

Universitas Muhammadiyah Yogyakarta Dental Students' Macronutrient Intake, Nutritional Status, and Immune System in the Context of the COVID-19 Pandemic

Ana Medawati^{1*}, Atiek Driana Rahmawati², Ika Andriani³, Lisha Aprilyanti⁴
Universitas Muhammadiyah Yogyakarta

Corresponding Author: Ana Medawati ana.medawati@umy.ac.id

ARTICLE INFO

Keywords: Covid-19,
Nutritional, Yogyakarta

Received: 12 December

Revised: 3 January

Accepted: 17 February

©2025 Medawati, Rahmawati, Andriani, Aprilyanti: This is an open-access article distributed under the terms of the [Creative Commons Atribusi 4.0 Internasional](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

This research aims to determine the relationship between macronutrient intake, nutritional status, and the immune system during the COVID-19 pandemic. This cross-sectional analytical observational study involved 89 UMY class of 2018 dental students and employed total sampling. BMI measured nutritional status; FFQ was calibrated with a 24-hour meal recall questionnaire to assess macronutrient intake; and ISQ assessed the immune system. Data was analyzed using the Spearman Rank test. The findings indicated that protein (48.3%), fat (49.4%), and carbohydrates (93.3%) were the most lacking in respondents' macronutrients. Nutrition was normal (65.2%), and immunological function was unchanged (75.3%). Protein, fat, and carbohydrate intake did not affect the immune system ($p=0.281$, 0.128 , and 0.648), and nutrition and immunity have a significant relationship ($p=0.000$)

INTRODUCTION

The emergence of COVID-19 was initially observed in Wuhan, China, in late December 2019, prompting the WHO (World Health Organization) to classify it as a global health emergency (Weston & Frieman, 2020). WHO documented a total of 32,110,656 global cases on September 26, 2020 (Zeng et al., 2021). Thus, the immune system serves as a means of safeguarding and fortifying against COVID-19 by eliminating harmful elements, such as viruses, which infiltrate the body (Chand, 2020).

Several factors can impact the immune system. Nevertheless, optimal and suitable nutritional conditions are crucial for a robust immune system capable of overcoming invading microorganisms and safeguarding the body against diseases³. According to Chandra, a correlation can be observed between immunity status and nutritional status (Chandra, 1997).

Moreover, the COVID-19 pandemic has led to several alterations in societal activities. One of them led to the implementation of a distance learning system for learning activities. The transition from a traditional face-to-face learning system to an online system induces stress among students (PH et al., 2020). This could potentially influence the development of unhealthy eating habits. Using food as a coping mechanism for stress involves eating not out of hunger but only to fulfill a need due to an inability to handle the current strain. Conversely, certain individuals encounter stress and then consume minimal or no sustenance. This habit would influence the amount of food consumed and the overall nutritional status of the body (Wijayanti et al., 2019).

On the other side, nutritional components exhibit a substantial influence on bolstering the immune system. When the body is in a state of nutritional deficiency, malnutrition can occur, which can inhibit the immune system (Bourke et al., 2016). Deficiencies in macronutrient elements (fat, carbs, and protein) might impair immune function and cause harm (Dewi Rahmawati & Rakhma, 2024).

Hence, the objective of this investigation is to establish the link between eating many macronutrients, being healthy, and having a strong immune system in dental students of the 2018 class at Universitas Muhammadiyah Yogyakarta, specifically amid the COVID-19 pandemic.

LITERATURE REVIEW

This conceptual framework highlights the interconnectedness of macronutrient intake and nutritional status during the pandemic, emphasizing the importance of the immune system against COVID-19.

Macronutrient Intake

This includes proteins, carbohydrates, and fats, which are essential for overall health and immune function. Adequate intake of these macronutrients supports metabolic processes that are crucial during infections like COVID-19.

Nutritional Status

This reflects the overall dietary quality and nutrient sufficiency in an individual. Poor nutritional status can lead to deficiencies that impair immune responses.

Immune System

A well-functioning immune system is vital for combating infections. The relationship indicates that both macronutrient intake and nutritional status directly influence immune health, especially in the context of viral infections such as COVID-19.

In the Context of COVID-19 Pandemic

The COVID-19 pandemic has underscored the critical relationship between macronutrient intake, nutritional status, and immune system functionality. Literature highlights that adequate macronutrient consumption – specifically proteins, carbohydrates, and fats – is essential for maintaining overall health and supporting immune responses. During the pandemic, many individuals experienced dietary changes due to lockdowns, leading to increased consumption of unhealthy foods and a decline in physical activity. This shift has been linked to a rise in obesity rates and malnutrition, both of which can impair immune function and increase susceptibility to infections, including COVID-19 (Clemente-Suárez et al., 2021; Mentella et al., 2021). Studies indicate that deficiencies in key nutrients such as vitamins C, D, B12, and minerals like zinc and selenium are prevalent among hospitalized COVID-19 patients, suggesting that proper nutritional status is vital for recovery and may influence disease severity (Galmés et al., 2020; Mentella et al., 2021).

Furthermore, research emphasizes the role of specific nutrients in modulating immune responses. For instance, vitamin D is recognized for its immunomodulatory effects, with evidence suggesting that adequate levels may reduce the risk of severe COVID-19 outcomes (Clemente-Suárez et al., 2021; Ebrahimzadeh-Attari et al., 2021). The interplay between nutrition and immune health illustrates the importance of dietary interventions not only for preventing infection but also for enhancing recovery in infected individuals. As such, addressing nutritional deficiencies through targeted dietary strategies could serve as a cost-effective approach to bolster public health during ongoing and future pandemics (Ebrahimzadeh-Attari et al., 2021; Rust & Ekmekcioglu, 2023).

METHODOLOGY

As many as 89 dentistry students from the Universitas Muhammadiyah Yogyakarta class of 2018 participated in this cross-sectional design analytical observational study, which used a complete sample technique. The inclusion criteria used were active dental students at Universitas Muhammadiyah Yogyakarta class of 2018 who were prepared to complete informed consent. The exclusion criteria were students who were currently affected by COVID-19, did not collect informed consent, and did not fill in the data completely. The influencing variables in this study comprised macronutrient intake, namely protein, fat, and carbohydrates, and nutritional status. The variable affected was the immune system.

Macronutrient intake, i.e., protein, fat, and carbohydrates, was obtained through FFQ (Food Frequency Questionnaire) and calibrated using a 1x24-hour food recall questionnaire. Nutritional status was obtained through anthropometric assessment by calculating BMI (Body Mass Index). Meanwhile, the evaluation of the immune system was conducted utilizing the Immune Status Questionnaire (ISQ).

When collecting data on macronutrient intake, the research subjects were asked to fill out an FFQ via Google Forms and write down all the food and drinks consumed during the day on the previous day. The data were then processed using NutriSurvey computer software. Then, macronutrient intake data were taken on average per day for each research subject and grouped into categories of deficient (<80%), sufficient (80-110%), and excessive (>110%) (Dewi Rahmawati & Rakhma, 2024).

Anthropometric data were obtained through BMI, the quotient of body weight by height in square meters. Then, the data were categorized into over-nutrition (>25 kg/m²), normal nutrition (18.5-25.0 kg/m²), as well as under-nutrition (<18.5 kg/m²) (Kementerian Kesehatan Republik Indonesia, 2014). Apart from that, the assessment of the immune system with the ISQ consisted of seven question items, which were then interpreted into a final score (scores ranged from 1-10). If the ISQ score is <6, there is a reduction in immune system function (Wilod Versprille et al., 2019). Following that, the data were tested univariately to ascertain the distribution of the data through the Kolmogorov-Smirnov test since the subjects were >50. Then, a bivariate analysis was conducted using the Rank-Spearman test due to the non-normal distribution of the data, with the objective of ascertaining the association between variables.

The study has obtained approval from the Health Research Ethics Council of the Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, as evidenced by Ethical Clearance (EC) No. 177/EC-KEPK FKIK UMY/VI/2021.

RESULTS

The research results revealed that the characteristics of the research subjects were macronutrient intake, nutritional status, and immune status, as displayed in Table 1. The characteristics of respondents based on macronutrients were mostly protein, fat, and carbohydrate intake in the deficient category. Based on the protein intake of 43 respondents (48.3%), the fat intake of 44 respondents (49.4%), and the carbohydrate intake of 83 respondents (93.3%), they were in the deficient category. Most of the distribution of nutritional status fell into the normal nutrition category, with 58 respondents (65.2%). Also, the immune status of 67 respondents (75.3%) did not experience a decline in their immune system, while the remaining 22 respondents (24.7%) experienced a decline in their immune system.

Based on the bivariate analysis presented in Table 2, a variable related to immune status was obtained, namely nutritional status ($p < 0.05$). This relationship had sufficient or moderate correlation because the r values were > 0.25 and < 0.5 . The variable influence of macronutrients, namely protein, fat, carbohydrates, and energy, overall, their relationship with immune status was not statistically significant ($p > 0.05$).

Table 1. Descriptive of Subject Characteristics

Variable	N	%
Macronutrient		
Protein		
Deficient (<80% AKP)	43	48.3
Sufficient (80-110% AKP)	28	31.5
Excessive (>110% AKP)	18	20.2
Fat		
Deficient (<80% AKL)	44	49.4
Sufficient (80-110% AKL)	26	29.2
Excessive (>110% AKL)	19	21.3
Carbohydrate		
Deficient (<80% AKK)	83	93.3
Sufficient (80-110% AKK)	4	4.5
Excessive (>110% AKK)	2	2.2
Energy		
Deficient (<80% AKE)	68	76.4

Sufficient (80-110% AKE)	18	20.2
Excessive (>110% AKE)	3	3.4
Nutritional status		
Over-nutrition (>25 kg/m ²)	17	19.1
Normal nutrition (18.5-25.0 kg/m ²)	58	65.2
Under-nutrition (<18.5 kg/m ²)	14	15.7
Immune Status		
Decreased (>6)	22	24.7
No decrease (≤6)	67	75.3

Table 2. Bivariate Analysis of Macronutrient Intake and Nutritional Status with the Immune System

Immune System	
r	p-value
0.116	0.281
0.163	0.128
-0.049	0.648
0.67	0.535
0.369	0.000*

*The Rank-Spearman correlation test is significant at the 0.05 level (2-tailed).

DISCUSSION

The research results in Table 1 exhibit that the macronutrient intake of final year dental students, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, class of 2018, was mostly in the deficient category (<80% RDA) for protein, fat, and carbohydrate intake. This aligns with research by Dewi regarding the consumption of nutritious food intake consisting of rice, fruit, side dishes, and vegetables among final-year sixth-semester students, with as many as 52% of respondents rarely consuming them. Findings are also consistent with those conducted by Cornia and Andriani that the results of macronutrient intake in UKM Taekwondo students in the form of carbohydrate intake (92.3%), energy intake (92.3%), and fat intake (86.53%) were in the deficient category, while protein intake (63.4%) was in the sufficient category (Cornia & Adriani, 2018). In contrast to research by Syafira Salsabilla, an average of 53,45% of students' eating patterns were classified into the moderate category, meaning that their consumption of nutritious food was sufficient (Salsabilla, 2017).

According to Angraini and Ayu, deficient food intake may be caused by students who mostly live alone, causing no one to prepare and pay attention to food when they get home or at the boarding house (Angraini & Ayu, 2014). In this study, several subjects said that when the research was conducted, they were in a KKN (Community Service) location, where their food intake received little attention. As a result, their nutritional intake was less than sufficient. Rika Fitriani asserted that nutritional status, as measured using BMI, is related to a person's nutritional status, and food intake is also associated with a person's level of nutritional knowledge (Fitriani, 2020).

Further, the nutritional status results of most students were in the normal classification as many as 58 respondents (65.2%), over-nutrition as many as 17 respondents (19.1%), and under-nutrition as many as 14 respondents (15.7%). The findings of this study corroborate with those performed by Roring, showing that most nutritional status fell into the normal (43.4%), over-nutrition (29.9%), and under-nutrition (26.9%) categories (Roring et al., 2020). Compared to research conducted by Pratami (2016), more final-year students had a higher nutritional status of 36.1% (Pratami et al., 2016).

This differs from the theory previously explained that during the COVID-19 pandemic, there will be eating pattern changes as a result of stress or changes in activity, which can impact the nutritional status of a person. In this sense, other factors influence nutritional status, namely the level of knowledge and physical activity (Roring et al., 2020). The results of interviews from several respondents obtained in this research demonstrated that several respondents already knew and were aware of maintaining health during the COVID-19 pandemic, such as having adjusted their food consumption patterns, exercising regularly, and being used to managing stress because of activities' changes amid the COVID-19 pandemic.

Additionally, the majority of students did not experience a decrease in their immune system, as many as 67 (75.3%), and the remaining 22 students experienced a decrease in their immune system (24.7%). The results of other research on immunity status revealed that abnormal immunity status in toddlers was 65.7%, and normal immunity status in toddlers was 34.3% (Noviyanti & Sarbini, 2010). Here, age influenced protein status, which had no relationship with the immune system ($p = 0.281$). This is because the research subjects' protein intake was very low, far below normal recommendations. In fact, protein intake is needed by the immune system and functions in the formation of antibodies. Consequently, the amount of protein intake influences the number of antibodies formed (Wanty et al., 2017). However, this study aligns with findings from Retno, which indicated no significant correlation between protein intake and immune status ($p = 0.255$) (Noviyanti & Sarbini, 2010).

Then, the fat intake in the table had no relationship with the immune system ($p = 0.128$). The findings of this study also do not match the theory because the fat intake of the research subjects was below normal. A lack of linoleic acid (omega-6 fatty acid) can suppress the antibody response, thereby eliminating the function of T-cells (one of the main components of the immune system). A study carried out by Fatmah exhibited that in older people, there was an increase in phospholipids compared to young people. The composition of these lipids can cause changes in the body's immunity so that, in old age, the body's immunity tends to decrease compared to young people (Fatmah, 2006).

The research results in Table 2 also show the association between macronutrient intake and nutritional status with the immune system. Macronutrient intake, consisting of protein, fat, and carbohydrates, was not related to the immune system. The table reveals that carbohydrate intake was not related to the immune system ($p = 0.648$). Fundamentally, carbohydrate intake acts as the body's main energy source. If carbohydrate intake is not met, the body will remodel other energy reserves (Fitriyah & Setyaningtyas, 2021). Lack of carbohydrate intake can cause energy deficiency and will be associated with impaired cell-mediated immunity and impaired secretion of immunoglobulin antibodies and cell phagocytic function (Unawekla et al., 2018).

Also, nutritional status in the table had a relationship with the immune system ($p = 0.000$). This study contradicts Retno's findings, which reported no correlation between nutritional status and the immune system (Noviyanti & Sarbini, 2010). Nevertheless, according to Supariasa et al., lack of nutritional intake related to nutritional status will directly influence the emergence of disease in children under five (Alam et al., 2019). Angraini and Ayu added that the contribution of a person's nutritional status does not have much influence on the formation of the body's immune system (Angraini & Ayu, 2014). LBW (Low Birth Weight) in babies 2.3 times boosts the risk of contracting infectious diseases and impacts the body's immunity (Raqib et al., 2007).

Essentially, measuring immunity can be seen from the levels of lymphocytes in the body. Lymphocyte levels will decrease if there is an energy restriction caused by a lack of nutritional intake that is related to a person's nutritional status. Decreased lymphocyte levels will result in the body being susceptible to infectious diseases and inhibiting cell activation in the immune system (Devaguru et al., 2023). Nutritional status is important for the immune response (Siagian, 2005).

This research does not prove a link between macronutrient intake and the immune system. This happens because, apart from nutritional intake, other factors influence the immune system. Aside from macronutrient intake, other factors can influence immune status, including genetics, age, hormones, infections, alcohol, smoking, and micronutrient intake (Carpenter et al., 2013). Other research states that immunity can easily be increased with physical exercise and adequate rest. Depression or fluctuations in immune function occur 3-24 hours after exercise, depending on the intensity of the exercise carried out (Sukendra, 2015). Factors influencing body immunity, in addition to macronutrients, are the intake of micronutrients, including vitamins A, B, C, D, E, zinc, selenium, iron, and phytochemicals (Iddir et al., 2020). This statement is supported by Adijaya and Bakti, who stated that micronutrient consumption is critical for strengthening the immune system. During COVID-19, an increase in respiratory tract infections occurred, one of which was due to nutritional deficiencies. Thus, preventing COVID-19 infection can be done by increasing micronutrients in the body (Adijaya & Bakti, 2021). Stress and anger can also affect the immune system. The health of older people with stress shows that IL-6 levels increase fourfold faster, making them susceptible to disease (Scanlan et al., 2001).

This research has many limitations, including not assessing other factors that cause changes in the immune system besides macronutrient intake and nutritional status. Other factors can include micronutrient intake, age, physical activity, age, stress level, and others. Therefore, future research can pay attention to other factors causing changes in the immune system. Other measuring tools can also be utilized with more detailed systems to measure the status of the immune system.

CONCLUSIONS AND RECOMMENDATIONS

Drawing from the findings and discourse around the correlation among dentistry students at Universitas Muhammadiyah Yogyakarta between macronutrient intake, nutritional status, and the immune system throughout the COVID-19 pandemic, the following conclusions can be drawn:

There is no correlation between macronutrient intake and students' immune systems amid the COVID-19 pandemic, and there is an association between nutritional status and students' immune systems during the COVID-19 pandemic.

ACKNOWLEDGMENT

The authors thank the Faculty of Dentistry, Universitas Muhammadiyah Yogyakarta, for their support in this research.

REFERENCES

- Adijaya, O., & Bakti, A. P. (2021). PENINGKATAN SISTEM IMUNITAS TUBUH DALAM MENGHADAPI PANDEMI COVID-19 Okta Adijaya Ananda Perwira Bakti. *Jurnal Kesehatan Olahraga*, 51–60.
- Alam, I., Almajwal, A. M., Alam, W., Alam, I., Ullah, N., Abulmeaty, M., Razak, S., Khan, S., Pawelec, G., & Paracha, P. I. (2019). The immune-nutrition interplay in aging – facts and controversies. *Nutrition and Healthy Aging*, 5(2), 73–95. <https://doi.org/10.3233/NHA-170034>
- Angraini, D. I., & Ayu, R. P. (2014). The Relationship Between Nutritional Status and Immunonutrition Intake With Immunity Status. *Juke*, 4(8), 158–165.
- Bourke, C. D., Berkley, J. A., & Prendergast, A. J. (2016). Immune Dysfunction as a Cause and Consequence of Malnutrition. *Trends in Immunology*, 37(6), 386–398. <https://doi.org/10.1016/j.it.2016.04.003>
- Carpenter, K., Strohacker, K., & McFarlin, B. (2013). Considerations to maximize fat mass gain in a mouse model of diet-induced weight gain. *Laboratory Animals*, 47(4), 266–273. <https://doi.org/10.1177/0023677213501658>
- Chand, V. (2020). Nutrition as a Key Weapon in Strengthening Immune System Relative to Pandemic Novel Coronavirus Disease (COVID-19): A Review. *Journal of Health Sciences and Research (Www.Ijhsr.Org)*, 10(8), 96.
- Chandra, R. (1997). Nutrition and the immune system: an introduction. *The American Journal of Clinical Nutrition*, 66(2), 460S–463S. <https://doi.org/10.1093/ajcn/66.2.460S>
- Clemente-Suárez, V. J., Ramos-Campo, D. J., Mielgo-Ayuso, J., Dalamitros, A. A., Nikolaidis, P. A., Hormeño-Holgado, A., & Tornero-Aguilera, J. F. (2021). Nutrition in the Actual COVID-19 Pandemic. A Narrative Review. *Nutrients*, 13(6), 1924. <https://doi.org/10.3390/nu13061924>
- Cornia, I. G., & Adriani, M. (2018). Hubungan Antara Asupan Zat Gizi Makro dan Status Gizi dengan Kebugaran Jasmani Mahasiswa UKM Taekwondo. *Amerta Nutrition*, 2(1), 90. <https://doi.org/10.20473/amnt.v2i1.2018.90-96>
- Devaguru, A., Gada, S., Potpalle, D., Dinesh Eshwar, M., & Purwar, D. (2023). The Prevalence of Low Birth Weight Among Newborn Babies and Its Associated Maternal Risk Factors: A Hospital-Based Cross-Sectional Study. *Cureus*. <https://doi.org/10.7759/cureus.38587>
- Dewi Rahmawati, N. I., & Rakhma, L. R. (2024). The Association Between Energy Adequacy Level And Physical Activity With Nutritional Status In Adolescents At Walisongo High School, Ketanggungan. *Eduvest - Journal of Universal Studies*, 4(7), 5612–5629. <https://doi.org/10.59188/eduvest.v4i7.1211>
- Ebrahimzadeh-Attari, V., Panahi, G., Hebert, J. R., Ostadrahimi, A., Saghafi-Asl, M., Lotfi-Yaghin, N., & Baradaran, B. (2021). Nutritional approach for increasing public health during pandemic of COVID-19: A comprehensive review of antiviral nutrients and nutraceuticals. *Health Promotion Perspectives*, 11(2), 119–136. <https://doi.org/10.34172/hpp.2021.17>
- Fatmah. (2006). Respons imunitas yang rendah pada tubuh manusia usia lanjut. *Makara Seri Kesehatan*, 10(1), 47–53.
- Fitriani, R. (2020). Hubungan Antara Pengetahuan Gizi Seimbang, Citra Tubuh,

- Tingkat Kecukupan Energi dan Zat Gizi Makro dengan Status Gizi pada Siswa SMA Negeri 86 Jakarta. *Journal Health & Science : Gorontalo Journal Health and Science Community*, 4(1), 29–38. <https://doi.org/10.35971/gojhes.v4i1.5041>
- Fitriyah, N., & Setyaningtyas, S. W. (2021). HUBUNGAN ASUPAN ENERGI, MAKRONUTRIEN, ZINK DAN FE DENGAN UNDERWEIGHT PADA IBU DAN BALITA DI DESA SUWARI BAWEAN, GRESIK. *Media Gizi Kesmas*, 10(1), 56. <https://doi.org/10.20473/mgk.v10i1.2021.56-62>
- Galmés, S., Serra, F., & Palou, A. (2020). Current State of Evidence: Influence of Nutritional and Nutrigenetic Factors on Immunity in the COVID-19 Pandemic Framework. *Nutrients*, 12(9), 2738. <https://doi.org/10.3390/nu12092738>
- Iddir, M., Brito, A., Dingo, G., Fernandez Del Campo, S. S., Samouda, H., La Frano, M. R., & Bohn, T. (2020). Strengthening the Immune System and Reducing Inflammation and Oxidative Stress through Diet and Nutrition: Considerations during the COVID-19 Crisis. *Nutrients*, 12(6), 1562. <https://doi.org/10.3390/nu12061562>
- Kementerian Kesehatan Republik Indonesia. (2014). *Peraturan Menteri Kesehatan Nomor 41 Tahun 2014 tentang Pedoman Gizi Seimbang*.
- Mentella, M. C., Scaldaferrri, F., Gasbarrini, A., & Miggiano, G. A. D. (2021). The Role of Nutrition in the COVID-19 Pandemic. *Nutrients*, 13(4), 1093. <https://doi.org/10.3390/nu13041093>
- Noviyanti, R. D., & Sarbini, D. (2010). Hubungan Status Gizi Dengan Status Imunitas Anak Balita Di RW VII Kelurahan Sewu, Kecamatan Jebres, Kota Surakarta. *Jurnal Kesehatan*, 3(1), 58–65.
- PH, L., Mubin, M. F., & Basthomi, Y. (2020). “Learning Task” Attributable to Students’ Stress During the Pandemic Covid-19. *Jurnal Ilmu Keperawatan Jiwa*, 3(2), 203–208.
- Pratami, T. J., Widajanti, L., & Aruben, R. (2016). Hubungan Penerapan Prinsip Pedoman Gizi Seimbang Dengan Status Gizi Mahasiswa S1 Departemen Ilmu Gizi Fakultas Kesehatan Masyarakat Universitas Diponegoro Semarang. *Jurnal Kesehatan Masyarakat (e-Journal)*, 4(4), 561–569.
- Raqib, R., Alam, D. S., Sarker, P., Ahmad, S. M., Ara, G., Yunus, M., Moore, S. E., & Fuchs, G. (2007). Low birth weight is associated with altered immune function in rural Bangladeshi children: a birth cohort study. *The American Journal of Clinical Nutrition*, 85(3), 845–852. <https://doi.org/10.1093/ajcn/85.3.845>
- Roring, N. M., Posangi, J., & Manampiring, A. E. (2020). Hubungan antara pengetahuan gizi, aktivitas fisik, dan intensitas olahraga dengan status gizi. *Jurnal Biomedik:JBM*, 12(2), 110. <https://doi.org/10.35790/jbm.12.2.2020.29442>
- Rust, P., & Ekmekcioglu, C. (2023). The Role of Diet and Specific Nutrients during the COVID-19 Pandemic: What Have We Learned over the Last Three Years? *International Journal of Environmental Research and Public Health*, 20(7), 5400. <https://doi.org/10.3390/ijerph20075400>
- Salsabilla, S. (2017). HUBUNGAN PENGETAHUAN GIZI DENGAN SIKAP

- MENGGONSUMSI MAKANAN SEHAT SISWA SMK. *Keluarga: Jurnal Ilmiah Pendidikan Kesejahteraan Keluarga*, 3(1). <https://doi.org/https://doi.org/10.30738/keluarga.v3i1.1958>
- Scanlan, J. M., Vitaliano, P. P., Zhang, J., Savage, M., & Ochs, H. D. (2001). Lymphocyte proliferation is associated with gender, caregiving, and psychosocial variables in older adults. *Journal of Behavioral Medicine*, 24(6), 537–559. <https://doi.org/https://doi.org/10.1023/A:1012987226388>
- Siagian, A. (2005). Lycopene Senyawa Fitokimia pada Tomat dan Semangka. *Info Kesehatan Masyarakat*, 9(2), 121–124.
- Sukendra, D. M. (2015). Efek Olahraga Ringan Pada Fungsi Imunitas Terhadap Mikroba Patogen: Infeksi Virus Dengue. *Jurnal Media Ilmu Keolahragaan Indonesia*, 5(2), 57–65.
- Unawekla, J. V., Moeis, E. S., & Langi, Y. A. (2018). Hubungan antara Status Gizi dan Sistem Imun Seluler pada Subyek Penyakit Ginjal Kronik Stadium V Hemodialisis di Instalasi Tindakan Hemodialisis RSUP Prof. Dr. R. D. Kandou Manado. *E-CliniC*, 6(1). <https://doi.org/https://doi.org/10.35790/ecl.v6i1.18682>
- Wanty, W., Widyastuti, N., & Purbosari, E. (2017). Asupan Zat Gizi Makro, Status Gizi, dan Status Imun pada Vegetarian dan Non-Vegetarian. *Journal of Nutrition College*, 6(3), 234. <https://doi.org/10.14710/jnc.v6i3.16915>
- Weston, S., & Frieman, M. B. (2020). COVID-19: Knowns, Unknowns, and Questions. *MSphere*, 5(2). <https://doi.org/10.1128/mSphere.00203-20>
- Wijayanti, A., Margawati, A., & Wijayanti, H. S. (2019). Hubungan stres, perilaku makan, dan asupan zat gizi dengan status gizi pada mahasiswa tingkat akhir. *Journal of Nutrition College*, 8(1), 1–8.
- Wilod Versprille, L. J. F., van de Loo, A. J. A. E., Mackus, M., Arnoldy, L., Sulzer, T. A. L., Vermeulen, S. A., Abdulahad, S., Huls, H., Baars, T., Scholey, A., Kraneveld, A. D., Garssen, J., & Verster, J. C. (2019). Development and validation of the immune status questionnaire (ISQ). *International Journal of Environmental Research and Public Health*, 16(23). <https://doi.org/10.3390/ijerph16234743>
- Zeng, Q.-L., Yu, Z.-J., Ji, F., Li, G.-M., Zhang, G.-F., Xu, J.-H., Lin, W.-B., Zhang, G.-Q., Li, G.-T., Cui, G.-L., & Wang, F.-S. (2021). Dynamic changes in liver function parameters in patients with coronavirus disease 2019: a multicentre, retrospective study. *BMC Infectious Diseases*, 21(1), 818. <https://doi.org/10.1186/s12879-021-06572-z>