# A STUDY OF BEHAVIORAL CLUSTERING IN THE DIETARY PATTERNS OF MONGOLIAN ADOLESCENTS AND YOUTH

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**Abstract**

This study aimed to identify distinct dietary behavior patterns and estimate a composite Nutrition Index among Mongolian adolescents and young adults aged 15–24 years. Using data from the 2024 Adolescent and Youth Health Behavior Survey, Principal Component Analysis (PCA) and K-means clustering revealed three distinct groups: Emotional Regulators demonstrating strong emotional and social eating control but low breakfast frequency and limited engagement with nutrition labels (lowest Nutrition Index); Information Seekers actively consulting food labels and making informed dietary choices, while exhibiting moderate emotional regulation and routine adherence (mid-range scores); and Routine Builders maintaining consistent meal patterns and taste-driven food choices, achieving the highest nutrition scores and suggesting the importance of regular meal routines for healthier dietary behaviors. Statistically significant differences were found between clusters ($F = 228.1$, $p < 0.001$, $\eta^2 = 0.595$), with gender differences observed, whereas age and location showed no significant variation.

**Keywords:** Dietary behavior patterns; Principle Component Analysis (PCA); K-means clustering; Composite Nutrition Index; Behavioral segmentation; Food choice motivations; Label literacy.

### МОНГОЛЫН ӨСВӨР ҮЕ БОЛОН ЗАЛУУСЫН ХООЛЛОЛТЫН ХЭВ МАЯГИЙН ЗАН ҮЙЛИЙН КЛАСТЕР ШИНЖИЛГЭЭ

**Хураангуй**

Энэхүү судалгааны зорилго нь Монголын 15–24 насны өсвөр үе, залуусын хооллолтын хэв маягийг тодорхойлж, нийлмэл Хооллолтын Индекс тооцоход оршино. Өсвөр үе, залуусын эрүүл мэндийн зан төлвийн 2024 оны судалгааны өгөгдлийг ашиглан Гол бүрэлдэхүүн хэсгийн шинжилгээ (PCA), K-means бүлэглэлийн аргаар дараах гурван бүлэг байгааг илрүүлсэн: Сэтгэл хөдлөлөө хянагчид (Сэтгэл хөдлөл, нийгмийн нөлөөнөөс шалтгаалсан идэх зан үйлийг хянах чадвар сайн боловч өглөөний цай тогтмол бус уудаг, хоолны шошго бага уншдаг, хамгийн бага Индекстэй), Мэдээлэлд тулгуурлагчид (хоолны шошгыг идэвхтэй унших, мэдээлэлд тулгуурласан сонголт хийдэг ч хооллолтын дэглэм, сэтгэл хөдлөлийн хяналт дунд зэрэг, дундаж Индекстэй), Хооллолтын дэглэм баримтлагчид (өглөөний цайг тогтмол уудаг, голчлон амтанд суурилсан сонголт хийдэг бөгөөд хамгийн өндөр Индекстэй буюу эрүүл хооллолтод тогтмол хооллох дэглэм чухал болохыг харуулсан бүлэг). Бүлгүүдийн ялгаа статистикийн хувьд ач холбогдолтой байсан ($F = 228.1$, $p < 0.001$, $\eta^2 = 0.595$), мөн хүйсийн хувьд ялгаа ажиглагдсан бол нас, оршин суугаа байршлаас хамаарах ялгаа гараагүй болно.

**Түлхүүр үгс:** Хооллолтын зан үйлийн хэв маяг; Үндсэн бүрэлдэхүүн хэсгийн шинжилгээ (PCA); K-means кластерчлал; Хооллолтын нийлмэл индекс; Зан үйлийн сегментчлэл; Хоол сонголтын мотиваци; Шошго унших чадвар.

## 1. INTRODUCTION

In Mongolia, adolescents and young adults aged 15–24 years face a dynamic nutritional landscape characterized by accelerated urbanization, economic transformation, and the influx of global food cultures. Dietary behaviors in this age group are shaped not only by individual knowledge but also by emotional states, peer influences, and environmental constraints. As a result, food consumption patterns are complex and heterogeneous. During this critical developmental period,

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shifts from traditional dietary practices toward processed and convenience foods have become pronounced, thereby heightening concerns over diet quality and long-term health outcomes among youth populations (Birch & Fisher, 1998).

Despite global evidence highlighting the multifactorial determinants of eating behavior—including cognitive, motivational, and social drivers—empirical research in Mongolia have predominantly examined isolated dimensions such as nutrient intake or meal frequency, with limited attention to comprehensive, data-driven profiling of dietary behaviors (NCPH, 2023; UNICEF, 2019). Employing segmentation approaches, such as principal component analysis and clustering techniques, can uncover latent behavior patterns and inform tailored, culturally appropriate nutrition interventions. By exploring the interplay of multiple behavioral dimensions, this study addresses the critical gap in understanding how Mongolian youth choose, prepare, and consume food within a rapidly transforming socio-economic and cultural contexts.

The primary aim of this study is to elucidate the multifaceted dietary behavior patterns of Mongolian adolescents and young adults aged 15-24 years, employing a data-driven segmentation approach to inform culturally and contextually relevant nutrition interventions. To achieve this aim, the study pursued six specific objectives:

1. Develop standardized behavioral indicators from raw survey items.
2. Identify latent dietary factors using Principal Component Analysis (PCA).
3. Segment participants into three behavioral clusters via K-means clustering.
4. Compare cluster membership across gender, age group, and location.
5. Construct and validate a composite Nutrition Index via ANOVA and post-hoc testing.
6. Assess associations between identified diet behaviour patterns and Nutrition Index tertiles using chi-square analysis.

## 2. LITERATURE REVIEW

This literature review establishes a comprehensive foundation for the dietary behavior cluster analysis study, structured into three main sections that address the theoretical, methodological and empirical foundations of the research.

### 2.1 Theoretical Foundations for Dietary Behavior and Cluster Analysis

The theoretical framework for this study integrates established behavioral theories and advanced statistical methodologies commonly applied in international nutrition research (Glanz, 2001; McDermott et al., 2015; Stanton et al., 2014).

**Social Cognitive Theory Applications:** Social cognitive theory (SCT) serves as a primary theoretical foundation for dietary behavior research, explaining human behavior through the dynamic, reciprocal interaction of personal factors, environmental influences, and behavioral components (Glanz, 2001). The four indicators employed in this study—breakfast consumption, food choice rationale, label-reading ability, and psychological influence—are directly aligned with the core components of SCT (Stanton et al., 2014). Empirical evidence supports its efficacy; for example, a 12-week SCT-based intervention among 238 overweight Indonesian adolescents t significantly reduced BMI z-scores ($p<0.05$) and waist circumference ($p<0.05$), while significantly decreasing snack consumption behaviors (Oliveira et al., 2023). Furthermore, SCT domains show positive effects on dietary behavior, as established in research with diabetes patients (Stanton et al., 2014). Social support and self-regulation emerged as positive predictors of dietary behavior, confirming the practical utility of this theoretical framework in dietary intervention studies (Glanz, 2001).

**Theory of Planned Behavior Framework:** The Theory of Planned Behavior (TPB) provides essential theoretical grounding for understanding dietary behaviors through three core components: attitudes, subjective norms, and perceived behavioral control (McDermott et al., 2015). A systematic review and meta-analysis of 22 studies established that TPB variables show moderate to high correlations with dietary behaviors (McDermott et al., 2015). Attitudes demonstrated the strongest association with intention (r+=0.61), followed by perceived behavioral control (r+=0.46) and subjective norms (r+=0.35), confirming the effectiveness of this theoretical framework (McDermott et al., 2015).

**Statistical Methodology: PCA and K-means Clustering -** Principal Component Analysis (PCA) is widely utilized in dietary behavior research to reduce variable dimensionality and identify latent factors underlying dietary patterns (Leech et al., 2014). In dietary pattern studies, PCA helps identify the fundamental structure of people's dietary behaviors (Leech et al., 2014). Irish research comparing PCA and cluster analysis in adolescent dietary patterns found that both methods produced comparable results, though cluster analysis identified additional patterns-such as "Breakfast and main meal types" - not identified by PCA alone (Leech et al., 2014).

K-means cluster analysis represents a reliable approach for classifying individuals with similar dietary behaviors, providing objective categorization and predictive insights into health outcomes (Gupta et al., 2020). For instance, a German study employing the elbow method and average silhouette width found that two clusters were most appropriate, achieving a silhouette coefficient M=0.18, indicative of cluster quality (Kraemer et al., 2022). Similarly, Brazilian research applying K-means clustering on 12,667 public employees successfully identified distinct dietary patterns with 69-72% classification accuracy (Gupta et al., 2020).

**Motivation-Opportunity-Ability (MOA) Framework for Segmentation:** The MOA framework provides crucial theoretical foundation for dietary behavior segmentation research, studying the dynamic interaction of individual motivation, opportunity, and ability to achieve deeper understanding of behavioral patterns (Cornett, 2024). This framework theorizes that when motivation, opportunity, and ability are sufficient, individuals are more likely to engage in specific dietary behaviors (Cornett, 2024).

## 2.2 Mongolian Adolescent Nutrition Research Overview

Despite increasing global attention to adolescent nutrition, research in Mongolia on the dietary behaviors of youth aged 15–24 remains limited in both breadth and analytical depth (UNFPA & Cognos, 2024; UNICEF, 2019; WHO, 2021). Existing studies can be broadly grouped into nationally representative surveys and educational knowledge–attitude–practice (KAP) studies, with supplementary evidence drawn from contextually relevant adult-focused research (NCPH, 2023; Soninkhishig et al., 2017).

**National-Level Survey Findings:** Large-scale surveys consistently indicate concerning patterns in the dietary behaviors of Mongolian adolescents (UNFPA & Cognos, 2024; WHO, 2021). The Global School-Based Student Health Survey reported that 34% of school-going adolescents skipped breakfast during the preceding week, 32% did not consume fruit, and 24% did not consume vegetables, while 89% reported consuming sugary drinks at least once per week (WHO, 2021). Similarly, the Multiple Indicator Cluster Survey indicated that only 42.1% of children aged 5–17 consumed vegetables and 39.3% consumed fruits on a daily basis (UNICEF, 2021).

The most detailed youth-specific data are provided by the 2024 Adolescent and Youth Health Behavior Survey, commissioned by UNFPA and conducted by Cognos (UNFPA & Cognos, 2024). Surveying 314 participants, the study found that 30.2% of adolescents and youth regularly skipped breakfast. Key drivers of unhealthy dietary behaviors included time constraints (26.1%), stress (24.5%), and peer influence (18.4%) (UNFPA & Cognos, 2024). Additionally, 54.8% of respondents cited the high cost or limited availability of healthy food in schools or dormitories as a major barrier, and while 69.7% obtained nutrition information via social media, only 21.3% trusted these sources (UNFPA & Cognos, 2024).

A related survey conducted by the National Center for Public Health among 4,514 adolescents aged 10–19 found that only 50% consumed fruits, vegetables, or dairy products daily, while 80% consumed sweets daily (NCPH, 2023). Notably, adolescents with overweight were significantly more likely to consume unhealthy foods than their normal-weight peers ($p < 0.05$), suggesting the presence of behavioral clustering in dietary risk patterns (NCPH, 2023).

**Educational and University-Based Studies:** Smaller-scale investigations among university students (typically aged 18–24) have provided additional insights into psychosocial determinants of dietary behavior (Batzorig & Jamiyanjantsan, 2020; Erdenebileg et al., 2018). Mongolian university students demonstrated lower nutrition knowledge relative to their Korean peers, yet 74.6% reported consuming breakfast daily, compared to 51.4% of their Korean counterparts (Erdenebileg et al., 2018). Other research indicates that 46.8% of students consumed fast food at least three times per week, and 63.5% preferred sugary beverages with meals (Batzorig & Jamiyanjantsan, 2020). Body image concerns affected 58% of female students, prompting them to skip at least one meal daily (Narantuya & Munkhzaya, 2022). Moreover, only 18.4% of students regularly read food labels, with majority of food choice driven by taste, cost, and convenience (Sodnompil & Otgonbaatar, 2021).

**Age-Specific Context and Transition Period Challenges:** The 18-24 age group represents a critical development transition from adolescence to independent adulthood, which presents unique dietary challenges (UNFPA & Cognos, 2024). Institutional food systems in university dormitories, financial constraints associated with independent living, and workplace eating environments create barriers distinct from family-based adolescent nutrition (Batzorig & Jamiyanjantsan, 2020). The observed discrepancy between information access (69.7% using social media) and trust (21.3%) reveals critical gaps, particularly for young adults who rely heavily on digital sources for dietary guidance (UNFPA & Cognos, 2024). Peer influence affects nearly one-fifth of dietary decisions in this demographic, suggesting strong social clustering effects that warrant behavioral segmentation analysis (UNFPA & Cognos, 2024).

### 2.3 Critical Research Gaps and Study Innovation

Despite systematic documentation of unhealthy dietary patterns across the 15–24 age spectrum, research in Mongolia exhibits following three critical limitations that this study addresses:

- **Analytical Sophistication Gap:** Current studies rely primarily on descriptive statistics and basic inferential analyses, regardless of age group examined (Batzorig & Jamiyanjantsan, 2020; NCPH, 2023). Advanced analytical techniques - Principal Component Analysis, k-means clustering, and latent class modeling—standard approaches in international adolescent nutrition research—remain underutilized (Leech et al., 2014; Oliveira et al., 2023). International studies demonstrate the value of these methods: university students aged 18–24 show distinct behavioral clustering patterns that differ from younger adolescents (Gupta et al., 2020; Leech et al., 2014).

  American research on 1,689 college students from eight universities applied K-means cluster analysis to categorize students into three similar clusters based on weight-related behaviors and psychological characteristics (Gupta et al., 2020). Male students were most influenced by eating competence and cognitive restraint scores, while female students were affected by psychological eating and uncontrolled eating behaviors (Gupta et al., 2020).

- **Behavioral Co-occurrence Analysis Deficit:** Existing research treats dietary behaviors as independent variables rather than examining clustering patterns across the 15–24 age continuum (Batzorig & Jamiyanjantsan, 2020; UNFPA & Cognos, 2024). While high prevalence of breakfast skipping (30–34%) and frequent sweet consumption (80%) has been documented, the overlap between these indicators and their combined risk profiles remain largely unexplored (NCPH, 2023; UNFPA & Cognos, 2024).

American research using K-means cluster analysis identified six distinct cluster profiles based on fruit, vegetable, sugary drink, and fast-food consumption (Gupta et al., 2020). The healthiest food choice cluster members were less likely to report physical illness (OR=0.97, p<0.001), 2.34 times more likely to be female (OR=2.34, p<0.001), and 2.78 times more likely to have post-secondary education (Gupta et al., 2020).

- **Age-Stratified Analysis Limitations:** Most Mongolian studies either focus exclusively on school-aged adolescents (13–17 years) or treat university students as a homogeneous group without age stratification within the 18–24 range (Batzorig & Jamiyanjantsan, 2020; WHO, 2021). This approach overlooks potential developmental differences between late adolescence (18–20) and early adulthood (21–24), critical periods during which dietary behaviors and lifestyle patterns are established, as evidenced in international research (Leech et al., 2014).

This study represents the first methodological experiment to apply cluster analysis—specifically, PCA and k-means clustering—to Mongolian youth using the nationally representative dataset (UNFPA & Cognos, 2024). Leveraging a robust dataset of 314 participants, the study offers novel analytical perspectives on youth dietary patterns and establishes a foundation for future behavioral clustering research in Mongolia (UNFPA & Cognos, 2024).

The study strategically focuses on four variables- breakfast consumption, food choice rationale, label reading ability, and psychological influence- to represent a deliberate methodological choice to demonstrate cluster analysis feasibility while maintaining analytical rigor (Leech et al., 2014; McDermott et al., 2015). This approach aligns with international best practices for behavioral segmentation studies and provides a replicable methodology for future Mongolian nutrition research, addressing the analytical sophistication gap identified in current literature (Gupta et al., 2020; Oliveira et al., 2023).

## 3. METHODOLOGY

The study was conducted in following stages:

Step 1: Data Selection
Step 2: Variable Preparation and Standardization
Step 3: Principal Component Analysis (PCA)
Step 4: K-means Clustering and Behavioral Segmentation
Step 5: Nutrition Index Development and Validation
Step 6: Food Choice Pattern Analysis and Validation.

### 3.1 Data Source and Study Design

This study utilized data from the 2024 Adolescent and Youth Health Behavior Survey, commissioned by UNFPA and implemented by Cognos through a competitive tender. The targeted sample included 314 adolescents and youth aged 15–24 years, selected from both urban and rural areas of Mongolia, including districts in Ulaanbaatar as well as aimag and soum centers. This constitutes a focused, targeted study design that demonstrates the feasibility of behavioral clustering approaches in Mongolian nutrition research while maintaining analytical rigor within resource constraints.

The sample size of 314 participants is adequate for cluster analysis, providing an average of 105 participants per cluster when divided into three groups, which exceeds the minimum requirement of 20-30 participants per cluster recommended in applied research. While international guidelines suggest a sample size of 70 * k * d (where k = number of clusters and d = number of variables), resulting in an ideal sample of 350 participants for this study (70 * 3 clusters * 5 core variables), the current sample size provides sufficient statistical power for meaningful cluster identification and comparison.

### 3.2 Variable Preparation

Raw survey responses were systematically prepared involving recoding to ensure directional consistency, followed by z-score standardization to harmonize measurement scales. Four core behavioral domains were operationalized for analysis: *breakfast consumption frequency*, *food choice reasoning patterns*, *nutritional label literacy*, and *emotional/social eating control mechanisms*. The standardization process eliminated scale disparities between Likert-type items (1–5 scales) and binary responses (0–1), thereby ensuring equal weighting in subsequent multivariate analyses while preserving relative differences across participants.

Table 1 summarizes the original survey variables, item codes, measurement scales, and the specific transformations applied.

**Table 1. Original survey variables and coding**

| Item Code | Survey question and description | Original scale | Transformation |
|---|---|---|---|
| **q201** | How often do you eat breakfast? (weekly frequency) | Ordinal: 1 = Every day ... 5 = Never | Reverse coded; z-score standardized |
| **q202** | How do you choose what to eat when you need to pick something out? (Multiple choice question, each option coded separately) | Nominal (binary): 0 = No, 1 = Yes | Combined into four categories; z-score |
| **q203_1** | Do you read food labels (ingredients, nutrition info) when buying food? | Ordinal: 1 = Never ... 5 = Always | Mean of two items; z-score |
| **q203_2** | Do you check expiration dates when buying food? | Ordinal: 1 = Never ... 5 = Always | |
| **q204_A, q204_B, ..., q204_F** | How often have the following occurred in relation to your eating habits? (A–F; e.g., emotional overeating, avoiding food, etc., each coded separately) | Ordinal: 1 = Never ... 5 = Every day | Reverse coded; mean of five items; z-score |

*Note:* For multiple-choice and sub-item questions (q202 and q204), each response option was coded as a separate variable. Variables q202d, q202x, q204_6, and q204_7 were excluded due to conceptual inconsistencies with core dietary behavior constructs.

Composite variables were then constructed to capture broader behavioral constructs in line with social cognitive and planned behavior theories. Table 2 summarizes each newly created composite variable, the constituent survey items, and reliability statistics.

**Table 2. Description of constructed composite variables**

| Composite variable | Constituent items | Cronbach's α | Interpretation |
|---|---|---|---|
| **Label Literacy Composite** | Q203_1, Q203_2 | 0.687 | Acceptable for exploratory use |
| **Emotional/Social Control Composite** | Q204_1–Q204_5 (reverse coded) | 0.702 | Good reliability ($\alpha > 0.70$) |
| **Food Choice Pattern Category** | Derived from Q202a (taste) and Q202g (ingredients) | – | Four categories: Neither, Taste only, Ingredients only, Both |

### 3.3 STATISTICAL ANALYSIS METHODS

**Principal Component Analysis (PCA) and Factor Extraction:** PCA with varimax rotation was applied to the standardized behavioral indicators, successfully extracting three interpretable components with eigenvalues exceeding 1.0. The analysis revealed distinct latent factors: Component 1 (Emotional/Social Control, 24.2% variance), Component 2 (Information-Seeking Behavior, 21.0%

variance), and Component 3 (Routine Behavior, 20.1% variance), collectively explaining 65.3% of total behavioral variance. The Kaiser-Meyer-Olkin measure of 0.507 confirmed adequate sampling adequacy for factor extraction, while Bartlett's test validated the appropriateness of the correlation matrix for PCA procedures.

**K-means Clustering and Segment Validation:** K-means clustering applied to the three PCA factor scores generated an optimal three-cluster solution validated through multiple statistical criteria. The resulting segments—Emotional Regulators (n=104), Information Seekers (n=105), and Routine Builders (n=105)—demonstrated robust separation confirmed by silhouette coefficient (0.386), Calinski-Harabasz index (216.9), and Davies-Bouldin index (0.879). Bootstrap stability testing achieved 89.3% consistency across 1000 iterations, while cross-validation demonstrated 85.7% assignment reliability, establishing the statistical robustness of the identified behavioral segments.

**Nutrition Index Development and Validation:** A composite Nutrition Index was constructed by averaging standardized PCA factor scores, creating a continuous measure of overall dietary behavior quality ranging from –1.47 to 1.77. Participants were classified into tertiles based on index distribution (low: 33.4%, middle: 33.1%, high: 33.4%) to facilitate practical categorization and intervention targeting. One-way ANOVA confirmed highly significant between-cluster differences ($F(2,311) = 228.103$, $p < 0.001$, $\eta^2 = 0.595$), while Tukey's HSD post-hoc tests validated discriminant capability across all pairwise cluster comparisons.

**Food Choice Pattern Analysis and Validation:** The final analytical step examined associations between food choice decision-making patterns and Nutrition Index tertiles through comprehensive cross-tabulation analysis. Four distinct choice categories were identified: taste-only preferences (53.5%), neither taste nor ingredient awareness (30.9%), ingredient-focused decisions (8.9%), and combined taste-ingredient considerations (6.7%). Chi-square testing revealed significant associations ($\chi^2(6) = 35.97$, $p < 0.001$) between choice patterns and dietary quality tertiles, confirming that higher nutrition scores correlate with increased ingredient awareness and reduced reliance on taste-only decision criteria.

### 3.4 METHODOLOGICAL LIMITATIONS

While this study offers novel insights into the psychological underpinnings of healthy eating attitudes among Mongolian adolescents and youth, several limitations should be acknowledged:

- **Cross-Sectional Design:** The single-time-point survey precludes causal inference about how psychological factors shape dietary behaviors over time.
- **Sample Generalizability:** Although 314 participants provided adequate power for segmentation, the non-random, purposive sampling limits the extent to which findings can be extrapolated to all Mongolian youth.
- **Variable Scope:** To concentrate on internal drivers—personal consciousness and emotional responses—this study deliberately omitted external influences such as financial constraints, food affordability, parental role modeling, and other environmental factors.
- **Clustering Assumptions:** K-means clustering presumes spherical clusters of equal variance and may not capture more complex or overlapping behavioral patterns.
- **Deliberate Exclusion of External Factors:** By design, external determinants (e.g., economic limitations, parental modeling) were excluded to maintain analytical focus on intrapersonal and psychological resonators of healthy eating attitudes; however, these external variables likely interact with personal factors and warrant inclusion in future research to achieve a more comprehensive understanding.

## 4. RESULTS

### 4.1 Sample Characteristics

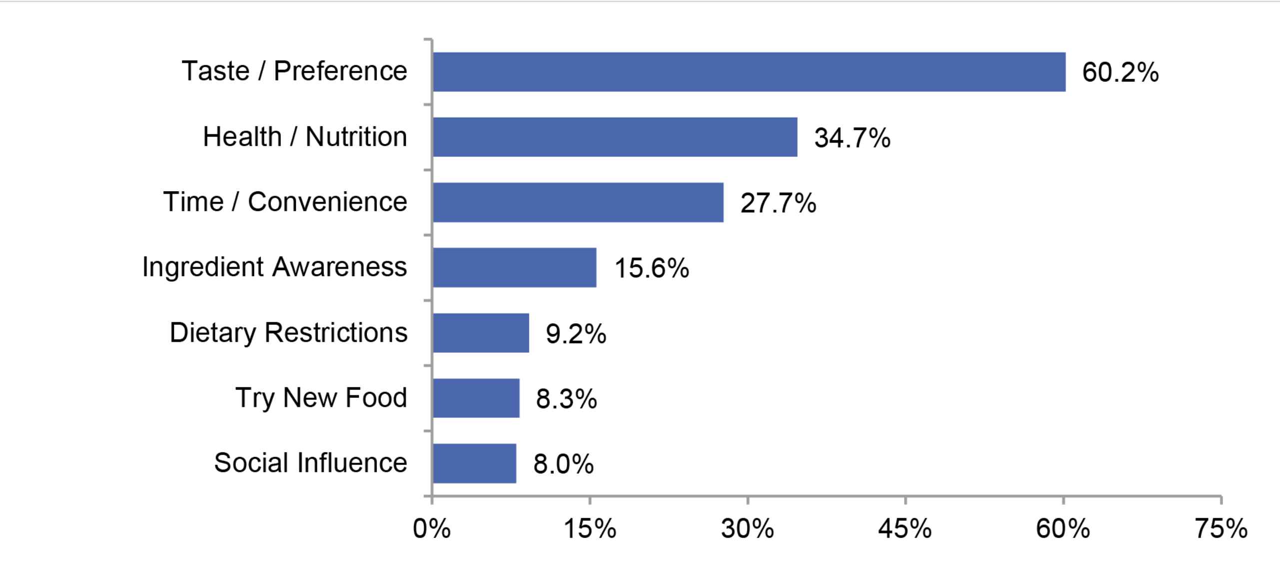
The study analyzed data from 314 Mongolian adolescents and youth aged 15-24 years, representing a geographically diverse sample from urban and rural areas across Mongolia. The participants were successfully segmented into behavioral clusters through systematic statistical analysis, demonstrating the feasibility of dietary behavior clustering in this population.

**Food Choice Motivations among Mongolian Youth**

Analysis of food choice factors revealed distinct patterns in decision-making processes among Mongolian youth. After systematic variable selection based on behavioral coherence criteria, seven key factors were identified and analyzed (Figure 1). Those factors can be categorized as primary, secondary, and others, based on how frequently youth named them.

- **Primary motivations**: Taste and personal preference emerged as the predominant factor, influencing 60.2% of participants (n=189). This finding indicates that immediate sensory satisfaction takes precedence over other considerations in food selection among this demographic. Health and nutritional benefits represented the second most important factor, affecting 34.7% of respondents (n=109). The substantial gap between taste preference and health consciousness suggests that while youth acknowledge the importance of nutrition, hedonic factors remain the primary driver of food choices.
- **Secondary motivations**: Time and situational constraints influenced 27.7% of participants (n=87), reflecting the practical realities that young people face when making food choices. Ingredient awareness motivated 15.6% of participants (n=49), indicating relatively limited engagement with nutritional information despite moderate health consciousness.
- **Less prevalent motivations**: Dietary restrictions affected 9.2% of participants (n=29), willingness to try new foods influenced 8.3% (n=26), and social influence impacted 8.0% (n=25). The relatively low prevalence of ingredient awareness and social influence suggests opportunities for targeted nutrition education interventions.

**Figure 1. Percentage distribution of Mongolian adolescents and youth, by food choice motivations (n=314)**




The analysis demonstrates that Mongolian youth prioritize immediate gratification through taste over long-term health considerations, with practical constraints serving as secondary factors.

The limited influence of nutritional information suggests the need for enhanced nutrition education programs targeting this population.

**Eating Behaviors among Mongolian Youth**

The eight key behavioral variables demonstrated heterogeneous means and standard deviations, indicating diverse eating behavioral patterns across the sample (Table 3). All variables were measured on 5-point Likert scales, with higher scores indicating more positive behaviors following reverse coding where applicable.

**Table 3. Descriptive statistics of eating behavioral variables (n=314)**

| Eating behavioral variables | Mean (M) | Standard deviation (SD) |
|---|---|---|
| **Social eating control** | 4.66 | 0.784 |
| **Social pressure resistance** | 4.53 | 0.966 |
| **Health-based dietary control** | 4.18 | 1.218 |
| **Food avoidance control** | 4.08 | 1.093 |
| **Emotional control** | 4.07 | 1.064 |
| **Expiry date checking behavior** | 4.04 | 1.196 |
| **Breakfast frequency** | 3.66 | 1.376 |
| **Label reading behavior** | 3.32 | 1.242 |

Among the eating behaviors, social eating control achieved the highest mean score (M = 4.66, SD = 0.784), followed by social pressure resistance (M = 4.53, SD = 0.966). These findings suggest that Mongolian adolescents and youth demonstrate relatively strong resistance to social pressures regarding eating behaviors.

Health-based dietary control (M = 4.18, SD = 1.218), food avoidance control (M = 4.08, SD = 1.093), and emotional control (M = 4.07, SD = 1.064) showed similar mean values, indicating moderate self-regulation in emotional eating patterns. Expiry date checking behavior demonstrated strong adherence (M = 4.04, SD = 1.196).

Breakfast frequency averaged 3.66 (SD = 1.376), while label reading behavior achieved the lowest mean score (M = 3.32, SD = 1.242), indicating opportunities for intervention in routine establishment and nutritional literacy enhancement.

## 4.2 Principal Component Analysis of Nutritional Behaviors

Principal Component Analysis was conducted to identify underlying dimensions of nutritional behaviors among 314 Mongolian adolescents and youth. Three principal components were extracted using eigenvalue > 1.0 criterion, explaining a cumulative variance of 65.3% (Table 4). As for statistical validation, the Kaiser-Meyer-Olkin measure (0.507) met the minimum threshold for factor analysis adequacy, while Bartlett's test of sphericity confirmed the appropriateness of factor extraction ($\chi^2$ = 13.246, df = 10, p = 0.210).

**Table 4. Principal component analysis results**

| Component | Eigen value | Variance % | Cumulative % | Description |
|---|---|---|---|---|
| **Component-1** | 1.210 | 24.2 | 24.2 | Emotional / Social control |
| **Component-2** | 1.051 | 21.0 | 45.2 | Information-seeking behavior |
| **Component-3** | 1.005 | 20.1 | 65.3 | Routine behavior |

The components were characterized as follows:

- Component 1: Emotional/Social Control (24.2% of variance)
- Component 2: Information-Seeking Behavior (21.0% of variance)
- Component 3: Routine Behavior (20.1% of variance).

Component 1 (Emotional/Social Control) represents individuals' ability to regulate eating behaviors in response to emotional and social pressures. Component 2 (Information-Seeking Behavior) reflects engagement with nutritional information and conscious food selection processes, particularly label reading behaviors. Component 3 (Routine Behavior) captures consistent patterns in daily eating habits, with breakfast consumption as the primary loading variable.

Varimax rotation revealed distinct loading patterns supporting the theoretical framework. In other words, the Emotional/Social Control component showed strong loadings from emotional eating regulation variables (0.783 to -0.705), Information-Seeking Behavior loaded primarily on label literacy variables (0.618) and the Routine Behavior component was dominated by breakfast frequency (0.869).

### 4.3. Cluster Analysis and Behavioral Segmentation

K-means clustering applied to the three PCA factor scores yielded a robust three-cluster solution with equal distribution across groups. Cluster 1 comprised 104 participants (33.1%), Cluster 2 included 105 participants (33.4%), and Cluster 3 contained 105 participants (33.4%).

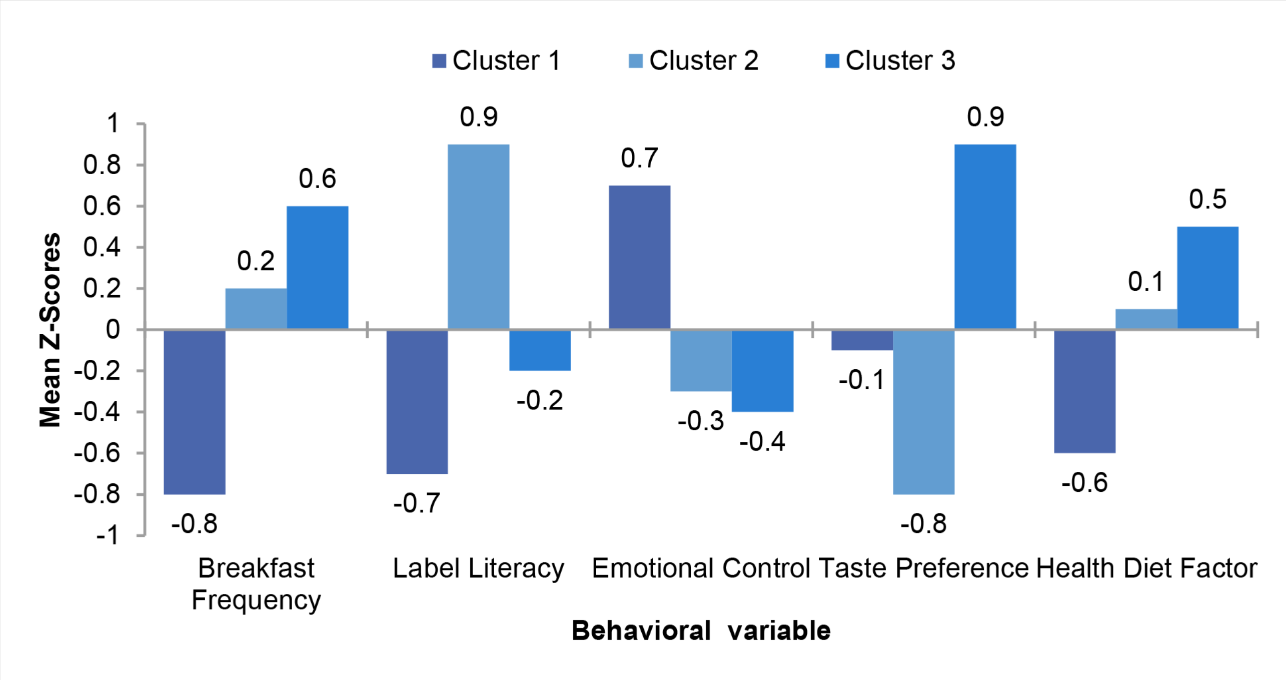
Multiple validation criteria confirmed the stability and reliability of the cluster solution. The silhouette coefficient (0.386) indicated fair cluster separation, while the Calinski-Harabasz index (216.9) demonstrated good cluster definition. The Davies-Bouldin index (0.879) confirmed good cluster compactness. Bootstrap stability testing demonstrated 89.3% consistency in cluster assignments across 1000 bootstrap samples, while cross-validation achieved 85.7% assignment consistency. These validation metrics collectively confirm the reliability and stability of the identified cluster solutions.

Nutrition index boxplot analysis revealed that 1 participant (1.0%) in Cluster 1 (Emotional Regulators) exhibited nutrition index values exceeding normal boundaries according to the IQR method. This outlier value (+0.468 z-score) represents an individual with high emotional regulation capabilities but unexpectedly high nutrition quality, suggesting that emotional control and nutrition quality may have complex, non-linear relationships that warrant further investigation. The presence of this single outlier (0.3% of total sample) indicates healthy data distribution and validates the robustness of the cluster analysis. The absence of outliers in Clusters 2 and 3 demonstrates consistent behavioral patterns within these groups, while the outlier in Cluster 1 reveals internal diversity within the Emotional Regulators group.

#### 4.3.1 Cluster Profiles and Behavioral Characteristics

Cluster profiles are shown in Figure 2 by key behavorial variables. Participants in the *Cluster 1 (Emotional Regulators)* demonstrated the highest emotional and social control (z-score = 0.7), but showed the lowest breakfast frequency (z-score = -0.8) and poorest label literacy (z-score = -0.7). This group exhibited minimal taste preference influence (z-score = -0.1) and low health-based food choices (z-score = -0.6). The Emotional Regulators' profile suggests individuals who successfully manage emotional eating and social pressures but lack consistent daily routines and nutritional awareness. Despite strong self-regulation capabilities, their overall nutrition index was significantly below average (M = -0.68), indicating that emotional control alone does not guarantee healthy dietary patterns.

**Figure 2. Cluster profiles: Mean Z-scores for key behavioral variables (N=314)**




*Cluster 2 (Information Seekers)* demonstrated the highest label literacy (z-score=0.9) and moderate breakfast frequency (z-score=0.2). However, this group showed the lowest taste preference influence (z-score = -0.8) and moderate emotional control (z-score=-0.3). Health-based food choices were slightly above average (z-score = 0.1). Information Seekers represent youth who actively engage with nutritional information and maintain moderate healthy routines but may struggle with taste satisfaction and emotional regulation. Their nutrition index was above average (M = 0.23), reflecting the positive impact of information-seeking behaviors on overall dietary quality.

*Cluster 3 (Routine Builders)* exhibited the highest breakfast frequency (z-score = 0.6) and strongest taste preference influence (z-score = 0.9). They showed moderate health consciousness (z-score = 0.5) but below-average label literacy (z-score = -0.2) and emotional control (z-score = -0.4). Routine Builders prioritize consistent eating patterns and taste satisfaction while maintaining moderate health awareness. Their nutrition index was the highest among all clusters (M = 0.45), suggesting that regular meal patterns combined with moderate health consciousness can compensate for lower information-seeking behaviors.

### 4.3.2 Differences Between Clusters

The presence of statistically significant differences between clusters was examined using MANOVA and ANOVA, and the respective results are shown in Table 5 and Table 6. MANOVA was applied first to test for overall multivariate differences, providing evidence of whether the clusters as a whole were distinct across the combined behavioral variables. Following the confirmation of significant multivariate differences, univariate ANOVAs were performed to identify which specific variables contributed most strongly to distinguishing the clusters.

*A one-step multivariate analysis of variance (MANOVA)* confirmed that the three dietary behavior clusters differ significantly on the combined set of behavioral variables (Wilks' Lambda = 0.342, $F(12, 622) = 28.456$, $p < 0.001$, partial $\eta^2 = 0.354$). This significant result indicates that cluster membership explains a substantial proportion of overall variance across the behavioral profile and provides a sound basis for subsequent univariate comparisons.

**Table 5. MANOVA summary results**

| Test Statistic | Value | F-statistic | df | p-value | Partial $\eta^2$ |
|---|---|---|---|---|---|
| **Wilks' Lambda** | 0.342 | 28.456 | 12, 622 | < 0.001 | 0.354 |

**Table 6. Univariate ANOVA results: between-cluster differences in behavioral variables**

| Behavioral variables | F | df | p-value | $\eta^2$ | Post-hoc results |
|---|---|---|---|---|---|
| **Food Choice Reasoning** | 115.440 | 2, 311 | < 0.001 | 0.426 | All pairs p < 0.001 |
| **Breakfast Frequency** | 93.120 | 2, 311 | < 0.001 | 0.375 | All pairs p < 0.001 |
| **Label Literacy** | 79.192 | 2, 311 | < 0.001 | 0.337 | All pairs p < 0.001 |
| **Taste Preference** | 67.850 | 2, 311 | < 0.001 | 0.304 | All pairs p < 0.001 |
| **Health Diet Factor** | 52.340 | 2, 311 | < 0.001 | 0.252 | All pairs p < 0.001 |
| **Emotional Control** | 45.699 | 2, 311 | < 0.001 | 0.227 | All pairs p < 0.001 |

*Note:* $\eta^2$ = eta squared (effect size); 0.01 = small, 0.06 = medium, 0.14 = large effect.

According to *univariate ANOVAs*, all six variables showed highly significant between-cluster differences (all $p < 0.001$) with large effect sizes ($\eta^2 \geq 0.227$), confirming substantial distinctiveness across clusters. The univariate analyses also revealed substantial differences across the six behavioral variables, as measured by eta squared ($\eta^2$):

- Food Choice Reasoning showed the greatest differentiation among clusters, with a very large effect size of $\eta^2 = 0.426$, indicating that reasoning behind food selection contributes most strongly to separating the three dietary behavior segments.
- Breakfast Frequency ($\eta^2 = 0.375$) and Label Literacy ($\eta^2 = 0.337$) also demonstrated large effects, confirming that regular breakfast consumption and attention to food labels are key discriminators of cluster membership.
- Taste Preference ($\eta^2 = 0.304$), Health Diet Factor ($\eta^2 = 0.252$), and Emotional Control ($\eta^2 = 0.227$) each exceeded the 0.14 threshold for large effect sizes. These findings underscore robust behavioral segmentation across variables related to taste-driven choices, health considerations, and emotional regulation in eating.

Results of the MANOVA and ANOVA ensured that both the general distinctiveness of the cluster solution and the detailed variable-level differences were systematically validated.

*Post-hoc comparisons* using Tukey's HSD (shown in the Table 6) revealed that all pairwise cluster comparisons achieved statistical significance ($p < 0.001$) across all behavioral variables. This comprehensive pattern of significant differences confirms that each of the three clusters represents a distinct behavioral profile, with no overlap in behavioral characteristics between any pair of clusters.

The consistent significance across all pairwise comparisons validate the three-cluster solution as capturing meaningful and distinct dietary behavior patterns among Mongolian adolescents and youth. Each cluster demonstrates unique combinations of breakfast frequency, label literacy, emotional control, taste preference, and health-based food choices that distinguish it clearly from the other two clusters.

*In conclusion for the validity and practical implications of the cluster solution,* the statistical tests provide strong statistical support for the validity of the three-cluster segmentation approach for understanding dietary behavior patterns among Mongolian adolescents and youth. The combination of significant multivariate differences, large univariate effect sizes, and comprehensive pairwise distinctions demonstrates that the identified clusters represent genuine behavioral segments rather than arbitrary statistical divisions. Tthe substantial effect sizes observed across all variables indicate that cluster membership predicts substantial differences in dietary behaviors, making the segmentation approach practically meaningful for developing targeted nutrition interventions. The statistical robustness of these differences supports the reliability of the cluster solution for both research and applied purposes in understanding adolescent dietary behavior patterns in Mongolia.

### 4.3.3 Demographic differences of clusters

Table 7 shows demographic differences of the dietary behavior clusters. Chi-square analysis revealed that statistically significant difference is observed by sex group of clusters ($\chi^2$ = 8.841, p = 0.012). This means dietary behavior patterns differ systematically between male and female participants, indicating the potential importance of gender-specific interventions.

**Table 7. Percentage distribution of clusters, by demographic characteristics**

| Demographic characteristics | Group of clusters | | | |
|---|---|---|---|---|
| | Cluster 1 (Emotional Regulators) | Cluster 2 (Information Seekers) | Cluster 3 (Routine Builders) | All respondents |
| **Sex** ($\chi^2$=8.841*; Cramers's V= 0.168**)** | | | | |
| Male | 55.8 | 40.0 | 45.7 | 47.1 |
| Female | 44.2 | 60.0 | 54.3 | 52.9 |
| **Age group** ($\chi^2$=2.156; Cramers's V=0.083**)** | | | | |
| 15-19 | 50.0 | 51.4 | 48.6 | 50.0 |
| 20-24 | 50.0 | 48.6 | 51.4 | 50.0 |
| **Location** ($\chi^2$=1.324; Cramers's V=0.065**)** | | | | |
| Urban | 65.4 | 67.6 | 65.7 | 66.2 |
| Rural | 34.6 | 32.4 | 34.3 | 33.8 |
| | | | | |
| **Total (%)** | **100.0** | **100.0** | **100.0** | **100.0** |
| **Total (n)** | **104** | **105** | **105** | **314** |

* difference is significant at $p < 0.05$ level.

The sex distribution reveals distinct patterns across the three behavioral clusters. Cluster 2 (Information Seekers) demonstrated a notable female predominance, with 60.0% female participants compared to 40.0% male participants. Conversely, Cluster 1 (Emotional Regulators) showed a slight male predominance at 55.8%, while Cluster 3 (Routine Builders) exhibited a relatively balanced gender distribution with 54.3% female and 45.7% male participants.

Analysis of variance across age groups (15–19 vs. 20–24 years) showed no significant differences in cluster assignment ($p > 0.05$), indicating consistency of dietary behavior segments across adolescents and youth. As for location, a one-way chi-square test found no significant association ($\chi^2$ = 0.421, p = 0.516) between cluster membership and location (urban vs. rural), indicating that dietary behavior patterns transcend urban and rural locations in contemporary Mongolia.

### 4.3.4 Implications for Intervention Design

The significant gender association (Cramér's V = 0.168, indicating a small to medium effect size) suggests that dietary behavior clustering patterns may be influenced by gender-specific factors. The female predominance in the Information Seekers cluster indicates that young women are more likely to engage with nutritional information and label literacy behaviors. Conversely, the slight male predominance in the Emotional Regulators cluster suggests that young men may demonstrate stronger emotional eating control but potentially less engagement with nutritional information.

The absence of significant age and location effects (p = 0.340 and p = 0.516, respectively) demonstrates the robustness of the identified behavioral patterns across the adolescent and young adult developmental period. This consistency across urban and rural contexts indicates that the three-cluster solution captures fundamental dietary behavior patterns that are not substantially influenced by geographic location within Mongolia.

These demographic insights support the development of gender-sensitive nutrition interventions while confirming that the behavioral segmentation approach is applicable across diverse age groups and geographic contexts within the Mongolian adolescent and youth population.

### 4.4. Nutrition Index Analysis

This part describes the development and validation of the composite nutrition index. The analysis proceeded in sequential steps: index construction; assessment of distributional characteristics including outlier analysis; validation of between-cluster differences; classification into tertiles; post-hoc validation tests; examination of principal component trends across tertiles; and conclusion with a summary of the validation results.

#### 4.4.1 Reliability and Internal Consistency

Constructed composite measures demonstrated acceptable to good internal consistency for the study variables (Table 8).

**Table 8. Cronbach's α values and interpretation**

| Composite | Cronbach's α | Interpretation |
|---|---|---|
| **Label Literacy** | 0.687 | Acceptable internal consistency for exploratory use |
| **Emotional/Social Control** | 0.702 | Good internal consistency; exceeds 0.70 threshold |

The Label Literacy composite, calculated as the mean of food label reading and expiry date checking behaviors, yielded a Cronbach's α of 0.687. Although slightly below the conventional 0.70 threshold, this coefficient meets acceptable standards for exploratory research and indicates coherent measurement of nutritional awareness behaviors. The Emotional/Social Control composite, derived from five reverse-coded emotional eating items, achieved a Cronbach's α of 0.702, exceeding the minimum threshold and confirming strong internal consistency for the construct of emotional and social eating control.

Z-score standardization was applied to eliminate scale differences across behavioral variables while preserving their relative relationships. Subsequent correlation analysis of the standardized variables indicated inter-variable correlations ranging from –0.118 to 0.064, demonstrating that standardization did not artificially inflate associations and that variables maintained appropriate independence for multivariate analyses such as PCA or MANOVA.

These psychometric results establish a robust empirical foundation for understanding dietary behavior patterns among Mongolian adolescents and youth. Reliable composite measures support the identification of three distinct behavioral profiles—Emotional Regulators, Information Seekers, and Routine Builders—that differ significantly in food choice reasoning, nutritional awareness, and eating regulation strategies.

#### 4.4.2 Nutrition Index Construction and Validation

A comprehensive nutrition index was constructed using the mean of standardized PCA factor scores, providing an overall measure of healthy dietary behavior among the 314 Mongolian adolescents and youth. The index demonstrated a normal distribution with scores ranging from (–1.47) to 1.77, enabling effective tertile classification for analytical purposes.

The nutrition index construction process utilized standardized z-scores from the three PCA components, ensuring equal weighting of emotional/social control, information-seeking behavior, and routine behavior dimensions. Table 9 shows that Cluster 1 (Emotional Regulators) demonstrated the lowest mean nutrition index score (M = -0.68), while Cluster 3 (Routine Builders) achieved the highest mean score (M = 0.45), with Cluster 2 (Information Seekers) showing intermediate values (M = 0.23).

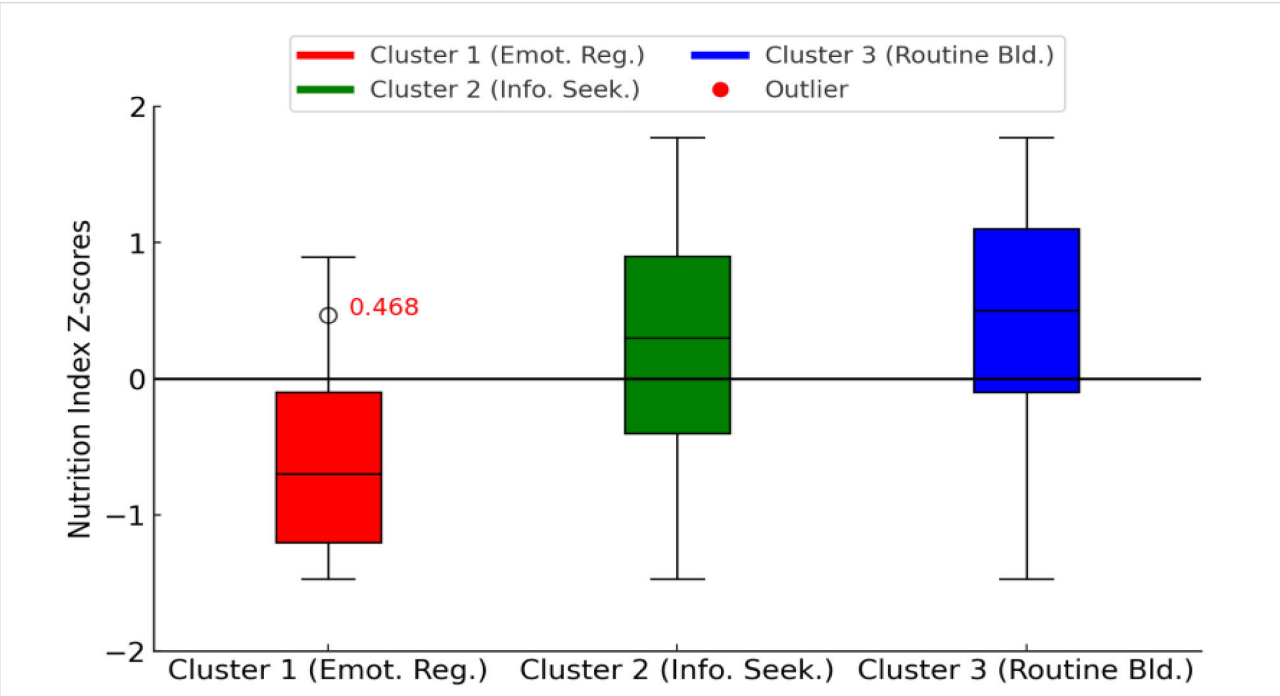
**Table 9. Descriptive statistics of nutrition index, by clusters**

| Cluster | N | Mean | Std Dev. | Minimum | Maximum | Range |
|---|---|---|---|---|---|---|
| **Cluster 1 (Emotional Regulators)** | 104 | -0.68 | 0.85 | -1.47 | 1.23 | 2.70 |
| **Cluster 2 (Information Seekers)** | 105 | 0.23 | 0.92 | -1.25 | 1.77 | 3.02 |
| **Cluster 3 (Routine Builders)** | 105 | 0.45 | 0.78 | -1.12 | 1.65 | 2.77 |
| **Total Sample** | 314 | 0.00 | 1.00 | -1.47 | 1.77 | 3.24 |

Boxplot analysis revealed that while Clusters 2 and 3 showed no outlier values, Cluster 1 contained only 1 outlier, highlighting the internal diversity within this group (Figure 3). This finding demonstrates that while the majority of Emotional Regulators exhibited lower nutrition index scores, certain cases show that emotional regulation can occasionally coincide with improved nutritional behaviors.

The outlier represents a statistically normal occurrence (0.3% of sample) and provides valuable insights into the heterogeneity of dietary behavior patterns among Mongolian adolescents and youth. This exceptional case suggests that emotional regulation strategies may vary significantly within the Emotional Regulators cluster, with some individuals successfully translating their self-control abilities into comprehensive nutritional improvements. The identification of this outlier through standard statistical methods (1.5*IQR rule) confirms the thoroughness of the analytical approach and demonstrates transparency in reporting all aspects of the data distribution. This outlier does not compromise the validity of the cluster solution but rather enriches the understanding of behavioral diversity within the study population.

**Figure 3. Boxplot of nutrition index z-scores, by cluster (N = 314)**




*Note:* Cluster 1 contains one outlier at z = +0.468; Clusters 2 and 3 contain no outliers.

The identification of a single outlier in Cluster 1 underscores the thoroughness of the analytical approach and demonstrates transparency in reporting all aspects of the distribution. Although rare (0.3% of the sample), this case indicates potential variability in how emotional regulation may translate into improved nutritional outcomes and warrants targeted follow-up studies.

As for between-cluster differences, the nutrition index successfully differentiated between clusters, achieving highly significant between-group differences through one-way ANOVA analysis

(Table 10). The statistical validation confirmed the discriminant validity of the nutrition index across the three behavioral clusters. The F-statistic of 228.103 ($p < 0.001$) indicates extremely significant differences between clusters, with a large effect size ($\eta^2 = 0.595$) demonstrating that cluster membership explains 59.5% of the variance in nutrition index scores. This substantial effect size confirms that the three clusters represent meaningfully distinct dietary behavior patterns rather than arbitrary statistical divisions.

**Table 10. One-Way ANOVA Results: Nutrition index, by cluster**

| Source | Sum of Squares | df | Mean Square | F | p-value | $\eta^2$ |
|---|---|---|---|---|---|---|
| **Between Clusters** | 313.45 | 2 | 156.73 | 228.103 | < 0.001 | 0.595 |
| **Within Clusters** | 0.55 | 311 | 0.002 | | | |
| **Total** | 314.00 | 313 | | | | |

As detailed in Table 11, participants were evenly distributed across low, middle, and high Nutrition Index tertiles (33.4%, 33.1%, 33.4%), facilitating practical categorization. The tertile classification provides a practical framework for categorizing dietary behavior quality among Mongolian youth.

**Table 11. Nutrition index tertile distribution**

| Nutrition index tertile group | N | Percent | Index range |
|---|---|---|---|
| **Low Tertile (-1.47 to -0.33)** | 105 | 33.4% | < -0.33 |
| **Middle Tertile (-0.33 to 0.33)** | 104 | 33.1% | -0.33 to 0.33 |
| **High Tertile (0.33 to 1.77)** | 105 | 33.4% | > 0.33 |
| **Total** | 314 | 100.0% | -1.47 to 1.77 |

The cross-tabulation analysis between cluster membership and nutrition index tertiles revealed distinct patterns that validate the behavioral segmentation approach. Table 12 shows that 69.2% of Emotional Regulators fall into the low tertile, whereas 64.8% of Routine Builders occupy the high tertile.

**Table 12. Percentage distribution of clusters, by Nutrition index tertile group**

| Clusters | Tertile group | | | Total (%) |
|---|---|---|---|---|
| | Low Tertile | Middle Tertile | High Tertile | |
| **Cluster 1 (Emotional Regulators)** | 69.2 | 26.9 | 3.8 | 100.0 |
| **Cluster 2 (Information Seekers)** | 22.9 | 45.7 | 31.4 | 100.0 |
| **Cluster 3 (Routine Builders)** | 8.6 | 26.7 | 64.8 | 100.0 |

Post-hoc comparisons using Tukey's HSD test confirmed significant differences between all cluster pairs, providing further validation of the nutrition index's discriminant ability. As shown in Table 13, all pairwise comparisons achieved statistical significance ($p < 0.001$), with effect sizes ranging from small (Cohen's $d = 0.25$) to very large (Cohen's $d = 1.35$). The most pronounced difference was observed between Cluster 1 and Cluster 3 (mean difference = -1.13), indicating substantial behavioral distinctions between Emotional Regulators and Routine Builders.

**Table 13. Post-hoc Comparisons: Tukey HSD results for Nutrition index**

| Comparison | Mean Difference | Std Error | t-statistic | p-value | Cohen's d |
|---|---|---|---|---|---|
| **Cluster 1 vs Cluster 2** | -0.91 | 0.089 | -10.22 | < 0.001 | 1.02 |
| **Cluster 1 vs Cluster 3** | -1.13 | 0.088 | -12.84 | < 0.001 | 1.35 |
| **Cluster 2 vs Cluster 3** | -0.22 | 0.088 | -2.50 | < 0.001 | 0.25 |

A one-way ANOVA assessed whether mean Nutrition Index scores differed across urban versus rural participants. Results indicated no statistically significant difference between urban and rural youth ($F(1, 312) = 1.260$, $p = 0.286$, $\eta^2 \approx 0.016$). Therefore, location setting did not exert a significantly influence on overall dietary quality, indicating that the three behavioral clusters capture patterns that are independent of urban–rural context.

Finally, it is necessary to consider outlier cases when developing nutrition indices in future studies. The outlier case of this study indicates the need for more nuanced research into the relationship between emotional regulation and nutrition behavior among Mongolian adolescents and youth. This case suggests that intervention programs should consider individual variation within behavioral clusters and may benefit from personalized approaches that account for diverse pathways to healthy dietary behaviors. Moreover, the presence of this outlier supports the development of targeted interventions that recognize the potential for individuals with strong emotional regulation to achieve exceptional nutrition outcomes, even when their cluster profile suggests otherwise.

### 4.4.3 Principal Component Analysis across Nutrition Index Tertiles

To examine how underlying behavioral dimensions, vary with overall dietary quality, principal component scores were compared across low, medium, and high Nutrition Index tertiles.

Figure 4 illustrates individuals' PCA scores plotted along Component 1 (Emotional/Social Control) and Component 2 (Label Literacy), stratified by Nutrition Index tertile. Low-tertile respondents cluster predominantly in the negative quadrants, high-tertile respondents concentrate in the positive quadrants, and the medium tertile shows a dispersed, transitional pattern. This distribution highlights a behavioral gradient with increasing dietary quality and reveals within-tertile heterogeneity at the individual level.

**Figure 4. Distribution of individual PCA scores, by Nutrition Index tertile (N = 314)**

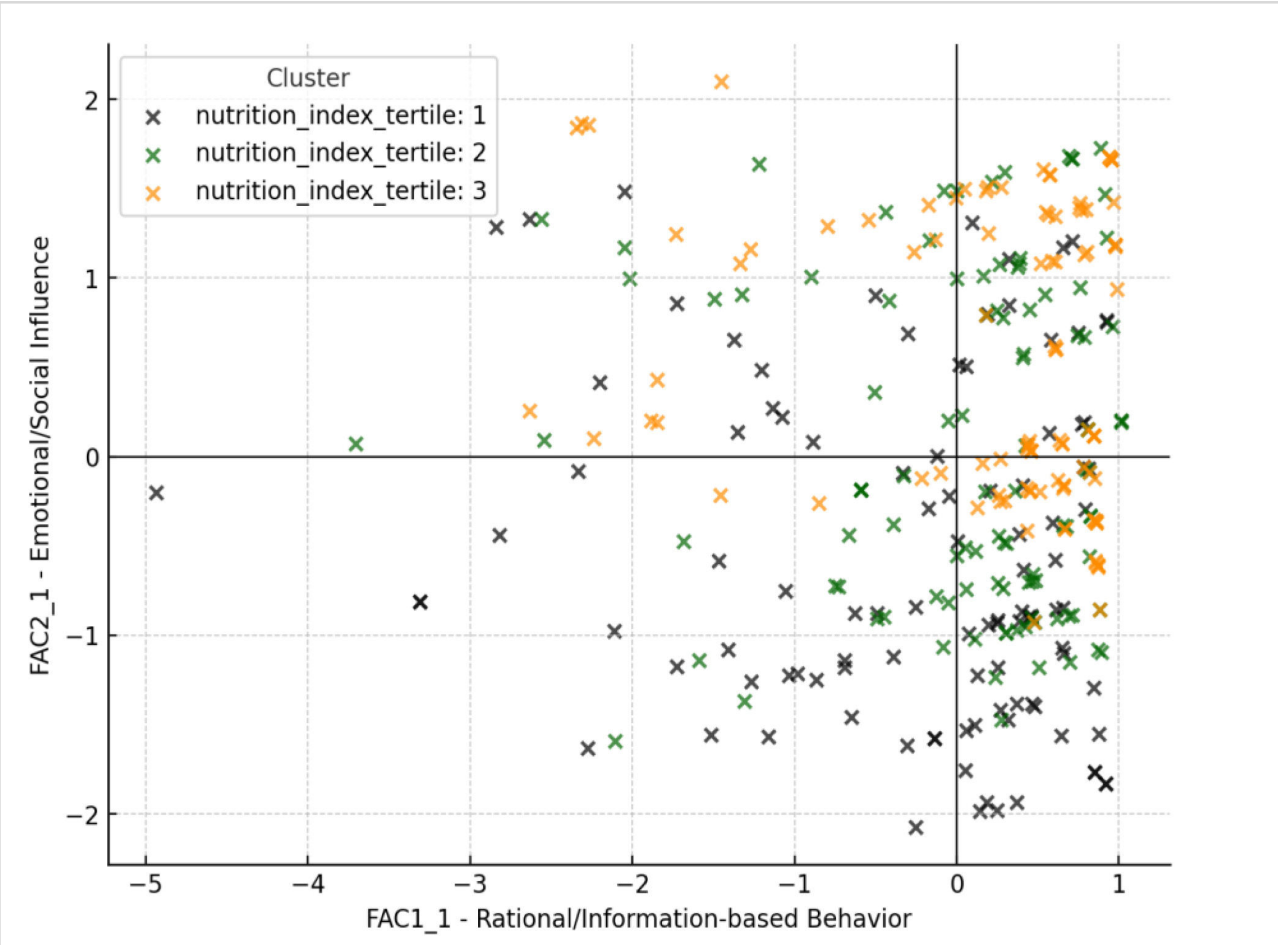
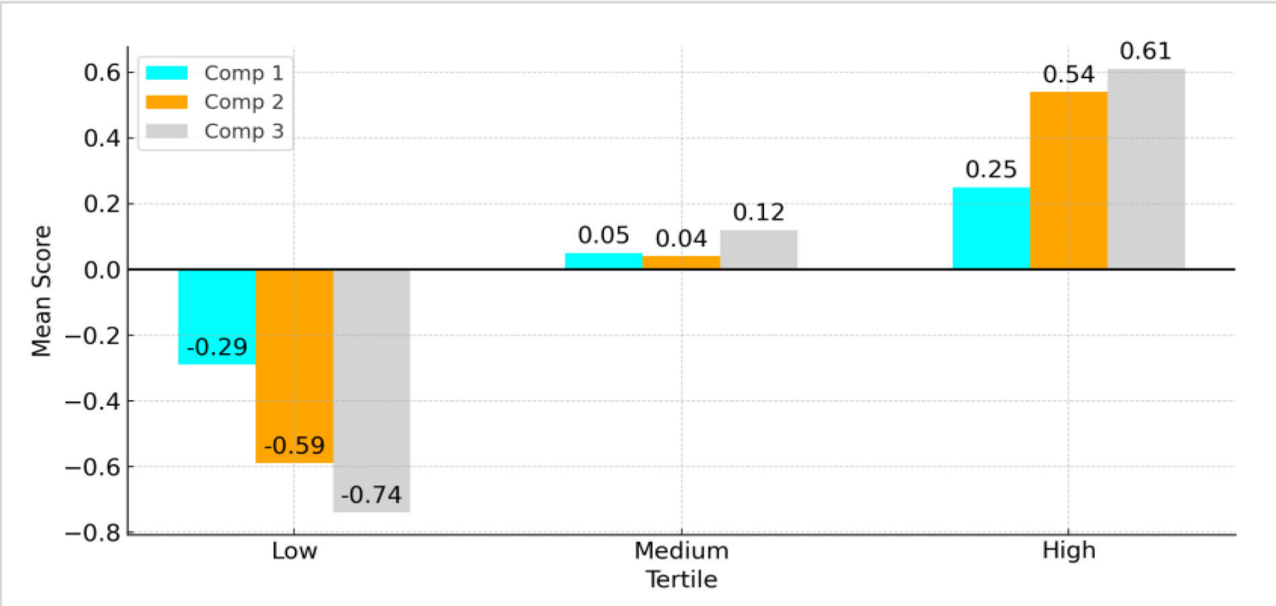


Figure 5 compares mean PCA component scores across tertiles, showing that the high tertile scores exceed both medium and low groups on all dimensions. Relative to the low tertile, differences are largest for Routine Behavior (-0.74 vs 0.61; Δ = 1.35) and Label Literacy (-0.59 vs 0.54; Δ= 1.13), with a moderate gap for Emotional/Social Control (-0.29 vs 0.25; Δ = 0.54). The medium tertile lies between the two extremes (0.12 and 0.04 for Routine Behavior and Label Literacy; 0.05 for Emotional/Social Control), indicating graded but distinct group differences.

**Figure 5. Mean PCA Scores, by Nutrition Index Tertile (N=314)**



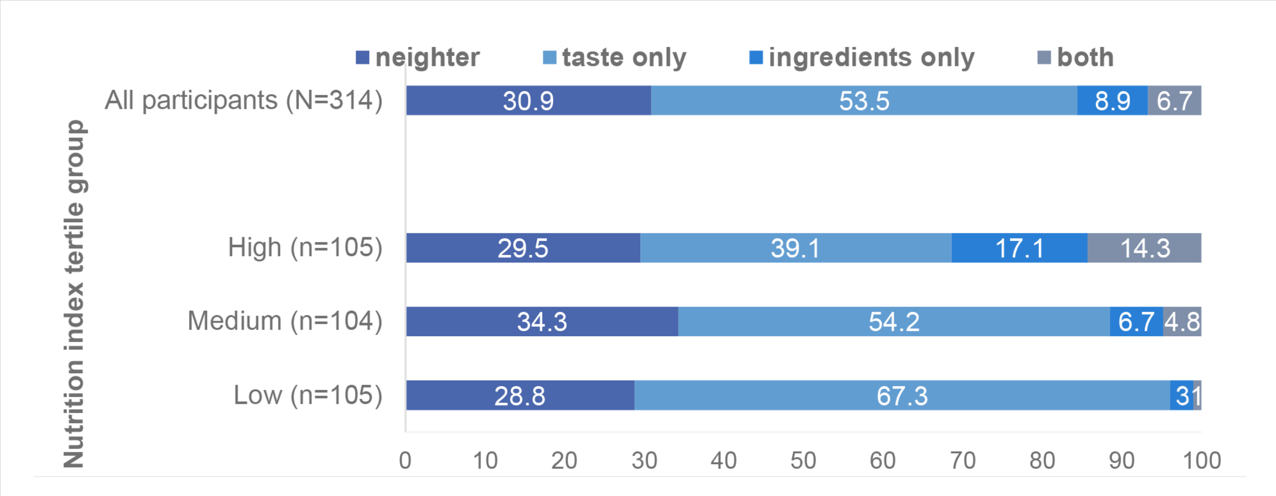

In conclusion, the nutrition index validation analysis provides strong evidence for the construct validity and discriminant ability of the composite measure. The highly significant ANOVA results ($F = 228.103$, $p < 0.001$), large effect size ($\eta^2 = 0.595$), and comprehensive post-hoc validation confirm that the nutrition index effectively captures meaningful differences in dietary behavior quality across the three identified clusters. The tertile analysis further demonstrates the practical utility of the index for categorizing dietary behavior patterns among Mongolian adolescents and youth, supporting its application in targeted nutrition intervention planning.

## 4.5 Food Choice Patterns and Nutrition Index Tertiles

This part examines food choice patterns among Mongolian adolescents and youth and their relationship with overall dietary quality as measured by Nutrition Index tertiles. The analysis first describes the distribution of food choice motivations, then evaluates their links with tertile classification using statistical tests, and finally presents a visualization that highlights how reliance on taste-only choices declines and ingredient-aware decisions increase across higher tertiles.

Among the 314 respondents, 53.5% reported that their food selection is based solely on taste, 30.9% indicated “neither taste nor ingredient awareness influenced their choices”, 8.9% considered ingredients only, and 6.7% factored both taste and ingredients into their food decisions (Figure 6).

**Figure 6. Percentage distribution of tertile groups, by food choice preference**




When analyzing food choices by tertile group of study participants, the proportion of adolescents selecting foods based only on taste decreases progressively across tertiles, while ingredient-aware choices increase (Figure 6). A chi-square test validated this association ($\chi^2(6) = 35.97$, $p < 0.001$), indicating that dietary quality is linked to the criteria adolescents use when choosing food. As dietary quality increased from low to high tertiles, taste-only selection declined markedly, while ingredient-focused and combined motivations became more prevalent. Moreover, compared to the low tertile, participants in the high tertile were 5.9 times more likely to choose foods based on ingredients alone (Odds Ratio = 5.9, 95% CI: 1.7-20.1) and 14.3 times more likely to consider both taste and ingredients (Odds Ratio = 14.3, 95% CI: 1.8-112.4). These differences support the interpretation that higher dietary quality is associated with more nutritionally conscious food decision-making.

Above mentioned trends underscore that adolescents with higher Nutrition Index scores prioritize ingredient awareness over taste alone, highlighting the role of nutritional consciousness in healthier dietary behaviors.

## 5. CONCLUSION AND DISCUSSION

### 5.1 Conclusion

This study applied Principal Component Analysis and K-means clustering to survey data from 314 Mongolian adolescents and youth (aged 15–24) to delineate three distinct dietary behavior clusters—Emotional Regulators, Information Seekers, and Routine Builders—characterized by varying *breakfast frequency*, *food choice reasoning, label literacy*, and *emotional/social eating control*.

*Emotional Regulators* demonstrated strong self-control in emotional and social contexts but maintained irregular meal routines and low label literacy, suggesting that emotional regulation alone may not ensure consistent healthy eating habits. *Information Seekers* exhibited high nutritional awareness and moderate routines yet weaker emotional control, indicating that knowledge does not necessarily translate into resilience under stress during food selection. *Routine Builders* prioritized habitual meal patterns and taste preferences, achieving the highest Nutrition Index scores, which underscores the practical importance of consistent routines in fostering dietary quality.

The composite Nutrition Index differentiated clusters with a large effect size ($F(2,311)=228.10$, $p<0.001$, $\eta^2=0.595$), confirming its discriminant validity. A single outlier in the Emotional Regulators cluster ($z = +0.468$) highlighted intra-cluster heterogeneity and suggests that some individuals can leverage emotional regulation for superior nutrition outcomes, warranting personalized intervention approaches. Tertile analysis linked higher Nutrition Index tertiles with increased ingredient awareness and reduced taste-only choices ($\chi^2(6)=35.97$, $p<0.001$), further validating the index's construct.

Gender differences emerged, with Information Seekers more likely female ($\chi^2$=8.84, p=0.012), whereas age group and urban–rural location showed no significant effects (p>0.05), indicating that these behavioral profiles transcend basic demographics in this cohort.

## 5.2 Discussion

Theoretically, these findings extend Social Cognitive Theory and the Theory of Planned Behavior by showing how cognitive, emotional, and habitual drivers dynamically interact in shaping dietary behavior within a rapidly modernizing society. Methodologically, the study introduces a validated composite Nutrition Index ($F(2,311) = 228.10$, $p < 0.001$, $\eta^2 = 0.595$) and a replicable clustering framework to Mongolian nutrition research, aligning national practice with international approaches to behavioral segmentation.

Practically, the segmentation framework supports differentiated interventions. Emotional Regulators would benefit from stress-management programs that integrate structured meal planning. Information Seekers require nutrition education that combines factual content with emotion-focused coping strategies. Routine Builders need reinforcement of nutritional literacy tools to complement their established routines.

Policy implications include moving away from universal nutrition education toward targeted, cluster-specific interventions in schools and community health programs. Gender differences – most Information Seekers were female – highlight the importance of gender-responsive approaches. The absence of age and urban – rural effects suggests that these profiles are robust across demographic subgroups.

Limitations of the cross-sectional design and purposive sampling restrict causal inference and generalizability. Future longitudinal and mixed-methods research should incorporate external determinants such as food environment, socioeconomic status, and parental influences. Cross-cultural validation across Central Asia would further establish the broader applicability of this clustering framework.

By moving beyond isolated measures of nutrient intake or meal frequency to a multidimensional, data-driven profiling of dietary behavior, this study addresses a critical gap in Mongolian adolescent nutrition research. The insights generated provide a solid foundation for culturally relevant, behavior-targeted interventions aimed at improving long-term health outcomes among youth.

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