combination of nutritional knowledge, nutritional status, other variables outside the measured analysis model, and measurement errors. The path analysis model formed, namely the direct variable, showed that students' achievement was majorly influenced by nutrition knowledge (-0.51) and interest in learning (-0.51), while the indirect variables with the greatest effect on student achievement were nutrition knowledge and nutritional status (0.89).

Multivariate Analysis

Junior High School students of Class VII to IX in Jayapura City in 2022 were analyzed through exogenous and endogenous variables with an indirect influence. The nutritional status was assessed based on BMI, which was found to be in the normal range (B*=3.09, SE=0.08, and B**=0.89). Furthermore, the results showed that the students' nutrition knowledge affected their nutritional status (*p-value* = 0.001).

Table 2.
Path Analysis (n=350)

Endogenous Variables		Exogenous Variables	B*	SE	B**	p-values
Indirect Effects						
Nutritional status	←	Nutrition Knowledge	3.09	0.08	0.89	0.001
Nutritional status	←	Diet	3.72	0.13	0.83	0.001
Nutritional status	←	Physical Activity	0.12	0.09	0.07	0.167
Direct Effects						
Learning achievements	←	Nutrition Knowledge	-8.03	0.71	-0.51	0.001
Learning achievements	←	Interest in learning	-8.03	0.71	-0.51	0.001
Learning achievements	←	Nutritional status	-1.99	0.21	-0.44	0.001

Note: Direct and indirect effects from exogenous to endogenous variables

The nutritional status could be improved through the consumption of a diet (B* = 3.72, SE = 0.13, and B** = 0.83). The significant results showed that the diet consumed affected this variable (p count = 0.001). BMI was an anthropometric assessment of the students' nutritional status through physical activity (B* = 0.12, SE = 0.09, and B** = 0.07). Based on the results, students' physical activity through sports at school or home had no effect (*p-value* = 0.167).

Analysis was carried out on Class VII to IX Junior High School students in Jayapura City in 2022 using exogenous and endogenous variables, which directly had an effect on learning achievement. The increase in achievement was caused by an improvement in nutrition knowledge (B* = -8.03, SE = 0.71, and B** = -0.51). Furthermore, the results showed that nutrition knowledge had a significant effect on learning achievement (*p-value* = 0.001). Achievement was also improved through an interest in learning (B* = -8.03, SE = 0.71, and B** = -0.51), where students with a high interest had a higher value of this variable (*p-value* = 0.001). Students' achievement was accomplished through optimal nutritional status (B* = -1.99, SE = .21, and B** = -0.44) and the consumption of nutritious food provided enormous benefits.

Discussion

This research aimed to explore the determinants of learning achievement according to nutritional status, nutrition knowledge, dietary intake, physical activity and learning interest. Generally, the obtained results showed that nutrition knowledge and a diet affected nutritional status, but physical activity had no effect. Besides, nutrition knowledge, interest in learning, and nutritional status directly influenced learning achievement. Results of this study will be discussed by comparing our results with previous findings and related theory. The relationship of determinants factors with nutritional status can be understood using UNICEF Conceptual Framework on Maternal and Child nutrition and related theories, will be discussed sequentially as follows.

The Effect of Nutrition Knowledge on Students' Nutritional Status

The results of this study show that nutritional knowledge has an impact on students' nutritional status. Analysis statistics result shows the value *r* = 0.89 (*p-value* =

0.001), this indicates that there is a strong unidirectional relationship between nutritional knowledge and nutritional status. The better students' nutritional knowledge, the better their nutritional status. This finding is in line with previous research conducted on junior high school students (Li et al., 2022), elementary students and university (Belogianni, Ooms, Lykou, & Moir, 2022). Li et al. (2022) found that overweight and obesity is related to nutrition knowledge in adolescents.

Previous studies have found that nutrition literacy contributes to children's dietary habits and nutrition. A study conducted by Zeng et al. (2022) in Chongqing China shows that several factors that influence low nutrition literacy originate from minority groups, live in rural areas, receiving school meal support from government, take care by other caregivers, from poor family with malnutrition and overnutrition. The eating habits of high school children are also influenced by pocket money. Furthermore, a relationship was found between pocket money and consumption patterns and nutritional status (Nurul et al., 2023). Thus, our findings are consistent with previous studies.

According to Lawrence Green's theory, knowledge is one of the perceived factors that can be targeted to deal with health problems related to health behavior (Al Daccache & Bardus, 2022). Interventions aimed at improving nutrition knowledge and behavior in children at junior high school have shown positive results (Abu-Baker, Eyadat, & Khamaiseh, 2021). Previous research showed that school nutrition education interventions should involve multisector, such as stakeholders, government, NGOs, and community (Ashoori et al., 2021). Nutrition education and physical activity programs improved body mass index and eating habits students (Makaracı et al., 2023). Thus, this strategy may improve nutritional status among students.

The Effect of Students Diet on Students' Nutritional Status

The results of this study show that there is a relationship between diet on students' nutritional status, indicated by *r* = 0.07 with *p-value* = < 0.001. This indicate that there is a positive relationship between diet and nutritional status. Accordingly, several previous studies have found the same result (Fatikhani & Setiawan, 2019). Good nutrition helped them to maintain a normal nutritional status. Conversely, the undernourished and poor nutritional status of female or male adolescent students was detected in the group with

bad eating habits, unhealthy dietary patterns, and lack of hygiene.

According to the UNICEF Conceptual Framework on Maternal and Child nutrition, diet is classified as immediate determinants of child nutrition which includes adequate food, adequate feeding, and dietary practices. Besides, nutritional status also determined by good care. Several factors identified as aspects that affects a healthy and diet is household food security, hygiene practices, sanitation, education and social protection services, financial, cultural, and social norms, and gender issue (Darling et al., 2020). Importantly, the age group of students between 12-15 years old was in a very rapid growth and development, where the body parts increased in size in terms of height and weight. The fulfillment of nutritious food intake during puberty among students is crucial, the increased need must be balanced with adequate nutritional intake (Rachmi, Jusril, Ariawan, Beal, & Sutrisna, 2021). Thus, it is also important to determine strategies that ensure children and adolescent can access food, which is nutritious, safe, affordable, attractive, and sustainable.

However, the diet of children and adolescents is experiencing changes which tend to lead to diets high in calories but minimal in vitamins and minerals, for example increasing consumption of processed foods and fast food among adolescent, frequently skip their meal and eating disorders (do Amaral E Melo et al., 2020). This pattern might trigger both undernourished and overweight/obesity among student (Taleb & Itani, 2021). Nutrition Improvement Program (NIP) conducted in rural China have significantly improved in-school education expenditure, eventually children health status and cognitive ability (Wang & Cheng, 2022). Nutrition education might be helpful to help students in choosing a diet as well as creating supporting environment for students to access healthy diet.

The Effect of Physical Activity on Students' Nutritional Status

Our analysis of junior high school students in Jayapura City, Indonesia, suggests a different relationship between physical activity and nutritional status. While physical activity is conventionally associated with improved nutritional health, in our context, its direct impact on students' nutritional status appears to be less significant. This unexpected observation prompts the need for a re-evaluation of traditional beliefs around the influence of physical activity on nutrition (Ross & Melzer, 2016).

Previous literature, notably by Watson, Timperio, Brown, Best, & Hesketh (2017) suggests a direct and strong link between consistent physical routines and improved academic performance and nutrition. In contrast, our findings suggest a more complex in-action in Jayapura City, where the direct benefits of physical activity on nutritional health are allegedly less pronounced. Such differences may be due to local cultural, environmental or socio-economic factors that influence health behaviors (Vidal, Oliveira, Pontes, Maia, & Ferraz, 2022).

Based on our observations, there is a clear need to tailor health education and physical intervention strategies to meet the needs of specific demographics. While the myriad benefits of physical activity cannot be ignored, other factors, such as balanced nutrition and nutrition education, are thought to play a more important role in shaping the health of students in certain demographics (McNamara & Wood, 2019). Our research primarily focuses on Jayapura City, which may limit the generalizability of the results. Furthermore, external factors or potential mediators unique to Jayapura's socio-economic and built environment may not be fully captured, affecting the interactions between observed variables. Relying on BMI for nutritional status may also ignore other important health markers (Irab & Tingginehe, 2020).

Given the surprising results surrounding the impact of physical activity, there is an imperative to explore specific socio-economic, cultural, or environmental mediators in greater depth. Future research should aim to dissect these local nuances across a range of urban environments to determine whether the observations in Jayapura are isolated or indicative of new, broader trends (Irab & Tingginehe, 2020). The combination of results and discussion revealed the complexity of understanding health dynamics in a particular region. The effect of physical activity on nutritional status in Jayapura underscores the importance of context-specific strategies, where traditional beliefs may require adaptation or refinement (Irab & Tingginehe, 2020). In certain demographics, such as Jayapura City, the direct influence of physical activity on students' nutritional status is likely more complex than conventionally assumed. Our findings emphasize the need for tailored health strategies, emphasizing the role of local factors and the importance of balanced nutrition and education.

The Effect of Nutrition Knowledge on Students' Achievement

The relationship between nutritional knowledge and student academic performance, in the context of Jayapura City, presents a complex picture. Surprisingly, there is a clear negative correlation, suggesting that an increase in nutritional knowledge coincides with a decrease in academic performance. This counterintuitive result suggests that while students may have good knowledge of nutrition, other factors may be masking its positive impact on academic success.

Historically, as seen in previous research, a direct relationship has been identified between increased nutritional knowledge and improved student academic outcomes (Mukhamedzhanov, Tsitsurin, Zhakiyanova, Akhmetova, & Tarjibayeva, 2023). Whereas, our findings deviate from the norm, raising questions about the unique dynamics within the educational and socio-cultural landscape of Jayapura. Certain educational or cultural nuances in Jayapura City are thought to influence how nutrition knowledge is integrated into students' daily routines and the subsequent impact on academic success

(Lakshman, Sharp, Ong, & Forouhi, 2010).

The observed negative correlation between nutrition knowledge and academic performance underscores the need for a holistic approach to education. While the development of nutrition knowledge remains important, its synthesis with practical application, presumably including hands-on activities or integration with curriculum subjects, is likely to result in improved academic outcomes. Policy makers and educators should look for ways to ensure that improved nutrition knowledge results in healthier lifestyles and better academic outcomes (Webb & Beckford, 2014; Abu-Baker et al., 2021).

Our focus on Jayapura City students limits the generalizability of these findings to other regions. In addition, potential external influences or intervention variables, which were not included in this study, are likely to play an important role in the observed results. Relying on direct correlations may also not cover the full spectrum of interactions between variables (Fatikhani & Setiawan, 2019; Lakshman et al., 2010; Mukhamedzhanov et al., 2023). The unexpected results in our study warrant further exploration. Future research could explore potential mediating or moderating factors in Jayapura that influence the relationship between nutrition knowledge and academic achievement. In addition, cross-cultural or multi-regional comparative studies are indicated to provide clarity on the generalizability of our observations (Watson et al., 2017; Mukhamedzhanov et al., 2023).

Our results, when juxtaposed with existing literature, highlight the unique intricacies of Jayapura City's academic and nutritional landscape. Bridging the gap between nutrition knowledge and academic performance requires an integrated understanding, ensuring students benefit holistically from their education (Watson et al., 2017; Mukhamedzhanov et al., 2023). Nutrition knowledge, while valuable, poses a conundrum in relation to academic achievement in Jayapura City. Addressing this requires a multifaceted approach, which not only focuses on imparting knowledge but also ensures its practical and beneficial application in students' lives.

The Effect of Nutritional Status on Students' Achievement

The results showed that there was an effect of nutritional status on academic achievement in junior high school students in Jayapura, Indonesia. These results confirm previous findings in Indonesia which show that students' nutritional status is significantly related to academic achievement (Sa'adah, Herman, & Sastri, 2014). Other findings abroad also found the same thing. Katiso, Kerbo, & Dake (2021) in their study in Ethiopia found that there was a significant relationship between nutritional status and student learning outcomes. Other researchers also found the same thing, namely that the nutritional status of students affects students' academic achievement (Haile, Nigatu, Gashaw, & Demelash, 2016).

While the findings of this study are supported by the results of other studies, we found that there are research results that differ from our findings. For example, Maleke, Umboh, & Pateda (2015) in his research proved that there is no significant relationship between nutritional status and students' academic achievement. Annas (2011) reported in his study that there was no significant relationship between nutritional status and student learning achievement. This indicates that studies related to nutritional status and student academic achievement are inconsistent.

We believe that this difference in results may be due to differences in the characteristics of the subjects in the study. In addition to the different characteristics of the research subjects, we also see that the sample size involved between studies is also different. Another reason for the difference in results is the method used to assess nutritional status. As is known, nutritional status assessment can be done directly including anthropometry, clinical, biochemical and biophysical and indirectly, which includes food consumption, vital statistics and ecological factors (Supariasa, 2001). In this study, nutritional status was obtained by anthropometric measurements, namely body weight and height expressed in Body Mass Index (BMI).

Limitations and Further Study Directions

Although we have tried to conduct an in-depth and comprehensive study, we see limitations in this study. As is known, the sampling in this study was conducted by accidental sampling. The use of this sampling technique has a relatively high probability of sampling error. In other words, the sample involved in this study may not reflect the population. That is why the findings of this study lack the power to be generalized in a broader context. When collecting BMI data, several supporting assessments are required to determined students' nutritional status, such as biochemistry assessment or laboratory examination. Secondly, other psychological variables that are closely related to learning achievement, for example, mental toughness, anxiety, religiosity, learning motivation, self-concept, and intelligence were not investigated.

Based on the above limitations, we provide recommendations for future studies as follows: (1) the research sample should be taken using multistage sampling or multistage cluster sampling techniques. The use of these techniques is believed to be better in dealing with the threat of sampling error. Thus, the research results will be generalizable in a broader context. (2) Future research can also consider other groups of students, for example, high school students and elementary school students. With the various levels of students involved, the information on the results of the study will be more complete. (3) Increasing the number of provinces and cities in Indonesia will be very useful information because the addition of these areas will make the study results more comprehensive. (4) Future studies are required to include biochemistry assessment or laboratory examination to justify students' nutritional status.

Conclusions

In conclusion, the indirect effect of exogenous variables on endogenous variables showed that nutrition knowledge and a diet affected nutritional status (0.89; 0.83), but physical activity had no effect (0.07). The direct effect of exogenous variables on endogenous variables further revealed that nutrition knowledge, interest in learning, and nutritional status directly influenced achievement (-0.51, -0.51; respectively). These findings have both theoretical ramifications, enriching our understanding of the role of nutrition in cognition, and practical implications, urging educators and policy makers in areas such as Jayapura to design tailored education programs. However, the study's focus on Jayapura City suggests cautious generalization, as local socio-economic and cultural nuances may not be fully represented. It is important to improve nutritional status through nutritional knowledge as well as diet, therefore this would eventually improve learning achievement.

Acknowledgments

Conflicts of Interest

The authors declare no conflict of interest.

References

Abu-Baker, N. N., Eyadat, A. M., & Khamaiseh, A. M. (2021). The impact of nutrition education on knowledge, attitude, and practice regarding iron deficiency anemia among female adolescent students in Jordan. *Heliyon*, 7(2), e06348. https://doi.org/10.1016/j.heliyon.2021.e06348

Akseer, N., Al-Gashm, S., Mehta, S., Mokdad, A., & Bhutta, Z. A. (2017). Global and regional trends in the nutritional status of young people: a critical and neglected age group. *Annals of the New York Academy of Sciences*, 1393(1), 3–20. https://doi.org/10.1111/nyas.13336

Al Daccache, M., & Bardus, M. (2022). *PRECEDE-PROCEED Model* (C. Fourali & J. French, eds.). The Palgrave Encyclopedia of Social Marketing Springer. https://doi.org/10.1007/978-3-030-14449-4_143-1

Al Ghwass, M. M. E., Halawa, E. F., Sabry, S. M., & Ahmed, D. (2015). Iron deficiency anemia in an Egyptian pediatric population: A cross-sectional study. *Annals of African Medicine*, 14(1), 25–31. https://doi.org/10.4103/1596-3519.148725

Annas, M. (2011). Hubungan Kesegaran Jasmani, Hemoglobin, Status Gizi, dan Makan Pagi terhadap Prestasi Belajar. *Media Ilmu Keolahragaan Indonesia*, 1(2),

192–196. https://doi.org/10.15294/miki.v1i2.2034

Ashoori, M., Omidvar, N., Eini-Zinab, H., Shakibazadeh, E., Doustmohamadian, A., Abdar-Esfahani, B., & Mazandaranian, M. (2021). Food and nutrition literacy status and its correlates in Iranian senior high-school students. *BMC Nutrition*, 7(1), 1–10. https://doi.org/10.1186/s40795-021-00426-2

Asmare, B., Taddele, M., Berihun, S., & Wagnew, F. (2018). Nutritional status and correlation with academic performance among primary school children , northwest Ethiopia. *BMC Research Notes*, 1–6. https://doi.org/10.1186/s13104-018-3909-1

Belogianni, K., Ooms, A., Lykou, A., & Moir, H. J. (2022). Nutrition knowledge among university students in the UK: a cross-sectional study. *Public Health Nutrition*, 25(10), 2834–2841. https://doi.org/10.1017/S1368980021004754

Blossfeld, H. P., Skopek, J., Triventi, M., & Buchholz, S. (2016). *Models of secondary education and social inequality: an international comparison*. Northamton, USA: Edward Elgar Publishing.

Bollwein, J., Volkert, D., Diekmann, R., Kaiser, M. J., Uter, W., Vidal, K., … Bauer, J. M. (2013). Nutritional status according to the Mini Nutritional Assessment (MNA®) and frailty in community dwelling older persons: A close relationship. *Journal of Nutrition, Health and Aging*, 17(4), 351–356. https://doi.org/10.1007/s12603-013-0034-7

Darling, A. M., Sunguya, B., Ismail, A., Manu, A., Canavan, C., Assefa, N., … Guwattude, D. (2020). Gender differences in nutritional status, diet and physical activity among adolescents in eight countries in sub-Saharan Africa. *Tropical Medicine and International Health*, 25(1), 33–43. https://doi.org/10.1111/tmi.13330

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, 42, 128–138. https://doi.org/10.1016/j.jenvp.2015.03.005

do Amaral E Melo, G. R., Silva, P. O., Nakabayashi, J., Bandeira, M. V., Toral, N., & Monteiro, R. (2020). Family meal frequency and its association with food consumption and nutritional status in adolescents: A systematic review. *PLoS ONE*, 15(9), 1–29. https://doi.org/10.1371/journal.pone.0239274

Dumilah, P. R. A., & Sumarmi, S. (2017). Hubungan Anemia Dengan Prestasi Belajar Siswi Di SMP Unggulan Bina Insani. *Amerta Nutrition*, 1(4), 331. https://doi.org/10.20473/amnt.v1i4.7140

Fatikhani, D. A., & Setiawan, A. (2019). The relationship between the level of knowledge regarding fast food and the dietary habits among adolescents in Jakarta, Indonesia. *Enfermeria Clinica*, 29, 172–175. https://doi.org/10.1016/j.enfcli.2019.04.025

Guntoro, T. S., & Putra, M. F. P. (2022). Athletes' religiosity: How it plays a role in athletes' anxiety and life satisfaction. *HTS Teologiese Studies/Theological Studies*, *78*(1), a7802. https://doi.org/10.4102/hts.v78i1.7802

Guntoro, T. S., Sutoro, Putra, M. F. P., Kurdi, Németh, Z., & Setiawan, E. (2023). The role of anthropometry, physical, psychological and personality for elite athletes in competitive sports. *Pedagogy of Physical Culture and Sports*, *27*(4), 331–339. https://doi.org/10.15561/26649837.2023.0409

Guntoro, T. S., Wandik, Y., Sutoro, Kristiyandaru, A., Kamaruddin, I., Mashud, … Putra, M. F. P. (2024). Online Lectures for Sports and Non-Sports Study Program Students: Interrelation of Attitudes, Involvement, Satisfaction, Happiness, and Learning Achievement. *Retos*, *57*(2020), 371–378. https://doi.org/10.47197/retos.v57.107222

Haile, D., Nigatu, D., Gashaw, K., & Demelash, H. (2016). Height for age z score and cognitive function are associated with academic performance among school children aged 8-11 years old. *Archives of Public Health*, *74*(1), 1–7. https://doi.org/10.1186/s13690-016-0129-9

Irab, S. P., & Tingginehe, R. M. (2020). Benefits of Halogen Nutrition for Human Health in Papua Province Indonesia. *International Journal of Advanced Research*, *8*(7), 712–719. https://doi.org/10.21474/ijar01/11330

Katiso, S. W., Kerbo, A. A., & Dake, S. K. (2021). Adolescents' nutritional status and its association with academic performance in South Ethiopia; a facility-based cross-sectional study. *BMC Nutrition*, *7*(1), 1–9. https://doi.org/10.1186/s40795-021-00420-8

Kogoya, K., Guntoro, T. S., & Putra, M. F. P. (2022). Sports Event Image, Satisfaction, Motivation, Stadium Atmosphere, Environment, and Perception: A Study on the Biggest Multi-Sport Event in Indonesia during the Pandemic. *Social Sciences*, *11*(6), 1–13. https://doi.org/10.3390/socsci11060241

Kogoya, K., Hijjang, P., Ahmad, K., Guntoro, T. S., Amali, Z., Ita, S., … Hidayat, R. R. (2024). Sports and culture: a perspective of the indigenous people of Papua, Indonesia. *SPORT TK-EuroAmerican Journal of Sport Sciences*, *13*(2), 1–15.

Kogoya, K., Hijjang, P., Ahmad, K., Guntoro, T. S., Amali, Z., Ita, S., … Putra, M. F. P. (2024). How is the role of sports in forming nationalism? A study on the most significant sports event in Indonesia. *SPORT TK-EuroAmerican Journal of Sport Sciences*, *13*(1), 1–10. https://doi.org/10.6018/sportk.568991

Lakshman, R. R., Sharp, S. J., Ong, K. K., & Forouhi, N. G. (2010). A novel school-based intervention to improve nutrition knowledge in children: Cluster randomised controlled trial. *BMC Public Health*, *10*, 1–9. https://doi.org/10.1186/1471-2458-10-123

Li, S., Zhu, Y., Zeng, M., Li, Z., Zeng, H., Shi, Z., & Zhao, Y. (2022). Association Between Nutrition Literacy and Overweight/Obesity of Adolescents: A Cross–Sectional Study in Chongqing, China. *Frontiers in Nutrition*, *9*(May), 1–9. https://doi.org/10.3389/fnut.2022.893267

Makaracı, Y., Yücetaş, Z., Devrilmez, E., Soslu, R., Devrilmez, M., Akpınar, S., & Popovic, S. (2023). Physical Activity and Nutrition Education Programs Changes Body Mass Index and Eating Habits of 12th Grade Students: An Intervention during the COVID-19 Pandemic. *Annals of Applied Sport Science*, *11*(2). https://doi.org/10.52547/aassjournal.1105

Maleke, V., Umboh, A., & Pateda, V. (2015). Hubungan Status Gizi Dengan Prestasi Belajar Siswa Sekolah Dasar Di Kecamatan Modoinding. *Jurnal E-CliniC*, *3*(3), 749–753. https://doi.org/10.35790/ecl.3.3.2015.9420

McNamara, K., & Wood, E. (2019). Food taboos, health beliefs, and gender: understanding household food choice and nutrition in rural Tajikistan. *Journal of Health, Population, and Nutrition*, *38*(1), 17. https://doi.org/10.1186/s41043-019-0170-8

Mukhamedzhanov, E., Tsitsurin, V., Zhakiyanova, Z., Akhmetova, B., & Tarjibayeva, S. (2023). The Effect of Nutrition Education on Nutritional Behavior, Academic and Sports Achievement and Attitudes. *International Journal of Education in Mathematics, Science and Technology*, *11*(2), 358–374. https://doi.org/10.46328/ijemst.3133

Mustafa, S., Haque, C. E., & Baksi, S. (2021). Low Daily Intake of Fruits and Vegetables in Rural and Urban Bangladesh: Influence of Socioeconomic and Demographic. *Nutrients*, *13*(8), 2808.

Nugraheni, A. N., Latifah, E., & Wijayatri, R. (2023). Influence of Knowledge Level about Anemia and Menstrual Patterns on Adherence to Consumption Iron Supplement in Adolescents at A Public Senior High School in Magelang. *Pharmacon: Jurnal Farmasi Indonesia*, *20*(1), 68–77. https://doi.org/10.23917/pharmacon.v20i1.21904

Nurul, A., Hakimi, Q., Sholichah, F., Hayati, N., Studi, P., Universitas, G., … Semarang, W. (2023). Hubungan Uang Saku dan Pola Konsumsi Makanan Terhadap Status Gizi Siswa SMP Negeri 16 Semarang. *Jurnal Ilmiah Gizi Dan Kesehatan*, *4*(02), 32–36. https://doi.org/10.46772/jigk.v4i02.1047

Panel, E., & Products, D. (2021). General scientific guidance for stakeholders on health claim applications (Revision 1)1. *EFSA Journal*, *19*(3), 1–44. https://doi.org/10.2903/j.efsa.2021.6553

Putra, M. F. P., & Guntoro, T. S. (2022). Competitive State Anxiety Inventory–2R (CSAI-2R): Adapting and Validating Its Indonesian Version. *International Journal of Human Movement and Sports Sciences*, *10*(3), 396–403. https://doi.org/10.13189/saj.2022.100305

Putra, M. F. P., Guntoro, T. S., Wandik, Y., Ita, S., Sinaga, E., Hidayat, R. R., … Rahayu, A. S. (2021). Psychometric properties at Indonesian version of the Sport Anxiety Scale-2: Testing on elite athletes of

Papua, Indonesian. *International Journal of Human Movement and Sports Sciences*, *9*(6), 1477–1485. https://doi.org/10.13189/saj.2021.090645

Putra, M. F. P., Kurdi, Syahruddin, S., Hasibuan, S., Sinulingga, A., Kamaruddin, I., … Hariadi, I. (2024). An Indonesian Version of Mental Toughness Index: Testing Psychometric Properties in Athletes and Non-athletes. *Retos*, *55*, 816–824. https://doi.org/10.47197/retos.v55.106086

Putra, M. F. P., Sutoro, Guntoro, T. S., Sinaga, E., Wanena, T., Rahayuni, K., … Wandik, Y. (2024). Cross-cultural adaptation of the psychological performance inventory-alternative (PPI-A) for the Indonesian context. *Retos*, *2041*, 990–997. https://doi.org/10.47197/retos.v56.103765

Rachmi, C. N., Jusril, H., Ariawan, I., Beal, T., & Sutrisna, A. (2021). Eating behaviour of Indonesian adolescents: a systematic review of the literature. *Public Health Nutrition*, *24*(Lmic), S84–S97. https://doi.org/10.1017/S1368980020002876

Ross, A. M., & Melzer, T. (2016). Beliefs as barriers to healthy eating and physical activity. *Australian Journal of Psychology*, *68*(4), 251–260. https://doi.org/10.1111/ajpy.12103

Sa'adah, R. H., Herman, R. B., & Sastri, S. (2014). Hubungan Status Gizi dengan Prestasi Belajar Siswa Sekolah Dasar Negeri 01 Guguk Malintang Kota Padangpanjang. *Jurnal Kesehatan Andalas*, *3*(3), 460–465. https://doi.org/10.25077/jka.v3i3.176

Sinaga, E., Padang, J. T., Womsiwor, D., Ita, S., & Sinaga, E. (2023). The Examination of the Knowledge Level of Young Papuan Female Athletes about Female Athletes Triad (FAT). *Amerta Nutrition*, *7*(4), 576–582. https://doi.org/10.20473/amnt.v7i4.2023.576-582

Supariasa, I. D. N. (2001). *Penilaian status gizi*. Jakarta: EGC.

Sutoro, Guntoro, T. S., & Putra, M. F. P. (2023). Development and validation mental training model: Mental Toughness Training Circle (MTTC). *F1000Reserach*, *12*(169), 1–36. https://doi.org/10.12688/f1000research.129010.1

Taleb, S., & Itani, L. (2021). Nutrition Literacy among Adolescents and Its Association with Eating Habits and BMI in Tripoli, Lebanon. *Diseases*, *9*(2), 25. https://doi.org/10.3390/diseases9020025

Vidal, D. G., Oliveira, G. M., Pontes, M., Maia, R. L., & Ferraz, M. P. (2022). The influence of social and economic environment on health. In *One Health: Integrated Approach to 21st Century Challenges to Health* (pp. 205–229). https://doi.org/10.1016/B978-0-12-822794-7.00005-8

Wandik, Y., Dina, Guntoro, T. S., Sutoro, Wambrauw, O. O. O., Abidjulu, C. F., … Putra, M. F. P. (2024). Interrelation of mental toughness, religiosity, and happiness of elite adolescent athletes based on gender, type of sport, and level of education. *Retos*, *56*, 981–989. https://doi.org/10.47197/retos.v56.103469

Wang, H., & Cheng, Z. (2022). Kids eat free: School feeding and family spending on education. *Journal of Economic Behavior & Organization*, *193*, 196–212. https://doi.org/10.1016/J.JEBO.2021.11.023.

Watson, A., Timperio, A., Brown, H., Best, K., & Hesketh, K. D. (2017). Effect of classroom-based physical activity interventions on academic and physical activity outcomes: A systematic review and meta-analysis. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1). https://doi.org/10.1186/s12966-017-0569-9

Webb, M. C., & Beckford, S. E. (2014). Nutritional knowledge and attitudes of adolescent swimmers in Trinidad and Tobago. *Journal of Nutrition and Metabolism*, *2014*. https://doi.org/10.1155/2014/506434

Yurisna, Sattu, M., Lanyumba, F. S., & Otoluwa, A. S. (2023). Gambaran Asupan Gizi Makro, Vitamin D Dan Aktivitas Fisik Pada Remaja Obesitas Di SMP Kota Luwuk Tahun 2022: Overview of Macronutrient Intake, Vitamin D and Physical Activity in Obese Adolescents in Luwuk City Junior High School in 2022. *Buletin Kesehatan MAHASISWA*, *1*(2), 61–68. https://doi.org/10.51888/JPMEO.V1I2.159

Zeng, M., Zhu, Y., Cai, Z., Xian, J., Li, S., Wang, T., … Zhao, Y. (2022). Nutrition Literacy of Middle School Students and Its Influencing Factors: A Cross-Sectional Study in Chongqing, China. *Frontiers in Public Health*, *10*(March). https://doi.org/10.3389/fpubh.2022.807526

Datos de los/as autores/as:

Semuel Piter Irab	samuelirab@gmail.com	Autor/a
Marlina Flassy	flassymarlina@gmail.com	Autor/a
Agus Zainuri	azainuri_fkm@yahoo.com	Autor/a
Evi Sinaga	evitioria.sinaga@gmail.com	Autor/a
Rodhi Rusdianto Hidayat	hidayatrod@gmail.com	Autor/a
Yos Wandik	yoswandik21@gmail.com	Autor/a
Miftah Fariz Prima Putra	mifpputra@gmail.com	Autor/a
Evi Sinaga	evitioria.sinaga@gmail.com	Traductor/a