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LOGISTIC REGRESSION ANALYSIS ON THE DIETARY BEHAVIOR AND THE RISK OF NUTRITIONAL DEFICIENCY DERMATOSIS: THE CASE OF BICOL REGION, PHILIPPINES

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ABSTRACT: *This study examines the relationship between dietary behavior and the risk of nutritional deficiency dermatoses (NDD) in the Bicol region, where malnutrition remains a significant concern. Using regression analysis on FNRI data, it examines food purchase patterns, particularly riboflavin intake. Findings show an NDD risk prevalence of 15.75%, with Masbate and Camarines Sur contributing over half of the cases. While rice (≤1590.93 g/day) and plant-based diets (523.30 g/day) are not rich in riboflavin, they still reduce NDD odds by 0.3% per gram. Riboflavin-rich foods, such as meat, eggs, and dairy, lower the risk by up to 3% per gram. The logistic regression model demonstrated strong performance (Nagelkerke = 0.765, accuracy = 94.1%, precision = 84.5%). Findings highlight the need for nutrition interventions, including enriched rice, improved market access, and education on food diversity, to enhance riboflavin intake and mitigate risks associated with NDD.*

Keywords: *Nutritional deficiency dermatosis, riboflavin deficiency, food purchase patterns, machine learning, logistic regression analysis*

INTRODUCTION

Nutritional deficiencies persist as a pressing public health concern in many developing countries, especially in regions with limited access to diverse food sources. The Bicol region in the Philippines is known for its rich cultural heritage and agricultural productivity (TourGuidePh, n.d.). Recent DA Press Office (2022) reports indicate a 4.01% growth in palay production and a 3.81% growth in corn output in 2021. Despite this, the region faces significant challenges related to malnutrition. The World Bank (2021) states that many Filipino adults suffer from health issues because of imbalanced nutrition. This leads to deficiencies and complications. Nutritional deficiency dermatoses (NDD) are among the early indicators of broader malnutrition. Johnson (2024) reports that skin conditions such as cheilosis, glossitis, and seborrheic dermatitis are often associated with riboflavin (vitamin B2) deficiency. These conditions are prevalent in areas like Bicol. Isaura et al. (2022) explain that this is due to compromised dietary diversity, resulting from socioeconomic factors and limited access to nutrient-rich foods.

These dermatological conditions, while non-fatal, result from riboflavin deficiency, affecting an estimated 10-15% of the global population (Marashly & Bohlega, 2017). Given these impacts, understanding dietary patterns that contribute to such deficiencies becomes crucial in addressing public health challenges in Bicolano communities. Building on this need, research by Li et al. (2022) identified a strong correlation between dietary behavior, particularly food purchase patterns, and deficiency-related conditions. However, despite this correlation, few studies have quantified or predicted these risks using advanced analytical techniques. Moreover, Khoo (n.d.) notes that traditional dietary assessment methods, such as 24-hour recalls and food diaries, frequently encounter challenges related to feasibility, accuracy, and cost.

These concerns about data quality are echoed by Ravelli and Schoeller (2020), who emphasize that self-reported dietary data are prone to memory lapses and social desirability bias—an issue that is particularly amplified in low-literacy populations. Similarly, Gibney et al. (2004) cautioned that these biases can distort the nutritional profiles of entire communities when applied to epidemiological surveillance. Beyond these flaws, it is evident that traditional dietary assessment tools struggle to reflect the dynamic and multidimensional nature of dietary behavior, particularly in regions where food availability fluctuates seasonally.

Given these challenges, the World Health Organization (2020) emphasized a pressing need for more accurate and context-specific nutritional assessment tools. Such tools should incorporate behavioral, economic, and environmental dimensions of food access to better understand local realities, especially in the Bicol region. In this context, even though agricultural productivity is strong, dietary adequacy in households does not always follow. Ruel-Bergeron et al. (2015) described this phenomenon as "hidden hunger," wherein energy sufficiency can mask micronutrient deficiencies—an issue particularly relevant in communities reliant on monotonous staple-based diets.

This concern is further reflected in the work of Drewnowski and Specter (2004), who found that low-income populations typically consume energy-dense but micronutrient-poor foods, a pattern largely shaped by economic constraints and food marketing. Chakona and Shackleton (2019) support this, stating that economic factors predominantly drive food choice in resource-constrained settings, often outweighing even nutritional knowledge or awareness. Thus, understanding food purchase behavior is essential not only for capturing dietary trends but also for diagnosing the underlying nutritional risks within these populations. Building on this, Kennedy et al. (2007) and Arimond et al. (2010) argued that dietary diversity scores can predict micronutrient adequacy, though they caution that these measures remain sensitive to context and must be evaluated alongside socioeconomic data. In the case of Bicol, access to diverse food groups is influenced by factors such as availability, affordability, preference, and cultural norms. Collectively, these factors shape local household purchasing decisions.

To bridge these layers of behavior and health, regression analysis allows researchers to quantify the connection between food purchases and nutrient intake. As Willett (2012) explains, regression analysis facilitates simultaneous adjustment for confounding variables, making it ideal for public health nutrition research where multiple factors influence outcomes. Building on this methodological strength, Satija et al. (2015) showed that regression methods can uncover dietary determinants of issues such as anemia, vitamin A deficiency, or stunting. For instance, Amugsi et al. (2013) employed regression analysis in sub-Saharan Africa to investigate the impact of maternal education and household wealth on the nutritional quality of children's diets, providing insights that would have been unattainable through descriptive statistics alone.

Despite the potential of regression analysis, a gap persists in its application to directly model the link between food purchase behaviors and nutrient deficiency dermatoses in Bicol. Most studies—such as those by Ivers and Cullen (2011) and Ferguson et al. (2015)—center on general malnutrition or anthropometric measures, with few addressing dermatological markers of deficiency. Furthermore, there is limited use of integrated models that combine actual purchase data with local nutrient profiling, which hinders the understanding of localized risk patterns. This highlights a methodological and contextual gap, underscoring the need for an analytical framework that accurately reflects the dietary experiences of at-risk Filipino communities.

In response to these gaps, this study employs regression analysis to integrate local food purchase patterns and FNRI secondary nutritional data, modeling how dietary behavior influences the risk of NDD in the Bicol region. This approach leverages improved dietary assessment techniques to provide greater objectivity and accuracy in predicting NDD risk. The resulting findings may guide targeted nutritional interventions, helping identify which strategies—such as subsidizing riboflavin-rich foods—are most effective at reducing local malnutrition rates. For example, a regional health officer may use these insights to implement subsidy programs for riboflavin-rich foods, such as fortified cereals or dairy products, thereby increasing access and affordability for low-income families and ultimately reducing the risk of NDD in Bicol. Beyond its local application, this study can also serve as a model for the use of advanced data analysis in public health and potentially be extended to other regions and nutrient-related conditions.

Objectives of the Study

The primary objective of this research is to investigate the relationship between dietary behavior and the risk of nutritional deficiency dermatoses (NDD) in Bicol, with a focus on riboflavin intake. By using regression analysis, this study identified key dietary patterns and consumption habits that contribute to dermatoses associated with nutritional deficiencies. The aim is to provide insights for nutritional interventions and public health strategies that can create a significant positive impact on the health of the Bicolano community. To prioritize the objectives, we assess which, if achieved, would create the greatest change for Bicolanos. The study's key objectives are ranked below, highlighting their potential impact:

1. Describe the logistic regression model's overall fit and performance in predicting NDD. This model is crucial as it provides a robust tool for assessing risk and can guide targeted interventions.
2. Determine the average daily riboflavin intake and prevalence of NDD in the Bicol region. Understanding the current riboflavin status can help identify the core areas that require intervention.
3. Present the odds ratio for each food group and its implications in predicting NDD. This helps in understanding which dietary changes can have the most significant impact on reducing the risk of NDD.
4. Determine the average daily purchase of specific food groups among Bicolanos. This objective provides insights into existing consumption patterns, which enable the tailoring of interventions to local behaviors.

Theoretical Framework of the Study

The theoretical framework for this study integrates nutritional epidemiology, dietary behavior theory, and machine learning-based health prediction to explain how dietary habits influence the risk of nutritional deficiency dermatoses (NDD) among Bicolanos. This framework is grounded in established theories and models that link nutrition, dietary choices, and disease risk.

Nutritional Epidemiology and the Diet-Disease Relationship. This study builds on the Dietary Patterns and Disease Risk Model, which suggests that long-term dietary habits have a significant influence on the development of nutrient deficiencies and associated diseases. According to Willett (1998), dietary patterns—shaped by cultural, economic, and environmental factors—impact nutrient intake and the likelihood of deficiency-related conditions. In this study, riboflavin deficiency is the primary concern, associated with cheilosis, glossitis, and seborrheic dermatitis. The concept of nutritional adequacy is also essential to this framework, emphasizing that the adequacy of micronutrient intake (e.g., riboflavin) determines whether individuals experience symptoms of deficiency. The research integrates this concept by assessing the food purchase patterns of Bicolanos and determining whether they meet the Recommended Dietary Allowance (RDA) for riboflavin.

The Theory of Planned Behavior (TPB) in Dietary Choices. This study aligns with Ajzen’s (1991) Theory of Planned Behavior (TPB) to explain how individuals make dietary decisions that influence their nutritional status. TPB suggests that attitudes, subjective norms, and perceived behavioral control drive dietary behavior. In the context of this research,

- Attitudes: Bicolanos may prioritize staple foods (e.g., rice) over riboflavin-rich foods

due to affordability and traditional dietary habits.
- Subjective norms: Cultural and societal influences, such as a preference for plant-based diets or economic constraints, shape food choices.
- Perceived behavioral control: Access to riboflavin-rich foods is affected by economic limitations, agricultural supply chains, and market accessibility.

By incorporating TPB, this study acknowledges that food purchase patterns are not solely determined by nutritional knowledge but are also influenced by a complex set of social and economic factors.

Logistic Regression and Machine Learning in Nutritional Risk Prediction. Logistic regression analysis aligns with predictive modeling approaches in public health, particularly in nutritional epidemiology. Hosmer & Lemeshow (2004) highlight logistic regression as a robust statistical method for estimating the probability of health outcomes based on predictor variables. In this study, logistic regression:

- Identifies significant predictors of NDD, including daily riboflavin intake, food group purchases, and socioeconomic factors.
- Provides odds ratios (OR) that quantify how food purchase patterns impact the risk of deficiency dermatoses.
- Helps develop a predictive model to guide nutritional interventions and policy recommendations in the Bicol region.

Additionally, integrating machine learning approaches (e.g., feature selection, model evaluation) improves the accuracy of dietary risk assessment, overcoming the limitations of traditional survey-based dietary assessments.

METHODOLOGY

This study employed a cross-sectional research design to investigate the relationship between dietary behavior and the risk of nutritional deficiency dermatoses among Bicolano households. The research primarily focused on analyzing food purchase patterns and their association with the prevalence of deficiency-related skin conditions such as cheilosis, glossitis, and seborrheic dermatitis, as determined by estimated riboflavin intake. The methodology of this research is comprehensively discussed below.

Data Collection, Sampling, and Descriptive Statistics Used

Secondary data were used in this study, specifically from the Expanded National Nutrition Survey (ENNS): Dietary Component Individual Food Consumption 2018, 2019, and 2021, provided by the Food and Nutrition Research Institute, which was promptly requested through their eNutrition website. ENNS utilized a rolling sample design, in which 117 Philippine Statistics Authority (PSA) domains, comprising provinces and highly urbanized cities (HUCs), were grouped into 24 replicates with similar characteristics, using data from the 2010 Census of Population and Housing (CPH). Eight replicates of 40 domains were independently allocated yearly to generate national-level estimates. For the regional estimates, the total number of provinces/HUCs covered in the three periods of the ENNS was cumulated to obtain the regional-level data for the different nutrition and health indicators collected in the survey. ENNS furthermore employed a two non-consecutive day 24-hour food recall to assess the food intake of individuals via their daily purchase patterns of specific food groups, some of which were considered as predictors of riboflavin intake and risk of NDD in the study namely: (a) cereals and cereal products, (b) starchy roots and tubers, (c) sugar and syrups, (d) dried beans, nuts, and seeds, (e) vegetables, (f) fruits, (g) fish and fish products, (h) meat and meat products, (i) poultry, (j) eggs, (k) milk and milk products, (l) fats and oil, and (m) beverages. For this study, a total of 724 individuals from the Bicol Region were extracted from the ENNS dataset, spread among its six provinces below: A note on representativeness: While the sample of 724 individuals provides a substantial dataset, it is important to acknowledge potential limitations in generalizing the findings to the entire Bicol Region due to sampling design constraints. The use of weighting adjustments was considered to enhance the accuracy and representativeness of the regional estimates. However, specific challenges such as variability in population density and diversity across provinces may affect the degree to which these results can be generalized.

Table 1. Sample distribution among Bicol's Provinces

Province	No. of Samples
Albay	169
Camarines Norte	75
Camarines Sur	210
Catanduanes	40
Masbate	129
Sorsogon	101
TOTAL	**724**

Moreover, the mean was used to provide a holistic view of the daily purchase patterns among Bicolanos, as no significant outliers were found in each food group after employing Grubb's test.

Riboflavin Assessment and Prevalence of NDD

The Individual Dietary Evaluation System (IDES), developed by DOST-FNRI (2022), was used to estimate the amount of food, including its energy and nutrient content, consumed by each individual. However, the ENNS dataset already contains the daily riboflavin intake for each individual, among other nutrients. According to a study by Poonam (2024), adults typically require between 1.3 and 1.6 milligrams (mg) of riboflavin daily to prevent deficiency. This literature was used to assess the potential risk of NDD prevalence among Bicolanos, particularly by noting individuals with riboflavin intake ≤ 1.3 mg as riboflavin deficient (hence potentially at risk of NDD), coded as "1", and coded as "0" otherwise. Prevalence, according to the National Institute of Mental Health (n.d.), is the number of people in the sample with the characteristic of interest divided by the total number of people in the sample. Therefore, we identify the prevalence of risk of NDD by following the formula below:

$$\text{Prevalence} = \frac{\text{No. of Bicolanos Potentially at Risk of NDD}}{\text{Overall Sample Size}} \times 100$$

Logistic Regression Analysis

To analyze the association between dietary behavior and the risk of nutritional deficiency dermatoses, logistic regression was applied. Logistic regression, among other machine learning methods, was strongly considered in this study since the target variable is categorical and dichotomous, representing the potential presence or absence of risk of dermatoses. However, the independent variables (predictors) are the purchase patterns from the specified food groups. The model allowed for the estimation of odds ratios, indicating the likelihood of developing dermatoses based on their dietary behavior. For instance, the model examined how the frequency of purchasing certain food groups affected the probability of riboflavin deficiency and the development of skin-related conditions. Results were reported with p-values and confidence intervals to understand the strength and significance of the relationships between dietary factors and dermatoses. Sensitivity analyses were performed to assess the robustness of the results, and multicollinearity was checked to ensure the reliability of the regression model. In comparison to alternative classifiers, such as decision trees and support vector machines, logistic regression was selected due to its interpretability and the ability to provide meaningful odds ratios. Preliminary cross-validation indicated that logistic regression offered comparable or improved accuracy and specificity in identifying NDD risk, making it the most suitable choice for this analysis.

This methodological approach provides a comprehensive framework for understanding the dietary behaviors of Bicolano households and their potential link to NDD, enabling the study to draw meaningful conclusions regarding dietary interventions and public health strategies aimed at reducing the prevalence of dermatoses in the region.

RESULTS AND DISCUSSION

Using logistic regression, the analysis evaluated how various dietary factors, particularly riboflavin intake, influence the likelihood of developing skin-related conditions such as cheilosis, glossitis, and seborrheic dermatitis. The discussion integrates these results with existing literature, highlighting the significance of dietary patterns and nutrient intake in preventing deficiency-related conditions. Additionally, potential implications for public health interventions in the region are considered, with a focus on improving nutrition through targeted dietary changes.

Average Daily Purchase of Specific Food Groups Among Bicolanos

This subsection examines the average daily purchase of specific food groups among Bicolano households, providing insights into their dietary behavior and nutritional intake. Understanding these purchasing trends is crucial for assessing how daily food choices may contribute to the risk of nutritional deficiency dermatoses in the region. This analysis also highlights the accessibility and affordability of these specific food groups in local markets. Table 2 shows the average daily purchase of these food groups.

As gleaned from the table, the main staple of Bicolanos revolves around cereals (1590.93 g/day), which according to FNRI include rice (ordinary, special, and glutinous), other rice products such as rice noodles (bihon), rice cakes (puto), biko, suman, arrozcaldo, champorado, milled corn, corn on a cob, other corn products like cornstarch, corn pudding (maja blanca), popcorn, corn chips, pandesal, bread, cookies/ biscuits, cakes/pastries, noodles, flour, and others. Rice alone, which is commonly found on Filipino tables, constitutes approximately 87.52% of this daily purchase (at 1,392.31 g/day), according to the data. This implies that Bicolanos may generally have an insufficient daily intake of riboflavin, considering that the most common type of rice consumed by Asians, according to Goh (2018), is medium-grain rice, which contains only 0.01mg of riboflavin per 100g, as reported in the literature (FitAudit, 2024). Consumption of enriched rice, however, can be a beneficial option for those seeking to increase their intake of riboflavin, as it is usually fortified with nutrients to enhance its nutritional value, according to the National Institute of Health (2022). In connection with this, it is important to note that cooking methods can impact the riboflavin content in rice. Riboflavin is water-soluble, meaning a portion of it can be lost during cooking, particularly if rice is rinsed before cooking. To minimize nutrient loss,

Table 2. Average Daily Purchase (in grams) of Bicolanos

	Valid	Missing	Mean	Std. Deviation
Vegetables	724	0	523.300	560.373
Fruits	724	0	139.294	401.180
Fish and Fish Products	724	0	428.034	508.987
Meat and Meat Products	724	0	160.470	295.644
Poultry	724	0	67.370	219.332
Eggs	724	0	53.525	100.424
Milk and Milk Products	724	0	194.816	730.881
Fats and Oils	724	0	91.527	160.084
Beverages	724	0	57.681	122.207
Cereals and Cereal Products	724	0	1590.930	874.365
Starchy Roots and Tubers	724	0	65.702	294.393
Sugar and Syrups	724	0	64.137	78.535
Dried Beans, Nuts, and Seeds	724	0	24.952	70.454

it is advisable not to rinse rice after cooking, per UMass Amherst. (n.d.).

It is also worth noting from Table 2 that the second most prioritized food in terms of daily purchase amongst Bicolanos is vegetables, with 523.3 g/day. Vegetables do provide some riboflavin, but they are generally not the richest sources compared to other notable food groups such as dairy products (194.816 g/day), eggs (53.525 g/day), and meat (160.47 g/day) which are considered to be the most abundant sources of riboflavin according to Poonam (2024) but is alarmingly at the bottom of the food priority of Bicolanos. One of the probable reasons behind this data is the primary concern for health for many individuals. For instance, according to Pickles (2017), high consumption of red and processed meats has been linked to numerous health issues, including heart disease, diabetes, and various cancers, thus prompting people to select a plant-based diet. Moreover, according to Scott-Reid (2021), economic factors such as rising costs associated with sustainably and ethically sourced meat and dairy often prompt consumers to opt for cheaper, plant-based alternatives. The perception of these products being more expensive creates a barrier for many consumers, making it more appealing to choose plant-based options that fit within their budget, specifically that a typical Bicolano family only spends an average of Php 202,620.00 yearly (roughly Php 555.12 per day) according to the Family Income and Expenditure Survey of Philippine Statistics Authority (PSA) as reported by Mapa in 2024.

While one may argue that these amounts collectively contribute to daily riboflavin needs, it is essential to note in this discussion the importance of including a variety of foods in your diet to ensure adequate riboflavin intake.

Average Daily Riboflavin Intake and the Prevalence of NDD in Bicol

According to the FNRI data, Bicolanos have an average daily riboflavin intake of 2.96 mg/day, which is more than twice the average intake reported in Poonam's (2024) study, suggesting that it is sufficient to avoid riboflavin deficiency. This is despite the contrasting data on the food purchase pattern of Bicolanos, which largely revolve around cereals (particularly rice) and vegetables. This may be attributed to some foods that are not typically recognized as high in riboflavin but can still contribute to overall intake. For example, dried beans, nuts, and seeds can provide moderate amounts of riboflavin, with one ounce providing approximately 23% of the daily recommended intake of riboflavin. As shown in Table 2, Bicolanos purchase 24.952 grams of these daily, equivalent to approximately 0.88 ounces. The table below shows the number of Bicolanos with a potential risk of NDD.

It can be inferred from Table 3 that 15.75% of Bicolanos are riboflavin-deficient and are therefore prone to having NDD. This number is at most 6% higher than the approximation in the study of Marashly and Bohlega (2017), though it may be more prevalent than currently acknowledged. This underscores a pressing public health concern and suggests potential gaps in local nutritional adequacy. These limitations often lead to reliance on riboflavin-less staples. For instance, the elevated prevalence indicates broader dietary challenges faced by the

Table 3. Riboflavin Deficiency Amongst Provinces of Bicol

Province	Sample Size	Riboflavin Deficient	Percentage
Albay	169	18	10.65
Camarines Norte	75	10	13.33
Camarines Sur	210	28	13.33
Catanduanes	40	11	27.50
Masbate	129	33	25.58
Sorsogon	101	14	13.86
BICOL REGION	**724**	**114**	**15.75**

population, highlighted by the data that Bicolanos tend to purchase foods according to their customs (rice dependence), other health beliefs (plant-based diet), and their purchasing capacity. Addressing these disparities requires targeted nutrition interventions, agricultural boosts, and public health strategies to improve access to riboflavin-rich foods, emphasizing the need for policies that support dietary diversity and food fortification in the region.

Notably, Camarines Sur and Masbate collectively account for over half of the NDD cases recorded in the Bicol region, warranting closer examination of their shared vulnerabilities. Several interrelated factors may explain this trend. First, both provinces are marked by elevated poverty incidence and relatively low household incomes, as documented by the Philippine Statistics Authority (2024), which limits access to nutrient-dense foods such as eggs, milk, and meat—key sources of riboflavin. Drewnowski and Specter (2004) argue that in low-income settings, households prioritize energy-dense but micronutrient-poor food items, a behavior driven by economic necessity rather than nutritional adequacy.

Masbate's geographic isolation as an island province may exacerbate the situation by restricting access to diverse food markets and perishable, nutrient-rich goods. Issaka et al. (2020) note that communities in geographically disadvantaged areas often face logistical and seasonal barriers that contribute to lower dietary diversity and increased risk of nutrient deficiencies. Camarines Sur, while agriculturally productive, experiences significant rural inequalities. Isaura et al. (2022) emphasized that agricultural abundance does not necessarily translate to household-level nutritional adequacy, particularly when food production is geared towards income generation rather than local consumption.

Cultural dietary norms may also reinforce these deficiencies. Bicolano households rely heavily on rice and plant-based meals, which, though affordable and satiating, are relatively poor in riboflavin. As Chakona and Shackleton (2019) observed, economic constraints often outweigh nutritional knowledge, leading households to opt for foods that align with their financial capacities rather than those that meet micronutrient requirements. This dietary monotony, coupled with limited purchasing power and market access, may contribute to the elevated prevalence of NDD in these provinces. Thus, targeted nutrition programs in Masbate and Camarines Sur should consider structural barriers and behavioral patterns, focusing on food fortification, improving accessibility of riboflavin-rich foods, and promoting culturally sensitive dietary education.

Logistic Regression Analysis on Food Purchase Pattern and NDD Prevalence

The logistic regression model was used to predict the likelihood of developing NDD based on the daily food purchase patterns of Bicolanos. The model was deemed fit since our target variable is binary, where 1 indicates the potential risk of dermatoses, and 0 indicates the opposite. The model demonstrated a good fit (Nagelkerke $R^2 = 0.765$, $p < 0.001$), explaining 76.5% of the variance in the risk of NDD. Additionally, the model performed well in predicting the NDD, with an overall accuracy of 94.061%, as shown in the confusion matrix below. This means that for every 100 predictions the model makes, it will accurately predict at most 95 of the cases correctly.

To put this into a practical context, consider a local clinic using this model to identify patients at risk for nutritional deficiency dermatoses. If the clinic evaluates 100 residents from the Bicol region using this model, approximately 94 individuals who truly are at risk of developing NDD would be correctly flagged for further counseling and

Confusion matrix

	Predicted		
Observed	0	1	% Correct
0	594	16	97.377
1	27	87	76.316
Overall % Correct			94.061

Note. The cut-off value is set to 0.5

Figure 1. Confusion Matrix of the Model

intervention. This high accuracy can help clinicians effectively allocate resources and personalize nutritional guidance, ensuring that those in need receive timely support and information to address their condition.

While accuracy is a useful metric, it does not always provide a complete picture, especially when the dataset is imbalanced, where some classes are significantly more common than others. This is the case in this study, where there are way fewer instances of Bicolanos at risk of NDD than those who are not. Figure 3 shows the other performance metrics of the model. It can be inferred from the figure that the overall precision of the model is 84.5%, which means that when the model predicts the existence of NDD, it correctly predicts at most 85 out of 100 NDD cases. When predicting actual positive cases of NDD as opposed to those classified as false negatives (sensitivity), the model correctly predicts 76.3% of the cases. On the other hand, when the model predicts actual negative cases of NDD as opposed to those classified as false positives (specificity), it correctly predicts 97.4% of such cases. Moreover, the variance inflation factors (VIFs) of the predictors were all found to be below 2, indicating no multicollinearity issues among the predictor variables.

Performance metrics ▼

	Value
Accuracy	0.941
Sensitivity	0.763
Specificity	0.974
Precision	0.845

Figure 2. Performance Metrics of the Model

From Table 4, it can be inferred that cereals and cereal products are a significant predictor (OR = 0.997, $p < .001$) of NDD, meaning that for every additional gram of purchase of these products, the odds of developing NDD decrease by 0.3%. The case is similar to that of vegetables, even when they are not good sources of vitamin B2 (also known as riboflavin). Notable sources of riboflavin, namely meat and meat products (OR=0.993, $p<0.001$), milk and milk products (OR=0.992, $p<0.001$), poultry (OR=0.981, $p<0.001$) and eggs (OR=0.970, $p<0.001$) were typically found to be significant predictors of NDD among Bicolanos, which reduces the odds of developing NDD by 0.7%, 0.8%, 1.9%, and

Table 4. Riboflavin Deficiency Amongst Provinces of Bicol

Predictor	OR	p-value
Cereals and Cereal Products	0.997	<.001
Starchy Roots and Tubers	1.001	0.056
Sugar and Syrups	0.998	0.700
Dried Beans, Nuts, and Seeds	0.984	0.061
Vegetables	0.997	<.001
Fruits	0.999	0.544
Fish and Fish Products	0.996	<.001
Meat and Meat Products	0.993	<.001
Poultry	0.981	<.001
Eggs	0.970	<.001
Milk and Milk Products	0.992	<.001
Fats and Oils	0.995	0.086
Beverages	0.990	0.013

3.0% respectively for every additional gram of purchase. The purchase of fish also significantly reduces the odds of NDD by 0.4%. Notably, every additional gram of purchased beverages can contribute significantly to decreasing the odds of NDD by 1%. Conversely, although the odds ratio for purchasing sugar and syrups, dried beans, nuts, seeds, fruits, fats, and oils shows evidence of reducing the odds of NDD for every additional gram purchased, the model indicates that these effects are not significant. This means that purchasing these products, although some have a reasonable riboflavin value based on prior studies and literature, such as those from WebMD (Poonam, 2024), will not significantly reduce the chance of developing NDD among Bicolanos. On the other hand, though every additional gram of purchase of starchy roots and tubers was found to increase the chance of having NDD by 0.1% (OR=1.001), this does not pose a significant result (p=0.056), hence showing evidence of no NDD harm to purchase these products.

These findings suggest that interventions to increase riboflavin intake could reduce the risk of NDD in the Bicol Region. For instance, taking into account the obsession of Bicolanos (Filipinos, in general) with rice, government units and other research bodies may look into the possible development and introduction of enriched varieties of rice, which can be equipped with additional nutrients such as riboflavin, since rice is found to significantly reduce the odds of NDD. However, while enriched rice could offer health benefits, it may disproportionately affect different income groups. Households with higher incomes may benefit more readily from such initiatives, as they may have better access to enriched rice markets, whereas lower-income families may struggle with affordability or access. Therefore, policymakers should consider implementing subsidies or price controls to ensure equity in the distribution and accessibility of enriched rice, thus preventing any unintended socioeconomic disparities.

Moreover, since Bicolanos have low expenditure resulting from relatively low annual income compared to other regions, as shown in the PSA data, the government could assist Bicolanos by improving access to markets with products rich in riboflavin to ensure more room for spending on diverse food groups, particularly in areas with limited food diversity.

CONCLUSIONS AND RECOMMENDATIONS

This study explored the relationship between dietary behavior and the risk of nutritional deficiency dermatoses (NDD) in the Bicol region of the Philippines by employing logistic regression analysis in existing data from the Food and Nutrition Research Institute (FNRI) on food purchase patterns of Bicolanos on specific food groups and riboflavin intake among Bicolano households, which is a key contributor in the development of dermatosis. Findings revealed that most Bicolanos spend their money on buying cereals and cereal products (1,590.93 g/day) and vegetables (523.30 g/day). The prevalence of nutritional deficiency dermatosis risk in Bicolanos is at 15.75%, with Masbate and Camarines Sur collectively contributing more than half of these cases. The logistic regression model demonstrated a good fit, with a significant Nagelkerke R^2 value of 0.765, accounting for 76.5% of the variance in the risk of NDD. Moreover, the metrics showed a promising performance of the model, with an overall accuracy of 94.1%, a precision of 84.5%, a sensitivity of 76.3%, and a specificity of 97.4%, with variance inflation factors (VIFs) all below 2, indicating no multicollinearity issues among the food groups. Cereals and vegetables significantly reduce the odds of NDD by 0.3% for every additional gram of purchase, even when they are not notable sources of riboflavin, according to existing literature. Typical sources of riboflavin such as meat and meat products (OR=0.993, $p<0.001$), milk and milk products (OR=0.992, $p<0.001$), poultry (OR=0.981, $p<0.001$) and eggs (OR=0.970, $p<0.001$) were found to be significant predictors of NDD among Bicolanos, which reduces the odds of developing NDD by 0.7%, 0.8%, 1.9%, and 3.0% respectively for every additional gram of purchase. The purchase of fish also significantly reduces the odds of NDD by 0.4%. However, every additional gram of purchased beverages can also significantly contribute to a 1% decrease in the odds of NDD.

On the other hand, purchasing sugar and syrups, dried beans, nuts, seeds, fruits, and fats and oil show evidence of reducing the odds of NDD for every additional gram of purchase but are not significant; and though every additional gram of purchase of starchy roots and tubers were found to increase the chance of having NDD by 0.1% (OR=1.001), this does not pose significant result (p=0.056).

To address these findings, a priority action for a regional nutrition program should be the development and introduction of riboflavin-enriched rice varieties. Given the significant dietary reliance on rice in the Bicol region, enhancing its nutritional profile could help immediately reduce the prevalence of NDD. Implementing educational campaigns to raise awareness about the benefits of consuming foods rich in riboflavin and promoting food diversity could further support this initiative. These efforts could be crucial steps toward improving nutrition and reducing NDD, supporting healthier dietary behavior among Bicolanos.

This study concludes that even for food groups with little known riboflavin content, such as rice, vegetables, and beverages, sufficient consumption of these products can significantly decrease the risk of acquiring NDD and can further complement the riboflavin sufficiency of noted riboflavin-rich foods, including meats, dairy products, and eggs. Purchasing riboflavin-rich foods, such as dried nuts and seeds, does not necessarily mean a lower chance of developing NDD among Bicolanos. On the other hand, purchasing food groups that show evidence of increasing the odds of riboflavin deficiency, such as starchy roots, does not mean harm in acquiring NDD. Considering the food purchase pattern and the economic background of Bicolanos, this study strongly suggests some public health interventions aimed at increasing riboflavin intake to significantly reduce the incidence of nutritional deficiency dermatoses in the Bicol region. First, the government may consider exploring potential efforts to develop enriched rice varieties, with a focus on incorporating riboflavin into these varieties. Campaign programs aimed at introducing this and other already known riboflavin-rich foods to the public, with an emphasis on food diversity, are also highly encouraged. Targeted dietary programs focusing on increasing the availability of riboflavin-rich foods, such as dairy products and meat products, may also be particularly effective. Moreover, since Bicolanos are known to have low annual incomes and hence limited expenditure capacity, the government could assist them by improving access to markets with products rich in riboflavin, thereby ensuring more room for spending on diverse food groups, particularly in areas with limited food diversity. Controlling the prices of these products is also highly encouraged.

Future research direction. The interaction effects between food groups and cost analysis of the proposed intervention in addressing nutritional deficiency dermatosis, which were considered as limitations of this study, may be explored in future research. Additionally, acknowledging potential limitations, such as measurement error and unmeasured confounders, in the current analysis can strengthen readers' trust in proposed future directions. A deeper analysis of why food groups known to have little to no riboflavin, such as beverages, have a significant impact on decreasing the chances of NDD may also be explored.

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