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An Integrated FMEA-TOPSIS Approach and Its Application in Prioritizing Barriers to Nutrition Knowledge

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ABSTRACT: Inadequate nutrition knowledge can hinder individuals' ability to understand, evaluate, and appropriately use nutrition information, yet existing research has paid comparatively less attention to systematically prioritizing the barriers underlying this problem. This study develops an integrated Failure Mode and Effects Analysis (FMEA), variance-based weighting, and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) framework for prioritizing barriers to nutrition knowledge among Vietnamese adults. Candidate barriers were identified from the nutrition and food-literacy literature and subjected to expert validation using a modified Delphi procedure. Eight multidisciplinary experts were specified using predefined criteria related to academic qualifications, professional experience, and expertise in nutrition, food science, public health, medicine, or health communication. Eight barriers were subsequently evaluated using two FMEA criteria: occurrence and severity. To address the equal-weighting and discrimination limitations of conventional Risk Priority Number calculations, statistical variance was employed to derive objective criterion weights, followed by TOPSIS to determine the relative priority of each barrier. In the illustrative application, occurrence received an objective weight of 0.572, while severity received a weight of 0.428. The resulting TOPSIS ranking placed exposure to nutrition misinformation first, followed by low ability to evaluate nutrition information, reliance on social and informal information sources, and commercial and misleading nutrition claims. Sensitivity analysis indicated that the two highest-priority barriers remained stable under alternative weighting scenarios. The proposed framework provides a transparent and reproducible approach for converting expert knowledge into a quantitative priority structure and offers a methodological basis for developing targeted nutrition-information and health-promotion interventions in Vietnam. The numerical application presented in this study is illustrative and should be replaced by actual expert assessments for empirical publication.

1. INTRODUCTION

Nutrition is a fundamental determinant of human health, and the quality of dietary choices is closely associated with the prevention of malnutrition and diet-related noncommunicable diseases (NCDs). The World Health Organization (WHO) identifies unhealthy diets as a major risk factor for disease and disability and emphasizes adequate, balanced, moderate, and diverse dietary patterns as core principles of a healthy diet [1]. Dietary decisions, however, are not made solely on the basis of food availability. Individuals must also obtain, understand, interpret, and evaluate nutrition-related information to determine whether particular foods, nutrients, dietary practices, or health claims are appropriate. Thus, nutrition knowledge represents an important foundation for informed dietary decision-making, although knowledge alone does not guarantee healthy food choices [2].

The importance of this issue has increased as food systems and information environments have become more complex. Vietnam has experienced a rapid nutrition transition characterized by changes in food supply, household expenditure, food consumption, and dietary patterns. While undernutrition has declined, overweight, obesity, and diet-related chronic diseases have become increasingly important public-health concerns [3]. At the same time, Vietnamese consumers are increasingly exposed to packaged foods, nutrition labels, health-related marketing, and digital information. For example, Nguyen-Anh et al. [4] analyzed data from 4,047 adults and 737 adolescents in urban Vietnam and found that nutrition-label use was associated with dietary characteristics related to added-sugar consumption. This finding illustrates the potential relevance of nutrition information to dietary behavior, but it also implies that consumers must be able to interpret and use such information appropriately. More recently, a national survey of 3,550 Vietnamese adults reported that 67.3% of participants had problematic general health literacy, despite 85.5% having sufficient eHealth literacy, highlighting a potential difference between access to digital information and the ability to use health information effectively [5]. Although general health literacy is broader than nutrition literacy, these findings indicate the relevance of information-processing capability in the Vietnamese context.

Nutrition literacy research provides further support for examining this problem from an information-processing perspective. Krause et al. [6], through a systematic review of definitions of nutrition literacy and food literacy, concluded that nutrition literacy primarily concerns the ability to obtain and understand nutrition information, whereas food literacy encompasses broader knowledge and practical skills, including critical reflection on food choices and their implications for health. Truman et al. [7] similarly showed that food literacy encompasses multiple forms of food-related knowledge and competence rather than a single factual construct. Consequently, inadequate nutrition knowledge may arise through different pathways. Individuals may have insufficient opportunities for nutrition education, encounter misleading or contradictory information, have difficulty evaluating the credibility of nutrition claims, struggle to interpret food labels, or rely heavily on social and informal information sources. These barriers are conceptually different and may therefore require different intervention strategies.

The problem is further complicated by the rapid growth of digital nutrition communication. Social-media platforms have created unprecedented opportunities for disseminating nutrition information but have also increased the circulation of misinformation. A recent review of 28 studies reported substantial dissemination of nutrition misinformation across social-media platforms, including unsupported claims concerning diets, foods, supplements, and disease prevention, and emphasized the importance of digital literacy and evidence-based communication in addressing this problem [8]. Evidence evaluating nutrition content on influential social-media accounts has similarly identified substantial levels of poor-quality and inaccurate information, with differences according to the type of account and topic [9]. These developments suggest that nutrition knowledge should be viewed not only as an educational outcome but also as a consequence of the interaction between individuals and a complex nutrition-information environment.

Despite the increasing attention to nutrition knowledge and nutrition literacy, an important research gap remains. Previous studies have predominantly focused on measuring the level of nutrition knowledge, identifying demographic correlates, examining associations with dietary behavior, or developing nutrition-literacy instruments [2, 6]. Such studies are valuable for establishing the existence and characteristics of knowledge gaps, but they do not necessarily answer a management-oriented question: which underlying barriers should be addressed first when resources for nutrition intervention are limited? In particular, a barrier can be frequent but relatively less consequential, while another may occur less frequently but have substantially more serious implications. A systematic prioritization procedure is therefore required to distinguish among heterogeneous barriers according to multiple dimensions of risk.

This problem can be formulated as a multi-criteria decision-making (MCDM) problem. Failure Mode and Effects Analysis (FMEA) provides an established risk-assessment logic for identifying potential failure modes and evaluating them according to criteria such as occurrence and severity. Nevertheless, conventional FMEA typically combines criterion scores through the Risk Priority Number (RPN). The conventional RPN approach has been criticized because it implicitly treats criteria equally and can assign the same RPN to different combinations of criterion scores, thereby reducing its ability to discriminate among alternatives with different risk profiles [10, 11]. A substantial body of research has consequently incorporated MCDM methods into FMEA to improve risk-factor prioritization; a systematic review identified 169 publications applying MCDM techniques to FMEA between 1998 and 2018 [12]. This methodological development suggests that FMEA can be extended beyond simple RPN calculation toward a more transparent multi-criteria ranking framework.

Among MCDM techniques, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) provides an appropriate mechanism for the present problem. TOPSIS ranks alternatives according to their relative distances from a positive ideal solution and a negative ideal solution [13]. This property allows multiple nutrition-knowledge barriers to be compared simultaneously while preserving information from separate evaluation criteria. However, TOPSIS requires criterion weights, and the resulting ranking can be influenced by how those weights are specified. Subjective weighting may introduce additional dependence on expert preferences, particularly when the expert panel is relatively small.

To address this issue, an objective variance-based weighting procedure can be integrated into the framework. The statistical variance method derives criterion weights from the degree of dispersion in the normalized decision matrix. A criterion exhibiting greater variation across alternatives provides greater discriminatory information and consequently receives a larger objective weight [14]. Unlike purely subjective weighting approaches, the variance method derives the weights directly from the observed evaluation matrix. This provides a useful methodological complement to expert-based scoring: experts provide the substantive assessment of occurrence and severity, whereas the mathematical weighting procedure determines the relative discriminatory importance of those criteria.

Accordingly, this study develops an integrated FMEA–variance weighting–TOPSIS framework to prioritize barriers to adequate nutrition knowledge among Vietnamese adults. The framework first identifies candidate barriers from the literature and uses structured expert assessment to establish their relevance to the Vietnamese context. An expert panel is then used to assess the occurrence and severity of each validated barrier. Instead of calculating a conventional RPN, the proposed framework normalizes the evaluation matrix, derives objective criterion weights using statistical variance, and applies TOPSIS to obtain a final priority coefficient for each barrier. This structure separates factor identification, risk evaluation, objective weighting, and priority ranking into distinct analytical stages, thereby improving methodological transparency.

The study addresses the following research question:

Which barriers to adequate nutrition knowledge should receive the highest intervention priority among Vietnamese adults when occurrence and severity are jointly considered?

The study makes three principal contributions. First, it develops a structured set of barriers to inadequate nutrition knowledge by integrating findings from nutrition-literacy research with expert knowledge relevant to Vietnam. Second, it proposes an FMEA-based MCDM framework in which occurrence and severity are assessed explicitly rather than compressed into a conventional RPN. Third, it integrates statistical variance weighting with TOPSIS to reduce reliance on arbitrarily assigned criterion weights and to provide a transparent relative-priority ranking. The resulting framework contributes an operations-research perspective to a nutrition and human-health problem and can subsequently be adapted to other contexts involving nutrition information, dietary supplements, functional foods, natural products, and other health-related food decisions.

2. EMPIRICAL CASE SETTING AND PROPOSED BARRIERS TO NUTRITION KNOWLEDGE

2.1 Empirical case setting and expert-based data collection

Vietnam was selected as the empirical context because the country is undergoing a rapid nutrition transition accompanied by changes in food supply, dietary patterns, food consumption, and nutrition-related health outcomes [3]. Although traditional dietary patterns remain important, Vietnamese consumers are increasingly exposed to packaged foods, nutrition labels, commercial food claims, and digital nutrition information. In particular, evidence from 1,590 households in Hanoi and Ho Chi Minh City, including 4,047 adults and 737 adolescents, showed that nutrition-label use was associated with a lower share of calories from foods and beverages containing added sugars, indicating the potential relevance of nutrition information to dietary choices [4]. Nevertheless, the ability to access information does not necessarily imply the ability to understand or evaluate it. A national survey of 3,550 Vietnamese adults conducted in 2025 reported that 67.3% had problematic general health literacy, although 85.5% had sufficient eHealth literacy; the study further found different associations between health literacy and the use of social media and official health websites [5]. These findings provide a relevant background for examining barriers associated with nutrition knowledge and nutrition-information processing in Vietnam.

The empirical investigation adopts an expert-based design because the primary purpose is to identify and prioritize heterogeneous barriers rather than estimate their population prevalence. Expert judgment is appropriate when a research problem involves multiple dimensions for which available empirical evidence is incomplete or difficult to compare directly [15].

Eight experts are selected purposively from Vietnamese universities, hospitals, public-health institutions, nutrition organizations, food-science institutions, and health-related research centers. To ensure sufficient domain expertise, eligibility requires a minimum master's degree in nutrition, dietetics, food science, medicine, public health, health education, or a closely related field, at least five years of relevant professional or research experience, direct involvement with nutrition, food, public health, health communication, or dietary practice, and professional familiarity with the Vietnamese population. A multidisciplinary panel is preferred, including nutrition/public-health researchers, clinical nutritionists or dietitians, food-science or food-safety specialists, public-health practitioners, and health-communication or digital-health specialists. Purposive expert selection and transparent eligibility criteria are commonly recommended in Delphi research because there is no universally accepted expert-panel size [16, 15].

The barrier-identification process follows a modified Delphi procedure. Candidate barriers are first derived from the literature on nutrition knowledge, nutrition literacy, food literacy, food labeling, nutrition misinformation, and health-information behavior [6, 7, 18]. The candidates are then presented to the eight experts in an anonymous questionnaire using a five-point relevance scale ranging from 1 = not relevant to 5 = highly relevant. Experts are also invited to recommend additional barriers or modify ambiguous definitions. After the responses are aggregated, the group-level results and anonymized comments are returned to the panel for reconsideration of items that require clarification or do not initially achieve the consensus threshold. Consensus is predefined as at least 75% of experts assigning a relevance score of 4 or 5, corresponding to at least six of the eight experts. A 70–80% agreement threshold is commonly used in health-related Delphi studies, although no universal consensus criterion exists [18, 15]. The Delphi process terminates when the retained barriers satisfy the predefined consensus criterion and no substantial conceptual ambiguity remains.

Following barrier validation, the same experts independently evaluate each retained barrier using two FMEA criteria: occurrence and severity. Occurrence represents the perceived frequency with which a barrier is encountered among Vietnamese adults, whereas severity represents the potential seriousness of the barrier for individuals' ability to understand, evaluate, and use nutrition information appropriately. Both criteria are scored on a 1–10 scale, where higher values indicate greater occurrence or greater severity. The completed questionnaires are collected electronically using a standardized Vietnamese-language form. Each expert is assigned an anonymous code (E1–E8), and individual identities are kept separate from the numerical decision matrix. The expert scores are subsequently aggregated to form the input matrix for the variance-based weighting and TOPSIS procedures.

2.2 Proposed barriers to nutrition knowledge

The literature indicates that nutrition literacy extends beyond factual knowledge and includes the ability to access, understand, evaluate, and apply nutrition information [6, 7]. Difficulties in these processes may arise from educational, informational, technological, cultural, and commercial factors. For example, low health literacy, literacy, and numeracy can hinder the understanding and use of nutrition labels [17], while nutrition misinformation is increasingly disseminated through social-media platforms [8]. Food literacy research additionally emphasizes the roles of knowledge, skills, culture, and the food environment in shaping food-related decisions [7]. Based on this literature and the relevance of these mechanisms to the Vietnamese context, eight candidate barriers are proposed for expert validation as shown in Table 1.

Table 1. Proposed barriers

Code	Barrier	Definition
F1	Insufficient nutrition education	Limited opportunities to acquire systematic and reliable nutrition knowledge through schools, healthcare services, workplaces, or community programs
F2	Low ability to evaluate nutrition information	Difficulty assessing the credibility, scientific validity, consistency, or applicability of nutrition-related information
F3	Exposure to nutrition misinformation	Exposure to inaccurate, exaggerated, incomplete, or scientifically unsupported information concerning foods, diets, nutrients, or health

F4	Reliance on social and informal information sources	Frequent reliance on social media, influencers, family, friends, or other informal sources rather than qualified or authoritative sources
F5	Complexity of food labels and nutrition terminology	Difficulty understanding nutrient declarations, ingredient lists, serving sizes, technical terminology, and nutrition or health claims
F6	Cultural and traditional nutrition misconceptions	Persistent beliefs about foods, nutrients, dietary practices, or food-health relationships that may conflict with current scientific evidence
F7	Limited access to reliable nutrition information	Difficulty obtaining nutrition information that is credible, understandable, accessible, and relevant
F8	Commercial and misleading nutrition claims	Influence of advertising, product promotion, sponsorship, or commercially motivated nutrition and health claims on consumers' understanding

The eight barriers represent different mechanisms within the nutrition-information process. F1 reflects the educational foundation of nutrition knowledge; F2 concerns the individual's ability to critically evaluate information; F3 and F4 represent characteristics of the contemporary information environment and information-source selection; F5 concerns the complexity of nutrition communication; F6 captures sociocultural influences; F7 addresses access to trustworthy information; and F8 reflects commercial influences on nutrition-related communication. The distinction among these barriers is important because they may require different intervention strategies. Moreover, evidence that food literacy encompasses knowledge, skills, culture, and food-system factors supports treating nutrition knowledge as a multidimensional problem rather than a single educational outcome [7].

The final set of barriers used in the FMEA-TOPSIS analysis is determined by the Delphi consensus results. Only barriers that satisfy the predefined 75% relevance criterion and remain conceptually distinct after expert review are retained.

3. TOPSIS METHOD FOR EVALUATING BARRIERS TO NUTRITION KNOWLEDGE

The proposed method integrates Failure Mode and Effects Analysis (FMEA), statistical variance-based weighting, and the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to prioritize the barriers to adequate nutrition knowledge identified in Section 2. FMEA is employed to provide the risk-assessment structure, while variance weighting and TOPSIS are used to determine criterion importance and establish the final priority order. This integration follows the broader methodological development of MCDM-enhanced FMEA, which has been widely investigated as a means of overcoming limitations associated with conventional Risk Priority Number (RPN) calculations [12].

For the present problem, occurrence (O) and severity (S) are selected as the two evaluation criteria. Occurrence represents how frequently a particular barrier is perceived to affect Vietnamese adults, whereas severity represents the potential seriousness of the barrier for understanding, evaluating, and using nutrition information. Both criteria are assessed using a 1–10 scale, with higher scores representing greater occurrence or severity. Consequently, a higher value indicates a greater intervention priority, and both criteria are treated as benefit-type criteria within the TOPSIS procedure. Detection is not included because the purpose of this study is to prioritize barriers to nutrition knowledge rather than determine the detectability of failures in a technical or production system.

Let F_i denote the i th barrier, where $i = 1, 2, \dots, m$, and let C_j denote the j th evaluation criterion, where $j = 1, 2, \dots, n$. In the present study, $m = 8$ and $n = 2$, corresponding to eight barriers and two criteria, occurrence and severity. Let x_{ijk} denote the score assigned by expert k to barrier i under criterion j , where $k = 1, 2, \dots, K$ and $K = 8$.

The individual expert assessments are first aggregated using the arithmetic mean:

$$x_{ij} = \frac{1}{K} \sum_{k=1}^K x_{ijk}. \quad (1)$$

The resulting aggregated decision matrix is:

$$X = \begin{bmatrix} x_{11} & x_{12} \\ x_{21} & x_{22} \\ \vdots & \vdots \\ x_{m1} & x_{m2} \end{bmatrix}. \quad (2)$$

For the present application, the two columns of X represent occurrence and severity, respectively.

The conventional FMEA approach would combine the criteria through an RPN. When only occurrence and severity are considered, the corresponding RPN can be expressed as:

$$RPN_i = O_i S_i. \quad (3)$$

However, RPN is not used as the principal prioritization measure in this study. Conventional FMEA has been criticized because its multiplicative structure may assign identical RPN values to different combinations of criterion scores and implicitly assumes equal importance of the risk criteria [11, 12]. MCDM-based extensions have therefore been developed to provide more flexible and discriminative risk prioritization [12]. The present study addresses this issue by determining objective criterion weights and subsequently applying TOPSIS.

The first step of the proposed procedure is normalization of the aggregated decision matrix. Vector normalization is applied as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}}, \quad i = 1, \dots, m, \quad j = 1, \dots, n. \quad (4)$$

This transformation eliminates differences in the numerical scale of the criteria while preserving the relative information contained in the decision matrix. Vector normalization is also commonly used in the classical TOPSIS procedure [13].

Because the present study employs an objective weighting mechanism, the normalized matrix is subsequently used to calculate the statistical variance associated with each criterion. The mean normalized value of criterion j is:

$$\bar{r}_j = \frac{1}{m} \sum_{i=1}^m r_{ij}. \quad (5)$$

The statistical variance of criterion j is then calculated as:

$$V_j = \frac{1}{m} \sum_{i=1}^m (r_{ij} - \bar{r}_j)^2. \quad (6)$$

The statistical variance method derives objective criterion weights from the dispersion of normalized criterion values. A greater variance indicates greater differentiation among alternatives and consequently greater discriminatory information for decision-making [14]. The resulting objective weight of criterion j is:

$$w_j = \frac{V_j}{\sum_{j=1}^n V_j}, \quad (7)$$

where:

$$w_j \geq 0$$

and:

$$\sum_{j=1}^n w_j = 1. \quad (8)$$

For the two criteria used in this study, the occurrence and severity weights are therefore:

$$w_o = \frac{V_o}{V_o + V_s}, \quad (9)$$

$$w_s = \frac{V_s}{V_o + V_s}. \quad (10)$$

The use of variance-based weighting provides an objective complement to expert judgment. Experts determine the actual occurrence and severity assessments, whereas the variance procedure determines the relative discriminatory importance of the two criteria from the resulting data matrix. This distinction reduces the need to impose predetermined subjective weights on occurrence and severity.

After determining the criterion weights, TOPSIS is applied to obtain the final priority ranking. TOPSIS, originally proposed by Hwang and Yoon [13], is based on the principle that an alternative should be simultaneously close to the positive ideal solution and distant from the negative ideal solution. The method has subsequently been widely applied to MCDM problems because it provides a direct mechanism for comparing alternatives evaluated against multiple criteria.

The weighted normalized matrix is first constructed as:

$$v_{ij} = w_j r_{ij}. \quad (11)$$

Thus:

$$V = [v_{ij}]_{m \times n}. \quad (12)$$

Because higher occurrence and severity scores indicate greater intervention priority in the present application, both criteria are treated as benefit-type criteria. The positive ideal solution is therefore defined as:

$$A^+ = \{v_1^+, v_2^+, \dots, v_n^+\}, \quad (13)$$

where:

$$v_j^+ = \max_i v_{ij}. \quad (14)$$

The negative ideal solution is:

$$A^- = \{v_1^-, v_2^-, \dots, v_n^-\}, \quad (15)$$

where:

$$v_j^- = \min_i v_{ij}. \quad (16)$$

The positive ideal solution therefore represents the highest observed intervention-priority profile, whereas the negative ideal solution represents the lowest observed profile.

The Euclidean distance of barrier i from the positive ideal solution is calculated as:

$$D_i^+ = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^+)^2}. \quad (17)$$

Similarly, its distance from the negative ideal solution is:

$$D_i^- = \sqrt{\sum_{j=1}^n (v_{ij} - v_j^-)^2}. \quad (18)$$

The relative closeness coefficient of barrier i to the positive ideal solution is then:

$$C_i^* = \frac{D_i^-}{D_i^+ + D_i^-}. \quad (19)$$

The coefficient satisfies:

$$0 \leq C_i^* \leq 1. \quad (20)$$

A larger value of C_i^* indicates that barrier i is closer to the positive ideal solution and farther from the negative ideal solution. Accordingly, barriers are ranked in descending order of C_i^* :

$$C_{(1)}^* > C_{(2)}^* > \dots > C_{(m)}^*. \quad (21)$$

The barrier with the largest C_i^* is consequently identified as the highest-priority barrier for intervention within the evaluated set.

4. RESULTS

4.1 Expert evaluation and Delphi validation

The expert-based assessment was designed to establish whether the proposed barriers were sufficiently relevant to the Vietnamese nutrition-information context before their prioritization. The illustrative panel consisted of eight experts representing nutrition and public health research, clinical nutrition, food science, public health practice, medicine, and health communication. All experts satisfied the predefined eligibility requirements described in Section 2, including relevant academic qualifications, a minimum of five years of professional or research experience, and familiarity with nutrition or health-information issues in Vietnam.

The Delphi assessment used a five-point relevance scale. A barrier was considered to have reached consensus when at least 75% of experts assigned a relevance score of 4 or 5. With eight experts, this required agreement from at least six experts. This threshold is consistent with the range of consensus levels commonly reported in health-related Delphi studies [18, 15].

As shown in Table 2, all eight candidate barriers achieved the predefined consensus threshold. The agreement level ranged from 75.0% to 100.0%, with mean relevance scores between 4.38 and 4.88. F2 and F3 obtained the highest mean relevance score, while F5 and F7 had the lowest agreement level at 75.0%. Nevertheless, both remained above the predefined inclusion criterion. No additional barrier proposed during the expert review was sufficiently distinct from the existing factors to warrant inclusion as a separate alternative.

Table 2. Delphi validation of barriers to nutrition knowledge

Code	Barrier	Mean relevance score	Experts rating 4–5	Agreement	Decision
F1	Insufficient nutrition education	4.63	7/8	87.5%	Retain
F2	Low ability to evaluate nutrition information	4.88	8/8	100.0%	Retain
F3	Exposure to nutrition misinformation	4.88	8/8	100.0%	Retain
F4	Reliance on social and informal information sources	4.75	8/8	100.0%	Retain

F5	Complexity of food labels and nutrition terminology	4.38	6/8	75.0%	Retain
F6	Cultural and traditional nutrition misconceptions	4.50	7/8	87.5%	Retain
F7	Limited access to reliable nutrition information	4.38	6/8	75.0%	Retain
F8	Commercial and misleading nutrition claims	4.63	7/8	87.5%	Retain

The Delphi results support the use of the eight barriers as alternatives in the subsequent FMEA-TOPSIS model. The high consensus for F2, F3, and F4 is also consistent with nutrition-literacy literature emphasizing the importance of information evaluation, information quality, and the contemporary information environment [6, 7]. The inclusion of food-label complexity is additionally consistent with evidence that consumers' ability to interpret nutrition information is relevant to food-related decision-making [4].

4.2 FMEA evaluation and variance-based criterion weighting

Following Delphi validation, the eight experts independently evaluated the retained barriers according to occurrence and severity using the 1–10 FMEA scales. The aggregated scores are presented in Table 3.

Table 3. Aggregated occurrence and severity scores

Code	Barrier	Occurrence O	Severity S
F1	Insufficient nutrition education	7.000	7.500
F2	Low ability to evaluate nutrition information	7.875	8.250
F3	Exposure to nutrition misinformation	8.125	8.375
F4	Reliance on social and informal information sources	7.750	7.875
F5	Complexity of food labels and nutrition terminology	6.875	7.125
F6	Cultural and traditional nutrition misconceptions	7.250	7.625
F7	Limited access to reliable nutrition information	6.250	6.750
F8	Commercial and misleading nutrition claims	7.500	8.000

The aggregated scores show that F3 received the highest occurrence score (8.125) and severity score (8.375), indicating that the illustrative expert panel regarded exposure to nutrition misinformation as both relatively frequent and consequential. F2 was the second-highest factor on both criteria, with occurrence and severity scores of 7.875 and 8.250, respectively. In contrast, F7 had the lowest occurrence score (6.250) and severity score (6.750). Table 4 displays the results.

The normalized decision matrix was then used to determine the objective criterion weights through the variance method. The calculated variance values were:

$$V_O = 0.0007586$$

and:

$$V_S = 0.0005675.$$

Accordingly, the objective weights were:

$$w_O = 0.5720$$

and:

$$w_S = 0.4280.$$

Table 4. Variance-based criterion weighting

Criterion	Mean normalized value	Variance	Objective weight
Occurrence	0.3488	0.0007586	0.5720
Severity	0.3491	0.0005675	0.4280
Total		0.0013261	1.0000

Occurrence therefore receives a greater objective weight than severity in the illustrative analysis. This does not indicate that occurrence is inherently more important than severity. Rather, it indicates that occurrence provides greater discriminatory variation among the eight evaluated barriers in the resulting decision matrix. This is precisely the purpose of objective variance weighting: criterion importance is derived from the information contained in the alternatives rather than imposed solely through subjective judgment [14].

4.3 TOPSIS prioritization of nutrition-knowledge barriers

After obtaining the criterion weights, the normalized decision matrix was weighted and the positive and negative ideal solutions were identified. Since higher occurrence and severity indicate a greater need for intervention, both criteria were treated as benefit-type criteria.

The positive ideal solution was:

$$A^+ = (0.2236, 0.1645),$$

while the negative ideal solution was:

$$A^- = (0.1720, 0.1326).$$

The distances from the two ideal solutions and the resulting TOPSIS closeness coefficients are shown in Table 5.

Table 5. TOPSIS results and priority ranking

Rank	Code	Barrier	D_i^+	D_i^-	C_i^*
1	F3	Exposure to nutrition misinformation	0.0000	0.0607	1.0000
2	F2	Low ability to evaluate nutrition information	0.0073	0.0535	0.8800
3	F4	Reliance on social and informal information sources	0.0142	0.0468	0.7667
4	F8	Commercial and misleading nutrition claims	0.0187	0.0423	0.6931
5	F6	Cultural and traditional nutrition misconceptions	0.0282	0.0324	0.5348
6	F1	Insufficient nutrition education	0.0354	0.0254	0.4173
7	F5	Complexity of food labels and nutrition terminology	0.0423	0.0187	0.3069
8	F7	Limited access to reliable nutrition information	0.0607	0.0000	0.0000

The resulting priority order is:

$$F3 > F2 > F4 > F8 > F6 > F1 > F5 > F7.$$

F3 obtained the highest TOPSIS coefficient ($C_i^* = 1.0000$), reflecting its position at the positive ideal solution because it simultaneously achieved the highest occurrence and severity scores among the eight barriers. F2 ranked second with a coefficient of 0.8800, followed by F4 (0.7667) and F8 (0.6931).

The first four positions therefore correspond to barriers associated primarily with the information environment and consumers' ability to evaluate nutrition information. Specifically, misinformation, difficulties in evaluating nutrition information, reliance on informal information sources, and commercial or misleading claims received greater priority than more general educational or accessibility-related barriers.

F6 occupied the fifth position with a coefficient of 0.5348. Although cultural and traditional misconceptions did not reach the same priority level as misinformation and information-evaluation difficulties, its occurrence and severity scores remained above the midpoint of the 1–10 scale. F1, F5, and F7 obtained lower coefficients, with F7 representing the negative ideal solution because it had the lowest scores for both occurrence and severity.

These findings should be interpreted as relative intervention priorities within the expert-defined decision set. They do not imply that F3 affects a particular percentage of Vietnamese adults or that F7 has no practical importance.

4.4 Sensitivity analysis

A sensitivity analysis was conducted to examine whether the ranking depended strongly on the criterion weights, as shown in Table 6. In addition to the variance-based weights (0.572/0.428), three alternative weighting scenarios were considered: equal weighting, occurrence-dominant weighting, and severity-dominant weighting.

Table 6. Sensitivity analysis under alternative criterion weights

Code	Variance-based 0.572/0.428	Equal 0.500/0.500	Occurrence- dominant 0.700/ 0.300	Severity-dominant 0.300/0.700
F3	1	1	1	1
F2	2	2	2	2
F4	3	3	3	4
F8	4	4	4	3
F6	5	5	5	5
F1	6	6	6	6
F5	7	7	7	7
F7	8	8	8	8

The first two priorities, F3 and F2, remained unchanged across all four weighting scenarios. F5 and F7 also maintained their positions. The only ranking change occurred between F4 and F8 under the severity-dominant scenario. F8 moved from fourth to third because its severity score was relatively high, whereas F4, although occurring frequently, had a slightly lower severity score.

The sensitivity analysis therefore indicates that the highest-priority barriers in the illustrative application are relatively robust to changes in criterion weights. At the same time, the exchange between F4 and F8 demonstrates why criterion weighting should be explicitly reported rather than treated as an inconsequential modeling choice.

Overall, the results demonstrate the ability of the proposed FMEA-variance-TOPSIS framework to convert expert assessments into an interpretable and sensitivity-tested priority structure. The framework identifies not only which barrier ranks first but also how the ranking changes when the relative emphasis placed on occurrence and severity is modified.

5. DISCUSSION

The results demonstrate the applicability of the proposed FMEA-variance-TOPSIS framework for prioritizing barriers to inadequate nutrition knowledge. Rather than treating nutrition knowledge as a single measurable outcome, the proposed approach decomposes the problem into several potentially actionable barriers and evaluates them according to two dimensions of risk: occurrence and severity. This distinction is important because a barrier that occurs frequently is not necessarily the barrier with the greatest potential consequences, while a less frequent barrier may have more serious implications. The integration of FMEA with MCDM therefore provides a decision-oriented perspective that complements conventional nutrition-literacy measurement.

The Delphi analysis provided the first stage of methodological filtering. All eight proposed barriers satisfied the predefined consensus threshold, indicating that the expert panel considered the factors relevant to the Vietnamese nutrition-information context. The strongest agreement was obtained for low ability to evaluate nutrition information, exposure to nutrition misinformation, and reliance on social and informal information sources. These factors correspond closely to the critical dimensions of nutrition and food literacy. Nutrition literacy is not limited to acquiring factual knowledge; it also involves understanding and evaluating nutrition information [6]. Similarly, food-literacy research emphasizes the importance of knowledge, skills, critical evaluation, and the broader food environment [7]. The Delphi findings therefore support a multidimensional representation of nutrition-knowledge barriers rather than a narrow focus on formal nutrition education.

The high relevance assigned to misinformation and information-evaluation ability is particularly meaningful in the present information environment. A recent systematic review of 28 studies found widespread dissemination of nutrition misinformation through social-media platforms and identified unsupported claims concerning diets, foods, supplements, and disease prevention as important themes [8]. The review further emphasized the role of healthcare professionals and public-health organizations in providing evidence-based information and strengthening users' ability to assess information credibility. These observations are consistent with the positioning of F3 and F2 among the highest-priority barriers in the present analysis. Importantly, however, the present expert-based ranking does not establish that misinformation causes inadequate nutrition knowledge or that it is the most prevalent barrier among Vietnamese adults. It indicates only that, within the proposed decision framework, the experts assigned this barrier a combination of relatively high occurrence and severity.

The ranking of F4, reliance on social and informal information sources, provides a similar interpretation. The Vietnamese national health-literacy survey conducted in 2025 found that 67.3% of respondents had problematic general health literacy, while 85.5% had sufficient eHealth literacy. The study also reported a positive association between official health-website use and literacy outcomes and a negative association between social-media use and general health literacy [5]. Although general health literacy should not be equated with nutrition literacy, these findings provide contextual support for considering information-source selection as an important component of the Vietnamese nutrition-information environment. In practice, interventions may therefore need to address not only whether reliable information is available but also how individuals identify and select information sources.

F8, commercial and misleading nutrition claims, also received a relatively high priority. This result is relevant because nutrition information is frequently communicated through products, advertisements, packaging, promotional content, and health-related claims. The challenge is not necessarily that all commercial information is inaccurate; rather, consumers may need sufficient knowledge to distinguish factual nutritional information from promotional communication. This distinction is particularly important in a changing Vietnamese food environment. Evidence from urban Vietnam has shown that nutrition-label use is associated with dietary characteristics related to added-sugar consumption, indicating that consumers' interaction with nutrition information can have practical dietary relevance [4]. The relatively high position of F8 consequently suggests that improving consumer understanding may require greater emphasis on critical interpretation of commercial nutrition communication.

An important finding from the methodology is that occurrence received a greater variance-based weight than severity. The resulting weights of 0.5720 and 0.4280 do not mean that occurrence is theoretically more important than severity. Instead, the statistical variance procedure assigns greater weight to occurrence because occurrence exhibited greater dispersion across the evaluated barriers. This distinction is important when interpreting objective weighting. The variance method is intended to reflect discriminatory information contained in the decision matrix; greater variance indicates greater differentiation among alternatives [14]. Therefore, the weighting result is data-driven rather than a substantive assertion that frequency should always dominate consequence.

The use of variance-based weighting also strengthens the methodological logic of the proposed model. In expert-based MCDM, criterion weights are often determined subjectively, for example by asking experts to directly state the importance of each criterion. Although such approaches can incorporate decision-maker preferences, they may also introduce another layer of judgment into an already judgment-dependent process. The present framework instead allows experts to assess the substantive characteristics of each barrier while deriving criterion weights mathematically from the resulting decision matrix. This creates a distinction between expert knowledge and mathematical weighting: experts determine the evaluations, whereas the variance method determines the discriminatory contribution of the criteria.

The TOPSIS results further demonstrate why an MCDM approach can provide additional information beyond conventional FMEA. F3 ranked first because it simultaneously attained the highest occurrence and severity scores, placing it at the positive ideal in the illustrative application. F2 ranked second, followed by F4 and F8. This ordering reflects the combined contribution of both FMEA criteria rather than a single score. In conventional RPN, different combinations of occurrence and severity can lead to the same numerical product, making it difficult to distinguish between risk profiles. This limitation has been extensively discussed in the FMEA literature and has motivated the development of MCDM-based FMEA approaches [11, 12]. A recent review of FMEA risk-assessment research likewise identifies limitations of conventional RPN as a major reason for methodological extensions.

The results also demonstrate the importance of sensitivity analysis. F3 and F2 remained in the first two positions when equal, occurrence-dominant, and severity-dominant weighting scenarios were considered. This stability indicates that their high priority in the illustrative analysis is not solely an artifact of the variance-based weights. In contrast, F4 and F8 exchanged positions when severity was given a substantially greater weight. This behavior is consistent with the general sensitivity of TOPSIS rankings to criterion weights and normalization procedures [19]. Consequently, sensitivity analysis should not be regarded as an optional graphical exercise; it provides evidence concerning the robustness of the decision outcome.

From a practical perspective, the ranking implies that intervention strategies should be aligned with the mechanism underlying each barrier. If misinformation and low information-evaluation ability are confirmed as the highest priorities using actual expert data, interventions could focus on strengthening critical nutrition literacy rather than simply increasing the quantity of nutrition information. This could include teaching consumers how to evaluate evidence, identify unsupported claims, distinguish professional from non-professional information sources, and recognize common characteristics of misleading nutrition content. Recent literature similarly recommends strengthening digital and health literacy and increasing the availability of credible, evidence-based nutrition information to counter misinformation [8].

The ranking of information-source reliance also has implications for the communication strategy of health institutions. Public-health organizations should not assume that publishing information on official websites is sufficient. Information must also be accessible, understandable, and capable of competing with the speed and engagement characteristics of social-media communication. The 2026 Vietnamese health-literacy evidence supports the relevance of official digital health resources while simultaneously showing the importance of critical appraisal skills among digitally connected adults [5].

The intermediate ranking of F6, cultural and traditional nutrition misconceptions, should be interpreted carefully. The purpose of this factor is not to characterize traditional Vietnamese dietary knowledge as incorrect or harmful. Traditional food practices can have nutritional, cultural, and social value. The factor specifically concerns beliefs that conflict with established scientific evidence when such conflicts affect nutrition understanding or dietary decisions. This distinction is important to avoid treating cultural knowledge and scientific knowledge as inherently competing systems.

F1, insufficient nutrition education, also deserves careful interpretation. Its lower illustrative ranking does not imply that nutrition education is unimportant. Rather, the model indicates that an intervention directed exclusively at increasing the amount of nutrition education may not address barriers arising from misinformation, information evaluation, or commercial communication. Nutrition education and information-literacy interventions may therefore be complementary rather than mutually exclusive.

The proposed methodology has broader implications for natural-resource-related nutrition and human-health research. The same framework can be applied to consumer misconceptions concerning functional foods, nutraceuticals, herbal products, dietary supplements, natural ingredients, traditional foods, and other products positioned at the intersection of natural resources and health. In these contexts, consumers may encounter scientific evidence, traditional knowledge, marketing claims, and social-

media information simultaneously. A structured prioritization method could therefore help identify which knowledge barriers deserve attention before more resource-intensive education or regulatory interventions are developed.

Several limitations should be considered. First, the analysis is based on expert judgment and therefore does not provide population-level estimates of the prevalence of each barrier. Second, the expert panel is relatively small. Although eight experts can provide useful multidisciplinary judgment when selection criteria are explicit, the resulting assessment remains dependent on panel composition. Third, objective variance weighting does not eliminate subjectivity from the study because occurrence and severity are themselves expert-assigned scores. It only makes the subsequent criterion-weighting step data-driven. Fourth, TOPSIS is a compensatory method, meaning that differences among criteria can offset one another. Fifth, the identified barriers and their definitions are partly dependent on the literature screening and conceptualization process. Finally, the numerical ranking presented in this study is based on an illustrative decision matrix and therefore should be replaced by actual expert observations before empirical publication.

Despite these limitations, the methodological framework provides a systematic bridge between qualitative nutrition-literacy research and quantitative intervention prioritization. Existing nutrition studies can establish that knowledge gaps exist, while the proposed FMEA-variance-TOPSIS framework addresses the subsequent decision problem of determining which barriers warrant greater attention. The combination of expert-based factor validation, risk-oriented evaluation, objective weighting, and sensitivity-tested ranking provides a transparent decision process that can be replicated in other populations and health-information contexts.

6. CONCLUSION

This study developed an integrated FMEA–variance weighting–TOPSIS framework for prioritizing barriers to inadequate nutrition knowledge among Vietnamese adults. The study responds to a methodological gap in existing nutrition-literacy research, which has largely focused on measuring knowledge levels and examining their associations with dietary behavior, while providing less attention to the systematic prioritization of the underlying barriers.

The proposed framework combines four analytical stages. First, candidate barriers are identified from the nutrition-literacy, food-literacy, health-information, and Vietnamese nutrition literature and assessed through a structured Delphi procedure involving qualified experts. Second, the validated barriers are evaluated according to occurrence and severity using the principles of FMEA. Third, statistical variance is used to determine objective criterion weights from the information contained in the expert decision matrix. Finally, TOPSIS is applied to calculate the relative closeness of each barrier to the positive and negative ideal solutions and establish the final priority order. Eight barriers were considered in the empirical framework: insufficient nutrition education, low ability to evaluate nutrition information, exposure to nutrition misinformation, reliance on social and informal information sources, complexity of food labels and nutrition terminology, cultural and traditional nutrition misconceptions, limited access to reliable nutrition information, and commercial and misleading nutrition claims. In the illustrative application, nutrition misinformation, low ability to evaluate nutrition information, reliance on social and informal information sources, and commercial and misleading nutrition claims occupied the four highest positions. The sensitivity analysis further indicated that the first two priorities remained stable under alternative criterion-weighting scenarios, while some intermediate rankings were more sensitive to changes in the relative importance assigned to occurrence and severity. The principal contribution of this study is methodological. Conventional FMEA reduces multiple risk dimensions to a single RPN, which may provide limited discrimination among alternatives and implicitly treat criteria as equally important [11, 12]. The proposed framework overcomes these limitations by separating risk assessment, objective weighting, and multi-criteria ranking. This structure allows expert knowledge to be incorporated into the evaluation of nutrition-knowledge barriers while avoiding the need to assign criterion weights entirely through subjective judgment. The findings also provide a decision-support basis for nutrition and health interventions. Higher-priority barriers can be used to guide the design of targeted nutrition education, digital nutrition-literacy programs, consumer information strategies, and communication policies. The framework may also be extended to specific contexts involving functional foods, nutraceuticals, dietary supplements, natural products, traditional foods, and other products where consumers must interpret potentially complex nutrition and health information.

Several limitations should be acknowledged. The proposed approach relies on expert judgment and therefore does not estimate the prevalence of barriers among the Vietnamese population. The relatively small expert panel also means that results may depend on panel composition. In addition, variance-based weighting makes the weighting process objective but does not remove subjectivity from the underlying expert assessments. Most importantly, the numerical results reported in the present

methodological demonstration are illustrative and must be replaced by actual expert evaluations before the study is presented as empirical evidence. Future research should therefore apply the framework using responses collected from qualified Vietnamese experts and subsequently validate the resulting priority structure using a larger consumer survey. Combining expert-based MCDM analysis with population-level nutrition-literacy and behavioral data would provide a stronger basis for identifying the barriers that most require intervention. Moreover, it is important to capture expert uncertainty through techniques such as Dempster-Shafer theory [20-21] or fuzzy logic [22]. Furthermore, future study can explore the relationships among these factors using decision-making trial and evaluation laboratory or interpretive structural modelling [23]. In conclusion, the FMEA–variance weighting–TOPSIS framework provides a systematic and reproducible approach for transforming a multidimensional nutrition-knowledge problem into a quantitative prioritization problem. By integrating domain expertise with objective weighting and MCDM analysis, the framework offers a useful methodological foundation for research and decision-making in nutrition and human health.

AUTHOR CONTRIBUTIONS

Thanh Tuong Vo: Methodology, Data Curation, Formal Analysis, Writing-Original Draft

Ha Ai Quynh Le: Investigation, Writing—Review & Editing.

Kai-Ming, Chen: Conceptualization, Writing—Review & Editing.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

Ethical approval was not required for this study.

DATA AVAILABILITY STATEMENT

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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