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Assessing the Role of Nutrition Knowledge and Dietary Diversity in Academic Performance of University Students: Ordinal Logistic Regression Analysis

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Abstract

This study examines the impact of nutrition knowledge and dietary diversity on the academic performance of university students in Islamabad, addressing a significant research gap in the context of Pakistan. Guided by Maslow's learning theory, the study employs a Proportional Odds Model to analyze primary data collected from 500 students across eight universities using a two-stage cluster sampling procedure. Student's academic performance is assessed as an ordinal variable based on their CGPA, while nutrition knowledge is measured through scores on three dimensions: (i) recommended nutritious diet, (ii) nutrient-based diet classifications, and (iii) diet-disease relationships. Dietary diversity scores are also calculated to capture the variety in students' food consumption patterns. The findings reveal that knowledge of nutrition security strongly enhances academic performance. Students with higher awareness of diet classifications, diet-disease relationships, and recommended nutritious diets are more likely to excel academically. The reason is that awareness of nutrition security leads them to a healthy diet, which contributes positively to their academic achievements. Coefficient estimates of dietary diversity also confirm these linkages as the results reveal that the students who fulfill the diet diversity plan have three times more chances to perform excellently as compared to those students who do not fulfill the diet diversity plan. Other significant factors include urban residence, female gender, and age (22–25 years), while parental education appears to have no significant effect. These results underscore the need for policies to promote nutrition awareness among students. Initiatives could include integrating nutrition education into school and university curricula, leveraging social media to disseminate information, and mandating nutrition labeling on food products. By addressing these factors, policymakers can improve students' academic outcomes and overall well-being.

Keywords: Food Security; Survey; Nutrition Knowledge; Ordinal Logistic Regression; Student's Performance

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1. Introduction and Literature Review

Adequate and sufficient intake of a healthy diet is essential for brain function (Bloom, 2009; Dauncey, 2009; Kazal, 2002; Shariff et al., 2000). Moreover, maximizing brain function is a prime factor in achieving appropriate cognitive capabilities, such as the ability to focus, comprehend, evaluate, and apply concepts in learning (Kretchmer et al., 1996; Schmitt, 2010). Balanced nutrition may improve students' educational performance, while unbalanced nutrition may result in low educational performance and mental illness in students (Arshad et al., 2014; Valladares et al., 2016). Balanced nutrition helps to live an active life, better education, and the highest percentage of academic achievements (Florence et al., 2008). Inadequate food and unbalanced dietary conditions are associated with poor academic outcomes for students, which adversely affect their careers (Kim et al., 2003). Obesity and overweight are related to fatty diets and limited consumption of fruits and vegetables (Florence et al., 2008). Due to an unhealthy diet, students may face diseases such as high blood pressure, heart disease, hypertension, bowel disorders, obesity, etc. (Wirth, 2015). According to Salama and Esmail (2018), awareness of nutrition knowledge, diet disease, and dietary intake can help students to consume a balanced diet, control their health problems, and improve their academic performance. Nawaz et al., (2016) suggests that increased nutrition knowledge is even better as it reduces unhealthy eating. Whatnall et al., (2019), Payne-Sturges et al., (2018), and Correa-Burrows et al., (2016) have found that students with a sufficiently healthy diet or food security perform better in academics than students with unhealthy diet or food insecurity have lower academic performance.

There are several learning theories related to the role of nutrition on academic performance. Some of these theories include (1). Social Cognitive Theory: This theory suggests that individuals learn by observing others and following their behavior. When it comes to nutrition and academic performance, students may observe their peers who eat healthy and perform well in school, and model their behavior after them. (2). Cognitive Load Theory: This theory suggests that the amount of mental effort required to process information affects learning. When students are hungry or malnourished, their cognitive load may increase, making it more difficult to concentrate and retain information. (3). Maslow's Hierarchy of Needs: This theory suggests that individuals must have to meet their basic needs before they can focus on higher level needs, such as learning and achievement. Nutrition is a basic need that must be met before students can focus

on academic performance. (4). Self-Determination Theory: This theory suggests that individuals are motivated when they feel competent, autonomous, and connected to others. Proper nutrition can help students feel competent and energized, which can lead to greater motivation and engagement in academic tasks. Overall, these learning theories suggest that proper nutrition is essential for academic performance because it can affect cognitive function, motivation, and overall well-being.

Literature provides evidence about the strong association of consumption of dietary factors (e.g., fish, vegetables, and fruits) with the academic performance of students (See e.g. Rytter et al., 2014; Kim et al., 2016; Purtell et al., 2015; Deliens et al., 2013; López-Gil et al., 2022; López-Gil et al., 2023). This association is justified as malnourishment badly affects cognitive functioning (Gómez-Pinilla, 2008). Hence, a balanced recommended diet optimizes mental functioning (Owen and Corfe, 2017), which ultimately might lead to improved academic performance (Florence, 2008). A systematic review conducted by Burrows et al., (2017) concludes the significance of balanced and nutritious food intake for high academic achievement. Conversely, an unhealthy diet has been linked to lower academic performance in young people (Naveed et al., 2020). Several studies are available in the literature that have explored the significant positive role of nutrition knowledge and/or dietary diversity on the academic performance of university students in developing countries. (See e.g. Kim et al., 2003; Florence et al., 2008; Kassier and Veldman, 2013; Mpofu, 2015; Valladares et al., 2016; Correa- Burrow et al., 2016; Priyadarshini and Dash, 2017; Farahbakhsh et al., 2017; Asigbee et al., 2018; Malki 2018; Omage and Omuemu, 2018; Barchitta et al., 2019; Whatnall et al., 2019, etc.).

To the best of the authors' knowledge, there is no published study analyzing the role of nutrition knowledge and dietary diversity on the academic performance of university students in Pakistan. In the case of other countries, however, many studies found the role of dietary patterns on academic performance while some others estimated the role of nutrition knowledge on academic performance. (See e.g. Kassier and Veldman, 2013; Mpofu, 2015; Valladares et al., 2016; Priyadarshini and Dash, 2017; Farahbakhsh et al., 2017; Omage and Omuemu, 2018; Nawaz et al., 2016; Khalid et al., 2018; Ashraf et al., 2019, etc.). Most of these studies are limited to descriptive analyses. However, some other empirical studies related to the topic have estimated multiple linear regression or binary logistic regression models (e.g. Arshad et al., 2014; Asigbee et al., 2018; Malki, 2018; Kim et al., 2003; Florence et al., 2008; Correa- Burrow et al., 2016). A generalized logistic framework for ordinal cases might be helpful to provide deep

insight into the phenomenon as compared to logistic regression analysis for binary cases. Therefore, this study has been designed to analyze the role of nutrition knowledge and dietary diversity along with other personal factors in the academic performance of university students. The study contributes in two ways. Firstly, it is perhaps the first study that provides model-based evidence about the role of nutrition knowledge in the academic performance of university students in Pakistan. Secondly, as compared to previous literature on the topic, statistical analysis in this study is based upon an estimation of the proportional odds model for ordinal cases which gives four levels of estimates for the analysis.

2. Material and Methods

The materials and methods section is further divided into three sub-sections, i.e. model's specification, data and construction of variables, and methodology of analysis.

2.1 Model Specification and Variables' Construction

Various learning theories are available to analyze the factors affecting students' academic performance. However, Maslow (1943) learning theory which was extended by Vygotsky (1978) provides the theoretical framework for understanding a fundamental link between food intake and students' academic performance. Maslow (1943) learning theory explains the body's physiological need for food, especially in terms of nutrients, vitamins, minerals, and temperature within the bloodstream. At a very basic level, humans who have not met their basic nutritional needs cannot perform to attain needs at the higher levels. Vygotsky, however, adds the socio-cultural dynamics germane to this topic. Vygotsky and the socio-culturists argue, that "a culture defines what knowledge and skills children need to acquire and that values and processes differ among different races, social classes, dual-career versus one-career families, rural versus urban communities, single-parent versus two-parent families, and so on" (Vygotsky, 1978, p. 47, 50). Maslow and Vygotsky provide a context for physiological and cultural approaches for how food and knowledge of diet adequacy affect human brain function and capability as well as sociocultural attitudes toward food and academic performance.

Hence, students' academic performance is considered as the response variable of the model. It is taken as a categorical ordered variable to be determined on the basis of students' CGPA. Order categories are 1, 2, 3, and 4 according to if CGPA of the students is D, C, B, and A respectively. Explanatory variables are selected on the basis of the above-mentioned theoretical framework and previous studies from the literature. Following Cooked and Papadaki (2014) and Parmenter

and Wardle (1999), awareness of nutrition is represented by three variables. These include (i) Knowledge of recommended nutritious diet, (ii). Knowledge of diet classifications having different nutrients like fats, protein, salt, cholesterol, etc. (iii). Knowledge of diet-disease relationships. According to Nani (2016), awareness about nutrition and a balanced diet are the best planning for a healthy life and well academic performance of a student. The dietary diversity variable is selected from the research work of Swindale and Bilinsky (2005). These variables were found to be highly significant for academic performance (Florence et al., (2008)). Moreover, some personal and demographic variables are also considered as explanatory variables. These include gender, age, height, residential status, parents' education level, Father's occupation, and degree program. A description of the explanatory variables is given in Table 1.

Table 1: Description of Explanatory Variables

Variables' label	Categories	Variables' label	Categories
Gender	0 = male (base) 1= female	Residential status	0=urban (base) 1=rural
Age	0 =18-21(base) 1= 22-25 2 = 26-29 3 = 30 or more	Height	0 < 4.5 feet (base) 1 = 4.5 to 5.2 feet 2 = 5.3 to 5.11 feet 3 = 6 feet or more
Father's Qualification	0 = uneducated (base) 1 = primary or secondary 2 = higher secondary and above	Mother's Qualification	0 = uneducated (base) 1 = primary or secondary 2 = higher secondary and above
Father's Occupation	0 = private job (base) 1= govt. servant 3 = own business 4 = other	Degree Program	0 = BS (base) 1= MSC 2 = MS 3 = PhD
Dietary diversity (DD) Score	0 = Low DD (base) 1= Medium DD 2= High DD	Knowledge of Recommended Nutritious Diet	Score
Knowledge of Diet Classifications	Score	Knowledge of Diet Diseases Relationships	Score

2.2 Survey and Data Collection

Primary data are collected by conducting a survey. The area of the study is Islamabad, the capital territory of Pakistan. The total number of universities in Islamabad is 23. Our population size is 116597 students in Islamabad universities. A two-stage sampling procedure is employed to collect the primary data. In the first stage, universities are treated as clusters, and eight clusters are selected using Probability Proportional to Size (PPS) sampling, following a cumulative total method without replacement.

Designing the statistical survey is an essential part of the preparation for data collection. Our questionnaire consisted of four sections. The first section consists of 12 questions related to personal and demographic characteristics. In the second section, 12 questions are asked related to dietary diversity. The third section has been designed to ask 83 questions related to nutrition knowledge while CGPA is asked to categorize students' academic performance in the last fourth section.[3] Before conducting a survey, appropriate sample size determination is an important task. Following the procedure explained by Kotrlik et al. (2001), a 500 sample size with a 5% margin of error is determined as a representative sample of the population in this study. Details of selected sampling units at the two stages are presented in Table 2. The researcher personally visited the selected universities and questionnaires were filled out by the students to obtain data.

Table 2: Sample Size Determination

	Selected First Stage Sampling Units	Cluster Size	Percentage of the population	Selected sample size
1	International Islamic university	19532	24	120
2	National University of Modern Languages	14194	17	85
3	Iqra university	2916	4	20
4	Quaid-i-Azam university	13000	16	80
5	Federal Urdu university	7800	9	45
6	Allama Iqbal Open University	9000	11	55
7	COMSAT Institute of Information Technology	8055	10	50
8	National University of Science and Technology	7195	9	45
	Total	81693	100	500

2.3 Methodology of Analysis

The response variable of the specified model is students' academic performance which is a categorical variable in four ordered categories. Therefore, the standard ordered logit model (Zucknick and Richardson, 2014) might be employed. Among various types of Ordinal Logit models, usually Cumulative Logit Models are applied because these models' interpretations are impressive. Cumulative Logit Models are further divided into 3 groups, i.e. Proportional Odds Model, Non-Proportional Odds Model, and Partial Proportional Odds Model. Cumulative Logit Models do work under the assumption of parallel line assumption. Brant test is applied to test parallel lines assumptions for the overall model and for each parameter separately. Usually, some parameters' estimates violate the parallel lines assumptions and, therefore unconstrained partial

[3] The survey was conducted during January 2021. The Survey and Questionnaire were approved by Quality Enhancement Directorate of the university. The Questionnaire and collected data are available as supplementary material.

proportional odds (PPO) model is estimated which is represented by the following function.

$$P\,[Y \leq y_{j/x}] = \tau_j = \left[\frac{exp(\alpha_j - x'\beta)}{1 + exp(\alpha_j - x'\beta)}\right] \; j = 1, 2, 3, \cdots J - 1 \qquad (1)$$

The maximum likelihood method is used to estimate the proportional odds model. Detailed discussion about the ordinal logit model and its extending form may be seen in Hilbe (2009).

3. Results and Discussion

Before regression analysis, it might be valuable to present descriptive summary measures of the variables. A brief summary of all the sample data is given in Table 3(a) and Table 3(b).

Table 3 (a): Summary of Sample Data

Variable	Summary of Data	Variable	Summary of Data
Gender	Male=251 Female=249	Residential status	Urban=299 (60) Rural= 201 (40)
Age	18-21=160 (32) 22-25=232 (47) 26-29=72 (14) ≥30=36 (7)	Height	< 4.5 feet= 21 (4) 4.5-5.2 =127 (26) 5.3-5.11= 316 (63) > or = 6= 36 (7)
Father Qualification	>5 years=105 (21) 5-10 years=101 (20) >10 years=294 (59)	Mother Qualification	>5 years=209 (42) 5-10 years=201 (40) >10 years=90 (18)
Degree Program	BS= 209 (24) M.Sc.= 138 (28) MS/M.Phil.=123 (24) Ph.D.=30 (6)	Dietary Diversity	Low=31 (6) Medium=152 (30) High=317 (64)

Table 3(b): Descriptive Analysis of Nutrition Knowledge.

Variable	Maximum Potential Score	Mean Percentage of Correct Answers
Knowledge of Recommended Nutritious diet	11	50.2
Knowledge of diet Classifications Score	50	45.6
Knowledge of Diet Diseases Relationship	22	55.8
Total Nutrition Knowledge Score	83	50.5

Table 3a shows that the collected data represent genders equally. The majority of the sampled students (47% n=232) are of age group (22-25), and just over half the students (63% n=316) belong to the height group (5.3-5.11 feet). Most of the selected students belong to urban areas which are (60% n=299). Most of the students' fathers (59% n=294) are highly educated but their mothers are uneducated (42% n=209). A total of 209 students (42%) have their enrollment in BS degree programs. The majority of the students (64% n=317) have high dietary diversity scores. Table 3b explains about scores of the variables regarding awareness about nutrition. An average score of awareness about the recommended diet is 50.2%. The mean score of knowledge of diet classification is 45.6% while the mean score

of knowledge of diet diseases is 55.8%. Brant's test indicates that the parallel line assumption is not violated so we can estimate the Proportional Odds Model (POM).

Results of the estimated PO model are presented in Table 4. Since Brant test shows that the estimated model fulfills parallel lines assumptions which implies that all the coefficients' estimates are the same across the three cut-off points. Hence common estimates for the three categories (1^{st}, 2^{nd}, 3^{rd}) versus 4^{th} category of the dependent variable are given in Table 4.

Table 4: Estimation Results of Proportional Odd Model

Explanatory variables	Categories	Coefficient Estimate	Odds Ratio
Gender	Female	0.3807***	1.463
Age	22-25	0.1667	1.181
	26-29	-0.4865	0.614
	≥30	-1.2176***	0.295
Height	4.5-5.2 feet	0.7990*	2.223
	5.3-5.11 feet	1.2317***	3.427
	6 feet or more	1.0961**	2.992
Residential status	Rural	-0.0859	0.917
Father Qualification	Primary or middle	0.4258	1.530
	Higher and above	-0.1773	0.837
Mother Qualification	Primary or middle	0.3268	1.386
	Higher and above	0.1580	1.171
Degree Program	MA/MSC	0.4186**	1.519
	MS/MPhil	0.7374***	2.091
	PhD	1.5081***	4.518
Dietary Diversity Score	Medium	0.8879**	2.430
	High	1.1775***	3.246
Knowledge of recommended nutritious diet		0.0128***	1.012
Knowledge of diet Classifications		0.0321***	1.032
Knowledge of diet-diseases relationships		0.0209***	1.021
Intercept		-3.523***	0.029
LR chi(20)		147.83***	
Log-likelihood		-587.095	
Pseudo R2		0.1118	

The results reveal that the estimate of the variable "knowledge of diet classification' is significant and positive with an odds ratio of 1.032. Marginal effects of diet classifications are negative for the lower two categories but positive for the two upper categories of students' performance. It implies that the students with awareness about diet classification are likely to better perform in academics than those students who are not aware of diet classification. Estimates of the knowledge of diet-based diseases are significant with positive signs and an odd ratio is 1.021. It indicates that the students having more awareness about the knowledge of diet-disease relationship are more likely to perform well in academics as compared to the other students. The marginal effects are significant and negative for two lower students' categories of academic performance but the estimated marginal effects are positive for good and excellent academic performance of university students. It means that, for the students who are well aware of diet-

disease relationships, the probability of the students lying in categories of poor academic performance decreases and the probability of such students is high to be lying in the categories of high academic performance. The coefficient estimates of the variable 'knowledge of recommended nutritious diet' are significant with a positive sign and an odd ratio is 1.012. It implies that a student having an awareness of a nutritious healthy diet is more likely to lie in the category of excellent academic performance. Estimates of the marginal effects are significant and negative for students' categories of poor and satisfactory academic performance but positive for the good and excellent academic performance categories of university students. It implies that improvement in knowledge about recommended nutritious healthy diet increases the probability of a student lying in the highest academic performance category.

Table 5: Estimates of Marginal Effects

Explanatory variables	Categories	M.E. for Y=1	M.E. for Y=2	M.E. for Y=3	M.E. for Y=4
Gender	Female	-0.027**	-0.061**	0.026*	0.062***
Age	22-25	-0.010	-0.02656	0.007234	0.029992
	26-29	0.041	0.076*	-0.045	-0.072*
	≥30	0.138***	0.156***	-0.15***	-0.14***
Height	4.5-5.2 feet	-0.099	-0.097**	0.111	0.084**
	5.3-5.11 feet	-0.132*	-0.166***	0.144**	0.153***
	6 feet or more	-0.123*	-0.144**	0.137*	0.130**
Residential status	Rural	0.006	0.013	-0.006	-0.014
Father Qualification	Primary or middle	-0.025	-0.066	0.013	0.079
	Higher and above	0.013	0.028	-0.014	-0.027
Mother Qualification	Primary or middle	-0.024	-0.052	0.022	0.053
	Higher and above	-0.012	-0.025	0.012	0.024
Degree Program	MA/MSC	-0.035**	-0.065**	0.039**	0.061**
	MS/M.Phil.	-0.055***	-0.116***	0.052***	0.119***
	PhD	-0.085***	-0.219***	0.011	0.294***
Dietary Diversity Score	Medium	-0.103**	-0.114***	0.117**	0.100***
	High	-0.124**	-0.161***	0.137***	0.148***
Knowledge of recommended nutritious diet		-0.001***	-0.002***	0.001***	0.002***
Knowledge of diet Classifications		-0.002***	-0.005***	0.002***	0.005***
Knowledge of diet-diseases relationships		-0.001***	-0.003***	0.001***	0.003***

Two dummies of dietary diversity (DD) scores are taken here. These dummies represent a medium dietary diversity score and a high dietary diversity score while the low dietary diversity score is considered as a reference category. Coefficient estimates of both categories of DD are positive and significant. Odd ratios are 2.43, and 3.25 for medium DD and high DD respectively. It implies that DD has a strong positive impact on the academic performance of the students. As

compared to the students with low DD, the students having medium dietary diversity scores are twice as likely to lie in the category of excellent academic performance while the students having high dietary diversity are three times more likely to lie in the category of excellent academic performance. Marginal effects for dietary diversity are significant and negative for poor and satisfactory academic performance, while the estimates are significant and positive for students' categories of good and excellent academic performance. Hence, the probability of the students with low DD increases to lie in the lower categories of academic performance and high DD increases the probability of the students to perform well.

The categories of degree programs are MA/MSC and MS/MPhil. and Ph.D. while taking BS as the reference category. Estimates of all the degree programs are positive and significant while odd ratios are 0.418, 0.737, and 1.508 for MSc, MS, and PhD respectively. In all three categories of degree programs, estimates of marginal effect are negative for poor and satisfactory academic performance and positive for good and excellent academic performance categories of university students. These results indicate that the students of higher degree programs are likely to be able to perform better in academics.

Estimates of some personal characteristics also show a significant impact on the academic performance of the students. These include urban versus rural background, female versus male gender, and taller height versus shorter height of the students increase the probability of better academic performance in their study programs. However, students of the age group (22-25 years) are likely to perform better than students of other age groups. All the coefficient estimates of both paternal and maternal education are insignificant. It implies that parental education seems to have no significant role in students' academic performance at the university level.

4. Conclusions and Policy Implications

Nutrition security is a vital determinant of university students' academic performance, physical and mental health, and long-term well-being. While studies from developed countries have demonstrated a strong association between nutrition awareness and academic achievements, this study addresses a significant gap by focusing on university students in Islamabad, Pakistan. Using primary data collected through a two-stage sampling procedure, this research evaluates the role of nutrition knowledge, dietary diversity, and some personal factors in academic success, measured through CGPA.

The model is specified based on Maslow learning theory, which provides the theoretical framework for understanding a fundamental link between food

intake and students' academic performance. Primary data are collected from universities in Islamabad by employing two sampling procedures. In the first stage, eight clusters (Universities) are selected using probability proportional to size procedure. In the second stage, a sample of 500 students is selected without replacement by proportional allocation from the eight selected clusters. After cleaning the collected data, the required variables are constructed. Students' academic performance is taken as a categorical ordered variable to be determined using students' CGPA. Nutrition awareness is assessed through three variables, i.e. Knowledge of (i) recommended nutritious diets, (ii) nutrient-based diet classifications, and (iii) diet-disease relationships. Scores for the three variables as well as the Dietary Diversity score are calculated on the basis of answers provided in questionnaires. The proportional Odds model is estimated using the maximum likelihood method to analyze the phenomenon.

Estimation results reveal that the estimates of the three variables explaining knowledge of nutrition security are highly significant with positive signs. In all three cases, estimates of marginal effects are negative for two lower categories but positive for the upper two categories of academic performance. Hence, it may be concluded that the students with better awareness about nutrition security are likely to perform better in academics. It means that improvement in awareness about nutritious healthy diet increases the probability that the students would perform well in their academic achievements. The dietary diversity of students shows a strong association with their academic performance. Results show that the students having medium dietary diversity score are twice as likely to lie in the category of excellent academic performance while the students having high dietary diversity are three times more likely to lie in the category of excellent academic performance. It is concluded that the students have more chances of excellent academic performance if they fulfill the dietary diversity plan. Demographic factors, such as urban background, female gender, taller height, and the age group of 22–25 years, also positively influence students' academic performance, while parental education is found to be insignificant.

This study supports Maslow's learning theory and concludes that awareness about nutrition security and dietary diversity are the important determinants of better students' academic achievements at the university level. To improve students' academic outcomes, targeted interventions are essential. The government should prioritize nutrition education by incorporating relevant topics into school and university curricula. Social media platforms, widely used by young people, can be leveraged to promote food and nutrition security awareness. Mandatory nutrition labeling on food products should be enforced, and awareness campaigns conducted

in universities to foster informed dietary choices. Collaboration between government and private organizations can amplify these efforts, helping students achieve better academic outcomes and overall well-being.

Acknowledgment of Limitations

This study relies on primary data collected through a survey, which inherently involves self-reported measures of students' knowledge and dietary habits. While this approach provides valuable insights, it is essential to acknowledge the potential for biases, particularly recall bias and social desirability bias. To mitigate these biases, several strategies were employed during data collection and survey design. Questions were carefully crafted to be clear and specific, reducing ambiguity and reliance on memory. A pre-test of the questionnaire was conducted to ensure its clarity and reliability. Additionally, the survey was administered anonymously to encourage honest and unbiased responses. Despite these precautions, the limitations of self-reported data must be considered when interpreting the findings. Future research could supplement self-reported data with objective measures, such as dietary records or nutritional assessments, to validate and strengthen the results.

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