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ORIGINAL ARTICLE

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Linking Nutrition, Immunity and Quality of Life Among Tarlac Senior High School Students: Bases for an Adolescent Health Program Framework

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ABSTRACT

Background: Adolescence, as a developmental phase, has a larger significant role in human nutrition, and immune health plays a vital role in defining their physical and psychosocial well-being. However, there is limited empirical data from the Philippines on identifying the collective effects of nutrition and immune health on health-related quality of life (HRQoL) among senior high school students. To address these gaps according to local needs, designing effective adolescent health programs is a good step forward.

Objectives: The study accomplished five objectives: (1) to assess the nutritional status of senior high school students using anthropometric measures interpreted through CDC growth charts in Tarlac City; (2) assess immune status through a validated immune function questionnaire; (3) determine HRQoL in physical, mental, and social dimensions using a standardized tool; (4) examine interrelationships among nutritional status, immune health, and HRQoL; and (5) create a 'conceptual framework' for adolescent health programming at Tarlac National High School.

Methodology: The study employed a quantitative, cross-sectional analytic design to examine the relationships of nutritional status, immune function, and HRQoL among 420 senior high school students, aged 16 to 18, enrolled at Tarlac National High School during the academic year 2024–2025. Nutritional status was assessed based on BMI-for-age and height-for-age percentiles using the CDC growth charts. Immune functioning and HRQoL were evaluated using validated self-report instruments, particularly the Immune Status Questionnaire (ISQ) and the KIDSCREEN-10 Questionnaire.

Results: The study showed that most students have optimal nutritional status, as measured by BMI and height-for-age percentiles, which is positively correlated with stronger immune function (r = 0.041 and r = 0.019, respectively; p <0.05) and higher scores in HRQoL (r = 0.032 and r = 0.028, respectively; p <0.05). This group also reported good to excellent general health and low prevalence of chronic diseases. However, a notable percentage of students were stunted (36.7%), underweight (16.7%), overweight (6.7%), or obese (5.2%). This documented coexistence of undernutrition and overnutrition reflects the dual burden of malnutrition in adolescents, emphasizing the need for tailored public health strategies.

Conclusion: The study revealed significant interrelationships among nutritional status, immune function, and HRQoL of senior high school students at Tarlac National High School. Therefore, this study developed a conceptual framework entitled T.A.R.L.A.C. Health+ Initiative Program, showing that optimal nutrition enhances immune function and quality of life, supporting a holistic, school-based adolescent health program for improved student well-being.

Keywords: adolescent health, nutrition, immune function, health-related quality of life (HRQoL), conceptual framework, Immune Status Questionnaire (ISQ), KIDSCREEN-10 Questionnaire

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INTRODUCTION

Adolescence is a critical developmental phase that transitions individuals from childhood to adulthood.[1] Globally, adolescents constitute 16% of the population, with around 1.3 billion individuals classified within this age group.[2] This phase is typically divided into three stages: early adolescence (10–13 years), middle adolescence (14–17 years), and late adolescence (18–21 years).[3] Middle adolescence is considered the second-fastest growth period after infancy, characterized by rapid physical, psychological, mental, and social changes. These changes increase the demand for proper nutrition to facilitate growth, immune function, and overall health. Adolescent girls are especially vulnerable, as malnutrition during this period can have compounding effects on maternal and child health, given the prevalence of adolescent pregnancies.[4] Cognitive and moral development during middle and late adolescence involves a future-oriented perspective making these stages a critical corrective window to mitigate intergenerational cycles of malnutrition by underscoring the importance of proper nutrition in both immediate and future contexts.[5] Monitoring and assessing the nutritional status of adolescents is imperative due to their age-specific growth patterns, changing dietary habits, and the opportunity to address health issues before adulthood.

Nutritional status is increasingly viewed as a significant determinant of overall health and well-being.[6] Body Mass Index (BMI) serves as a widely used screening tool to assess weight relative to height and determine nutritional status. BMI is calculated by dividing a person's weight in kilograms by the square of their height in meters. For adolescents, age- and sex-specific BMI percentiles are used to classify nutritional categories. According to the Centers for Disease Control and Prevention (CDC), BMI percentiles are categorized as underweight (<5th percentile), normal weight (5th–85th percentile), overweight (85th–95th percentile), and obesity (>95th percentile). The American Academy of Pediatrics (AAP) recommend that pediatric health care providers conduct BMI screening for all adolescents at least once a year.[7-9]

Malnutrition, as defined by the World Health Organization (WHO), encompasses overnutrition (e.g., overweight, obesity, and diet-related noncommunicable diseases), undernutrition (e.g., wasting, stunting, and underweight) and deficiencies in vitamins and minerals.[10]

Obesity is a chronic condition characterized by excessive fat accumulation that can impair health, while overweight represents a less severe form of excess weight.[11] The AAP Clinical Practice Guideline for the Evaluation and Treatment of Children and Adolescents With Obesity offers an expanded definition of severe obesity, Class 2 Obesity which is BMI >120% to <140% of the 95th percentile or BMI >35 kg/m^2 to <40 kg/m^2 and Class 3 Obesity which is BMI >140% of the 95th percentile or BMI >40 kg/m^2.[12] Globally, over 390 million children and adolescents were overweight in 2022, with 160 million classified as obese. According to the 2017–2018 National Health and Nutrition Examination Survey (NHANES), 16.1% of children 2-19 years old were overweight and 19.3% were obese. Among adolescents ages 12 to 19, more than 1 in 5 (21.2%) have obesity.[13] From 2000 to 2016, the proportion of overweight children between 5 and 19 years of age doubled from 1 in 10 to almost 1 in 5. According to the 2018 Philippine Expanded National Nutrition Survey, adolescent obesity among Filipinos has almost tripled in the last 15 years.[14] The prevalence of obesity among Filipino adolescents increased from 11.6% in 2018 to 13% in 2021.[15]

Underweight or low BMI-for-age, reflects nutritional deficiencies and can result in stunted growth and weakened immune function.[16] According to the 2017–2018 NHANES, 4.1% of children and adolescents aged 2–19 years were underweight.[17] Stunting, or low height-for-age, results from chronic malnutrition and is closely linked to poverty, inadequate maternal nutrition, and poor early-life feeding practices.[18] In 2018, 26.3% of Filipino adolescents were reported as stunted.[19] The national average of stunting for adolescents aged >10–19 years, at 22.3%, is considered high from a public health perspective. Those belonging to the poorest quintile (disproportionately higher at 35.2%) suffered most from stunting.[20] Stunting not only hinders physical growth but also compromises cognitive function, educational achievement, and future economic productivity.[21]

The phenomenon of the "double burden of malnutrition," which involves coexisting issues of undernutrition and overnutrition, is increasingly evident in low- and middle-income countries (LMICs) including the Philippines.[22,23] Malnutrition leads to the weakening of the immune system and increased susceptibility to infections and diseases.[24-26] Undernutrition suppresses the innate immune defenses and impair the immune function by causing bone marrow atrophy, resulting in reduced cell proliferation, fewer mature immune cells and decreased lymphocytes. It also leads to atrophy of thymus and lymphoid tissues such as lymph nodes, tonsils, and spleen, which contributes to leukopenia and higher risk for infection. Obesity is linked to an increase in fatty tissue within the bone marrow and thymus causing adipocytes hypertrophy, hyperplasia, hypoxia, oxidative stress, and cell death, leading to a state of chronic inflammation, a critical component in the pathophysiology of chronic conditions such as cardiovascular diseases, type 2 diabetes mellitus, autoimmune disorders and cancer.[27] These can substantially affect the health-related quality of life (HRQoL) of adolescents, referring to their physical,

mental, and social well-being.[28,29] Despite the critical role of nutrition in shaping immune health and quality of life, there is limited empirical evidence linking these factors among Filipino adolescents.

Existing programs in the Philippines include Barangay Nutrition Scholar (BNS) Program which targets malnutrition among children aged 0–5, pregnant or lactating women and School-Based Feeding Program (SBFP) which focuses on students from kindergarten to Grade 6. However, this initiative fails to address the nutritional needs of adolescents. If not addressed, a significant portion of the population remains vulnerable to compromised immune function and diminished quality of life, with potential long-term implications for their academic and professional outcomes.

This study addresses these gaps by examining the relationships between nutrition, immune status, and quality of life among senior high school students in Tarlac City. By generating evidence specific to this demographic, the study will lay the groundwork for a conceptual framework that will serve as a basis for the development of adolescent health programs. The findings aim to guide policymakers and practitioners in creating inclusive, data-driven strategies that promote adolescent well-being and ensure sustainable public health outcomes.

METHODOLOGY

A quantitative cross-sectional analytic design was employed in this study conducted from February to May 2025 among senior high school students, aged 16 to 18, enrolled at Tarlac National High School during the Academic Year 2024–2025. The total enrolment of 4,327 senior high school students was distributed across 84 sections. A stratified random sampling technique was used to ensure representativeness. Five students were selected from each section using a random name generator, and only those who voluntarily co-signed the informed consent form with their parents were included in the study. The Bataan General Hospital and Medical Center Research Ethics Review Committee (BGHMC-RERC) approved the implementation of this study. The study adhered to the highest ethical standards, guided by the Declaration of Helsinki (1964) and the Philippine Health Research Ethics Board (PHREB) (2006) ethical guidelines.

For the nutritional status assessment, the students' height and weight were measured using calibrated weighing scales and stadiometers to ensure accuracy. These measurements were used to calculate Body Mass Index (BMI) and interpret height-for-age and BMI-for-age percentiles using the Centers for Disease Control and Prevention (CDC) growth charts. The height-for-age percentile was generated using the calculator created by QxMD on Medscape website. The BMI was calculated using the Child and Teen BMI calculator on CDC website, which also generates BMI percentile, and BMI category.

For the immune status assessment, the Immune Status Questionnaire (ISQ) was administered to the students. The ISQ is a validated self-assessment instrument of perceived immune status over the preceding year and at the moment. The questionnaire is available in English version and consists of a 7-item scale that includes sudden high fever, diarrhea, headache, skin problems (e.g., acne and eczema), muscle and joint pain, common cold, and coughing of which the occurrence was rated on a 5-point Likert scale. The researchers guided the students in answering the questionnaire to ensure accuracy.

For the health-related quality of life (HRQoL) assessment, the KIDSCREEN-10 questionnaire was administered to the students. It is a validated self-report instrument available in English and Filipino versions used to assess subjective health and psychological, mental, and social well-being. It consists of 10 items measuring HRQoL across five dimensions in general: Physical Well-Being, Psychological Well-Being, Autonomy and Parent Relation, Peers and Social Support, and School Environment.

Data analysis was conducted using SPSS software. A statistician analyzed and interpreted all the data obtained. Descriptive statistics such as means, standard deviations, and frequency distributions were used to provide an overview of the students' nutritional and immune status, as well as their HRQoL dimensions. Correlation analysis using Pearson's correlation coefficient was utilized to identify and quantify the relationships between the variables. The significance level for all statistical tests was set at $p < 0.05$. A conceptual framework was designed based on the interactions of quantitative data obtained from the interplay of nutritional status, immune status, and health-related quality of life (HRQoL) to guide adolescent health programs.

RESULTS

Among the 420 senior high school students who participated in the study, 71.0% had normal BMI and 63.3% had normal height-for-age. However, 36.7% were stunted, 16.7% were underweight, 6.7% were overweight, 5.2% obese and 0.5% were severely obese (Table 1).

There is variability in immune status among the students ($SD = 2.44$). Significant positive correlations were found between immune status and general health ($r = 0.193$, $p < 0.01$), immune functioning ($r = 0.252$, $p < 0.01$), reduced immune functioning ($r = 0.080$, $p < 0.01$), and chronic

diseases (r = 0.012, p <0.01). Notably, immune functioning showed a strong positive relationship with general health (r = 0.656, p <0.01) (Table 2). The reported chronic diseases were asthma, anemia, allergic rhinitis, hypertension, diabetes mellitus, dyslipidemia and gastroesophageal reflux disease.

The mean score for overall HRQoL (KSOverall) was 3.52 (SD = 0.502). The general health subscale (KSGeneralHealth) had a slightly lower mean of 3.39 (SD = 0.814), indicating some variation in students' self-rated health. A strong positive correlation (r = 0.558, p <0.01) between overall HRQoL and general health was noted (Table 3).

The correlations between these variables are statistically significant but relatively weak. Nutritional status showed small positive correlations with both immune status (r = 0.041 and r = 0.019, respectively; p <0.05) and HRQoL (r = 0.032 and r =0.028, respectively; p <0.05). Additionally, immune status demonstrated a modest yet statistically significant correlation with HRQoL (r = 0.131, p <0.01), suggesting a potential link between better immune functioning and improved perceptions of overall quality of life (Table 4).

DISCUSSION

A substantial proportion of senior high school students face nutritional challenges, indicating that undernutrition remains a significant issue among this population coupled with emerging signs of overnutrition. These findings mirror previous research in similar socioeconomic settings, which point to a double burden of malnutrition where both under- and overnutrition are prevalent.[4]

While nutrition, immune function, and HRQoL are significantly interrelated, the strength of these associations is limited. This may be due to the multifactorial nature of health and well-being, particularly in adolescents, where psychological, environmental, and social factors also play major roles. These patterns align with global literature recognizing the interdependence of physical health, immunity, and psychosocial well-being in adolescence.[10,14,29]

The majority of students rated their immune status as good based on the Immune Status Questionnaire and most students who answered the KIDSCREEN-10 questionnaire reported average to high quality of life. In both questionnaires, more than half of the students evaluated their general health as good to excellent. The students who perceive themselves to be in good general health also tend to rate their overall quality of life more favorably. These findings highlight the central role of perceived general health in shaping adolescents' broader sense of well-being. This supports existing literature, which emphasize the interconnectedness of subjective health perceptions and HRQoL in adolescents.[29] The implications suggest that improving nutrition and immune health as part of a holistic intervention strategy might contribute positively to adolescents' HRQoL.

Table 1. Distribution of age, BMI percentile interpretation and height-for-age status (n = 420)

Variable	Category	n	%
BMI %	Normal	298	71.0
	Underweight	70	16.7
	Overweight	28	6.7
	Obese	22	5.2
	Severe	2	0.5
Height-for-Age %	Normal	266	63.3
	Stunted	154	36.7

Note: BMI = Body Mass Index

Table 2. Descriptive statistics and correlation among immune status variables of students (n = 420)

Measure	SD	1	2	3	4	5
Immune status	2.44	–				
General health	1.57	0.193**	–			
Immune functioning	1.27	0.252**	0.656**	–		
Reduced immune functioning	0.422	0.080**	0.227**	0.258**	–	
Chronic diseases	0.223	0.012**	0.206**	0.144**	0.201**	–

*Note: ** = correlation is significant at p = 0.01 (1-tailed)*

Table 3. Descriptive statistics and correlation of Health-Related Quality of Life (n = 420)

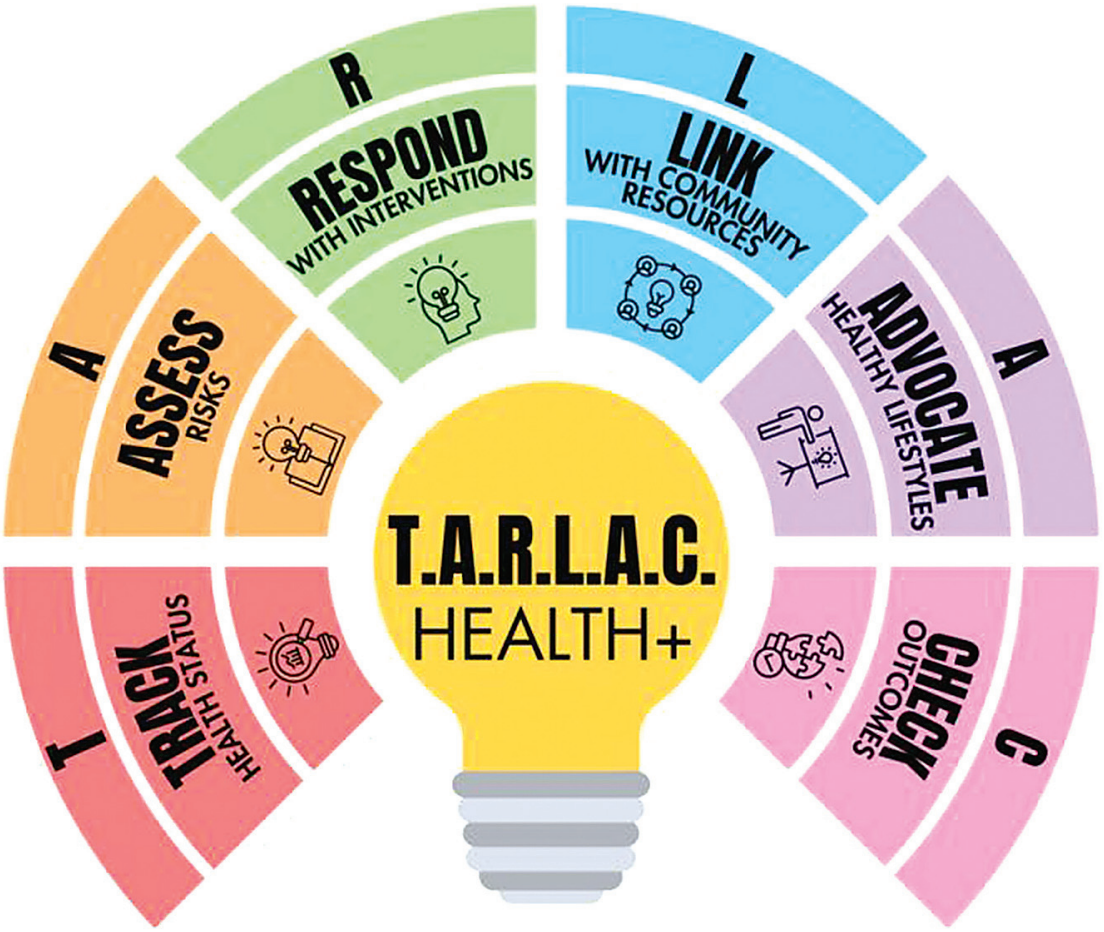
Measure	Mean	SD	1	2
KSOverall	3.52	0.502	–	
KSGeneralHealth	3.39	0.814	0.558**	–

*Note: ** = correlation is significant at p = 0.01 (1-tailed)*

Table 4. Correlation among nutrition, immune status and Health-Related Quality of Life (N = 420)

Measure	1	2	3
Nutrition station	–		
BMI			
Height-for-age			
Immune status	0.041*	–	
	0.019*		
Health-Related Quality of Life	0.032*	0.131**	–
	0.028*		

*Note: ** = correlation is significant at p = 0.01 (1-tailed)*
** = correlation is significant at p = 0.05 (1-tailed)*



- Regular screening of BMI, height-for-age, immune functioning and health-related quality of life using validated tools
- Identify at-risk students (stunted, underweight, overweight, obese, reduced immune functioning, poor health-related quality of life)
- Health education, referral to appropriate clinician or medical specialist, nutritional supplementation
- Partner with schools, local government unit (LGU), rural health unit (RHU), non-government organization (NGO), and parents
- Promote physical activity, balanced diet, adequate sleep, hygiene, and stress management
- Monitor improvement in student health indicators and adjust interventions accordingly

Figure 1. T.A.R.L.A.C. health+ Initiative Program Conceptual Framework.

The data emphasize the urgent need for a school-based health framework. In response, this study developed a conceptual framework entitled T.A.R.L.A.C. Health+ Initiative Program (Table 5, Figure 1) specifically tailored for senior high school students in Tarlac National High School using the mnemonic T.A.R.L.A.C. which stands for Track Health Status, Assess Risks, Respond with Interventions, Link with Community Resources, Advocate Healthy Lifestyles, and Check Outcomes. This framework provides a comprehensive and localized approach to improving adolescent health in Tarlac National High School. It recognizes the interconnected nature of nutrition, immune function, and health-related quality of life (HRQoL), and seeks to integrate health promotion efforts into the academic environment. By aligning school-based health initiatives with community partnerships and evidence-based strategies, the model aims to cultivate a supportive environment where students are actively engaged in their physical, mental, and social well-being. This framework also serves as a foundation for future programs that are participatory and longitudinal, allowing for continuous adaptation to the evolving needs of adolescents. Implementing this model in Tarlac City holds the potential to enhance student health outcomes, boost

Table 5. T.A.R.L.A.C. Health+ Initiative Program

Program pillars	Descriptions
Track health status	Regular screening of BMI, height-for-age, immune functioning, and HRQoL using validated tools
Assess risks	Identify at-risk students (undernourished, stunted, low immune function, poor HRQoL)
Respond with interventions	Nutritional supplementation, health education, medical referrals
Link with community resources	Partner with LGUs, schools, RHUs, NGOs, and parents
Advocate healthy lifestyles	Promote physical activity, balanced diets, hygiene, and stress management
Check outcomes	Monitor improvements in student health indicators and adjust interventions accordingly

academic engagement, and build long-term resilience by embedding a culture of wellness within the school and its surrounding community.

A key limitation of this study is the reliance on cross-sectional data, which limits the ability to determine causality. Moreover, self-report measures may not fully capture the complexity of immune function or HRQoL. Nutritional assessments based solely on BMI and height-for-age may overlook other critical indicators like micronutrient intake or dietary diversity and important factors such as stress, physical activity, social support and socioeconomic status that can contribute to malnutrition and also influence the immune status and HRQoL. Future research should consider longitudinal designs, incorporate more comprehensive nutritional assessments, and explore mediating variables such as stress, physical activity, social support and socioeconomic status to better understand the dynamics between these domains.

CONCLUSION

The findings of this study reveal significant inter-relationships among nutritional status, immune function, and health-related quality of life (HRQoL) of senior high school students in Tarlac National High School. The data highlight that while most students fall within normal ranges of BMI and height-for-age, a considerable portion experience stunting and underweight conditions, which are associated with lower immune functioning and overall well-being. Additionally, moderate yet significant correlations between general health, immune status, and HRQoL emphasize the need for holistic and preventive health strategies tailored for adolescents. These insights emphasize the importance of integrating school-based health assessments with supportive interventions to enhance student health and academic performance.

It is recommended that Tarlac National High School and local stakeholders adopt the proposed T.A.R.L.A.C. Health+ conceptual framework to guide the development of a sustainable adolescent health program. This should include routine screening for nutritional and immune status, health education focusing on nutrition and lifestyle, partnerships with local health units, and the active involvement of students and families. By institutionalizing health initiatives within the school setting, Tarlac City can foster a more resilient, health-conscious generation equipped for lifelong wellness.

Statement of Authorship

The authors certified fulfillment of the ICMJE authorship criteria.

Author Disclosure

The authors declared no conflict of interest.

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