



ORIGINAL ARTICLE

Nutrition, Education, and Dietetics

The Moderating Role of Nutrition Knowledge in an Extended Theory of Planned Behavior Model of Ultra-Processed Food Consumption Among University Students in Saudi Arabia

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ABSTRACT

Aims: This study aimed to examine the influence of nutrition knowledge on the pathways of the Theory of Planned Behavior (TPB) — specifically attitudes, subjective norms, perceived behavioral control (PBC), intention, and behavior — in predicting ultra-processed food (UPF) consumption among university students in Saudi Arabia.

Methods: A cross-sectional design was employed, involving 384 students enrolled at Northern Border University (NBU). Data were collected through a validated questionnaire that assessed socio-demographic characteristics, UPF-related knowledge, TPB factors, and self-reported UPF consumption. Participants were stratified into low, moderate, and high knowledge groups for comparative analysis.

Results: Significant associations were observed between UPF knowledge and sex, marital status, and academic discipline. Higher knowledge levels were correlated with less favorable attitudes toward the safety of UPFs and heightened susceptibility to social influence. Structural Equation Modelling (SEM) revealed that, across the overall sample, attitudes significantly predicted behavioral intention ($\beta = 0.59, p < 0.001$), whereas perceived behavioral control (PBC) exerted a negative effect on behavior ($\beta = -0.22, p < 0.001$). Notably, among participants with high-knowledge, neither intention ($p = 0.884$) nor PBC ($p = 0.453$) significantly predicted UPF consumption, and the model accounted for a negligible proportion of variance in behavior ($R^2 = 0.01$), indicating a pronounced intention–behavior discrepancy within this group.

Conclusions: Among NBU students, nutrition knowledge regulates psychosocial determinants of UPF consumption but appears to weaken the intention–behavior connection. These findings suggest that effective interventions should extend beyond educational initiatives to incorporate habit-formation strategies and environmental modifications that support sustained dietary behavioral modification.

Keywords: Ultra-Processed Foods; Theory of Planned Behavior; Nutrition Knowledge; Saudi Arabia; University Students.

Article Information

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1 INTRODUCTION

Globally, diets are becoming increasingly dominated by ultra-processed foods (UPFs), raising significant concerns regarding their impact on public health (Monteiro *et al.*, 2013, 2019). According to the NOVA classification, UPFs are foods that have undergone intense industrial processing (physical, chemical, or biological) or contain industrial substances not typically found in domestic kitchens, such as hydrogenated oils, preservatives, and artificial flavor enhancers (Monteiro *et al.*, 2009). Examples of such products include carbonated drinks, chocolate, ready-to-eat meals, energy bars, instant noodles, dehydrated soups, fish and chicken nuggets, powdered or “fortified” meals, and meat

substitutes containing protein isolates or additives that modify color and flavor. The UPFs are characterized by high convenience, affordability, and palatability, and consequently contribute substantially to daily energy intake, with global consumption steadily increasing (Baker *et al.*, 2020). Lane *et al.* (2021), in a systematic review and meta-analysis, reported that UPFs accounted for 17% to 56% (mean: 37%) of total daily energy intake across 28 countries, and concluded that significant associations exist between UPF consumption and various chronic diseases. Furthermore, greater exposure to UPFs has been associated with an increased risk of adverse health outcomes, especially cardiometabolic diseases, common mental disorders, and mortality outcomes (Lane *et al.*, 2024; Kim *et al.*, 2023). These findings underscore the

urgent need to better understand the factors influencing UPF consumption patterns.

Accordingly, numerous researchers have applied behavioral, health, and social theories to identify the determinants of high UPF consumption, despite ongoing efforts to limit this unhealthy eating behavior within communities (Kelly *et al.*, 2022; da Cruz *et al.*, 2024; Calvo-Porrall *et al.*, 2024). Among these frameworks, the Theory of Planned Behavior (TPB) provides a robust basis for examining individual perceptions and behaviors related to UPF consumption (Seo *et al.*, 2014), as it seeks to elucidate the underlying determinants of such behaviors (Ajzen, 1991). According to TPB, behavioral intentions constitute the primary predictor of actual behavior, and intentions are in turn shaped by three core constructs: attitude, subjective norm, and perceived behavioral control (Ajzen, 1991). Attitude refers to an individual's positive or negative evaluation of a given behavior; for instance, if UPFs are perceived as safe, convenient, or enjoyable, individuals are more likely to intend to consume them. Subjective norms capture the social pressures or perceived expectations of significant others, such as family and friends, that influence behavior (Ajzen, 1991). Perceived behavioral control reflects an individual's perception of the ease or difficulty of performing a given behavior, as shaped by available resources and opportunities (Ajzen, 1991). The present study therefore explores the determinants of intention to consume ultra-processed foods through application of the TPB. Understanding the roles of family and social influence, alongside factors such as food availability and affordability, is essential for predicting consumer behavior regarding UPF; when processed foods are easily accessible and affordable, individuals are more likely to purchase them. Perceived behavioral control, particularly with respect to the availability and affordability of UPFs—therefore plays a substantial role in shaping consumption patterns (Ajzen, 1991). Existing evidence suggests that TPB constitutes an effective framework for explaining, and potentially improving nutrition-related behaviors across diverse populations (Zendehtalab, 2014).

In recent decades, Saudi Arabia has experienced rapid modernization, urbanization, and globalization, all of which have profoundly influenced food consumption patterns (Alqurashi *et al.*, 2024). These lifestyle shifts have been especially evident among university students, a population transitioning from adolescence to adulthood during which individuals typically often initiate making independent food choices, frequently influenced by academic demands, limited time, financial constraints, and exposure to fast food environments (Deliens *et al.*, 2014). Consequently, unhealthy dietary practices, such as meal skipping, high consumption of fast foods and sugar-sweetened beverages, and low intake of fruits and vegetables, have been widely

documented among university students in Saudi Arabia (Al-Qahtani *et al.*, 2016; Hamam *et al.*, 2017). Research on UPF consumption specifically within this population, however, remains limited. To date, only one study, conducted by Alessa *et al.* (2023), has examined UPF consumption among the general Saudi population, revealing that a significant portion of respondents regularly consumed UPFs, yet very few were aware of the associated health risks, including the association with colorectal cancer. This finding underscores the pressing necessity for a more comprehensive understanding of UPF consumption patterns and their health implications within the Saudi context. Moreover, although prior research has characterized general dietary behaviors among Saudi populations (Alshehri, 2024; Rabiah *et al.*, 2023; Alqurashi *et al.*, 2024), limited number of studies have employed theoretical frameworks such as the TPB to explore the psychological and social determinants of dietary choice. The present study therefore aims to examine the determinants of UPF consumption among university students in the Northern Borders Region of Saudi Arabia, employing an extended TPB model that incorporate the potential role of nutrition knowledge.

2 METHODS

2.1 Study Population and Study Design

This cross-sectional study was conducted in 2025. The study population included all university students enrolled at Northern Border University (NBU), Saudi Arabia, with eligibility restricted to Saudi citizens residing in the Northern Borders Region. Students were excluded if they were younger than 18 years of age, were pregnant or breastfeeding, or had a chronic disease or were following a specific diet likely to affect their dietary habits.

Ethical approval for this study was obtained from the Institutional Local Committee of Bioethics at Northern Border University (HAP-A-043) on February 26, 2025 (Ref. No. 42/24/H). All participants received study information in Arabic regarding the study's aims and procedures and provided written informed consent prior to enrollment. Participants were assured that the study posed no risks and that no incentives would be provided for participation; they were further informed of their right to ask questions at any time and to withdraw from the study without any penalty. To ensure confidentiality, no personal identifiers were collected; each participant was instead assigned a unique code. All data collected were utilized exclusively for research purposes, stored on a password-protected computer under a coded filename, and permanently deleted at the conclusion of the study period.

2.2 Sampling Technique and Sample Size Calculation

The minimum required sample size was calculated as 385 participants, utilizing the formula proposed by [Lwanga et al. \(1991\)](#). Given the absence of national data on UPF consumption, a prevalence estimate of 50% was assumed to maximize sample size precision, and an additional 10% was incorporated to account for potential non-response, yielding a final target of 422 participants. A non-probability convenience sampling technique was employed, whereby an online questionnaire was disseminated to NBU students, and participation was voluntary among those meeting the inclusion criteria. Data collection continued until the minimum required sample size of 385 participants was achieved; as all 384 responses collected were complete, with no incomplete or invalid entries requiring exclusion, the additional buffer incorporated into the 422-participant target was not required, and recruitment concluded once the minimum threshold was reached.

2.3 Data Collection Tool

The study employed a structured questionnaire comprising the following sections:

Section 1: General Information

This section collected data on age, sex, marital status, academic level (semesters 1–2, 3–4, 5–6, 7–8; master student; or doctoral student), field of study (health-related or non-health-related), family monthly income, and presence of any diagnosed disease. Body weight (Kg) and height (cm) were also recorded, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared (kg/m^2) and categorized according to World Health Organization (WHO) cut-off values: underweight ($< 18.5 \text{ kg}/\text{m}^2$), normal weight ($18.5\text{--}24.9 \text{ kg}/\text{m}^2$), overweight ($25.0\text{--}29.9 \text{ kg}/\text{m}^2$), and obesity ($> 30.0 \text{ kg}/\text{m}^2$) ([World Health Organization \[WHO\], 2000](#)).

Section 2: Knowledge Related to UPF

This section assessed the level of knowledge about UPF using five items. Respondents were asked whether they felt they had received sufficient information regarding UPFs, whether they had previously encountered the term “UPF”, and whether they were aware that UPF consumption is associated with adverse health outcomes. Respondents were further asked to indicate (yes/no) whether UPFs were rich in specific components and to accurately categorize a list of food items, adapted from [Stamatelou et al. \(2024\)](#) and modified to reflect common Saudi dietary habits.

Section 3: Consumption Patterns Related to UPF

This section assessed habitual UPF consumption employing a 13-item checklist covering the most commonly consumed UPF categories in the Saudi diet (regular or diet carbonated beverages; canned or boxed fruit juice/drink; powdered fruit drink mixes; instant noodles; potato chips, crackers, or other packaged salty snacks; instant coffee; flavored yogurt; sausages, hamburgers, or nuggets; sweet cakes; pasta/macaroni/spaghetti; margarine; branded salad dressing, mayonnaise, ketchup, or mustard; and fast food such as burgers, pizza, or broasted items), adapted from [Kébé et al. \(2024\)](#) and [Seo et al. \(2014\)](#) and refined to reflect common Saudi dietary patterns. For each item, participants indicated frequency of consumption on a 6-point scale (0 = never, 1 = < 1 time/month, 2 = 2–3 times/month, 3 = 2–3 times/week, 4 = 4–6 times/week, 5 = daily). Item scores were summed to derive a total behavior score reflecting overall UPF consumption frequency, with a possible range of 0–65 (13 items $\times$ 0–5). The complete 13-item list is provided in [Supplementary material](#).

Section 4: TPB Construct Items

Survey items were developed and adapted from existing literature on processed food consumption, notably [Seo et al. \(2014\)](#) and [Ajzen \(1991\)](#).

- *Attitudes* toward the consumption of UPF were evaluated using four statements: “Consuming UPF is the right choice,” “is safe,” “fits with my dietary preferences,” and “suits my lifestyle.” Participants were asked to rate their agreement with each statement on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).
- *Subjective norms* regarding UPF consumption were evaluated using four statements: “My friends think that consuming UPFs is acceptable”; “My family thinks that consuming UPFs is acceptable”; “Social media encourages the consumption of UPFs”; and “In my community, it is common for people to consume ultra-processed foods during social gatherings.”
- *Perceived behavioral control* was assessed employing three statements: “I think that consumption of UPF is under my control”; “Whether I consume UPF is a decision that depends entirely on me”; and “I am confident that I can consume UPF safely”.
- *Behavioral intentions* to consume UPF was evaluated using three items: “I intend to consume UPF less than other foods.”; “I intend to consume particular UPF that are advertised”; “I intend to consume UPF regardless of their safety.”

For each item of the TBC construct items, participants indicated their level of agreement using the same 5-point Likert scale (1 = strongly disagree to 5 = strongly agree).

2.4 Validity

Upon finalization, the questionnaire was submitted to a panel of five experts in nutrition and public health for evaluation of its face validity, following the framework proposed by Mokkink *et al.* (2010). The review addressed three main elements described by Ehrenbrusthoff *et al.* (2018): completeness of content, clarity of wording, and time required for completion. With respect to content coverage, experts were asked to judge whether the instrument adequately reflected the study objectives and, where relevant, to suggest additional topics for inclusion. To assess comprehensibility, experts evaluated whether the questions were clear and readily understood, noting any items considered potentially confusing. Finally, the practicality of completing the instrument was rated on a 0–10 scale, with higher scores indicating a lower time burden.

The experts' assessments provided valuable feedback on the instrument's usability, pointing out minor areas for improvement prior to data collection (Janssens *et al.*, 2017). All reviewers concurred that the questionnaire captured the essential content and was generally easy to understand; the time required for completion was rated as appropriate, with a mean score of 8.3 ± 1.3 out of 10. The panel additionally evaluated content validity using a 4-point Likert scale (1 = not relevant to 4 = highly relevant). Both the Item Content Validity Index (I-CVI) and Scale Content Validity Index (S-CVI) were calculated. The I-CVI ranged from 0.80 to 1.00, the S-CVI/Average reached 98.0%, and the S-CVI/Universal Agreement reached 92.75%, corresponding to an overall expert agreement of 98.5%, consistent with the approach of Rodrigues *et al.* (2017).

2.5 Statistical Analysis

TPB constructs were assessed using a 5-point Likert scale: attitude toward the behavior was measured employing four semantic differential items, subjective norm with four items, perceived behavioral control (PBC) comprising three items, and behavioral intention through three items. Actual behavior was captured as a summed frequency-of-consumption score across 13 commonly consumed UPF items (possible range 0–65), rather than a single global consumption item, in order to capture the cumulative, multi-source nature of UPF exposure—consistent with established food-frequency-questionnaire (FFQ) practice, whereby summed multi-item consumption scores provide greater measurement precision and more effectively capture variance in habitual intake than a single omnibus item (Cade *et al.*, 2002; Thompson & Subar, 2017). Knowledge of UPFs was evaluated employing five items, and participants were categorized into three knowledge groups based on tertiles of the total knowledge score: low (< 10 ; $n = 120$), medium (11–14; $n = 132$), and high (≥ 15 ; $n = 132$), yielding

approximately equal group sizes. Internal consistency analyses (Cronbach's alpha) confirmed satisfactory homogeneity of the scales.

Analysis started with descriptive statistics (means, standard deviations, frequencies, and percentages) followed by group comparisons employing one-way ANOVA and chi-square or Fisher's exact tests to identify differences in TPB constructs across knowledge groups. Pearson correlation coefficients were computed to examine associations among TPB variables.

Structural equation modeling (SEM) was applied to test the hypothesized relationships among TPB variables. Model fit was evaluated using the χ^2 statistic, the Comparative Fit Index (CFI), Tucker–Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean Square Residual (SRMR); a model was considered acceptable when CFI and TLI exceeded 0.90 and RMSEA and SRMR were below 0.08. The explained variance of the endogenous variables (intention and behavior) was quantified using the coefficient of determination (R^2), and model estimation was performed using maximum likelihood.

The moderating role of knowledge was assessed through multi-group SEM, testing whether PBC and intentions exerted differential effects on behavior across knowledge levels. Invariance testing was conducted sequentially: first, the configural model was evaluated within and across groups to establish baseline validity; second, measurement invariance was assessed to examine equivalence of item loadings across groups; and third, structural invariance was tested with respect to factor covariances and structural paths. Evidence of invariance was considered supported when $\Delta\chi^2$ was non-significant, ΔCFI and ΔTLI were < 0.01 , $\Delta RMSEA$ was < 0.015 , and $\Delta SRMR$ was < 0.02 . All analyses were conducted using R version 4.4.0, with statistical significance set at $p < 0.05$.

3 RESULTS

3.1 Sociodemographic Characteristics

Table 1 presents the sociodemographic characteristics of participants ($N = 348$) stratified by level of knowledge regarding UPFs. The majority of respondents were aged 20–29 years (71.63%), with no significant difference observed across knowledge groups. Females constituted the majority of the sample (82.3%), and sex distribution was significantly associated with knowledge level, with a higher proportion of females represented in the high knowledge group (90.15%) relative to males ($p = 0.008$). BMI category did not reveal significant differences across knowledge groups, with more than half of participants falling within the normal-weight

Table 1. Sociodemographic Characteristics by the Level of Knowledge about Ultra-Processed Foods (N = 384)

	Total N = 384	Low Knowledge N=120	Moderate Knowledge N=132	High Knowledge N=132	p-value
Age (years)					
< 20	91 (25.07%)	34 (30.91%)	29 (23.02%)	28 (22.05%)	0.434
20–29	260 (71.63%)	72 (65.45%)	91 (72.22%)	97 (76.38%)	
30–39	5 (1.38%)	1 (0.91%)	3 (2.38%)	1 (0.79%)	
40–49	7 (1.93%)	3 (2.73%)	3 (2.38%)	1 (0.79%)	
Missing data	21	10	6	5	
Sex					
Female	316 (82.29%)	97 (80.83%)	100 (75.76%)	119 (90.15%)	0.008*
Male	68 (17.71%)	23 (19.17%)	32 (24.24%)	13 (9.85%)	
BMI					
< 18.5	56 (15.73%)	18 (16.36%)	21 (17.21%)	17 (13.71%)	0.294
18.5–24.9	196 (55.06%)	61 (55.45%)	61 (50.00%)	74 (59.68%)	
25–29.9	67 (18.82%)	15 (13.64%)	28 (22.95%)	24 (19.35%)	
> 30	37 (10.39%)	16 (14.55%)	12 (9.84%)	9 (7.26%)	
Missing data	28	10	10	8	
Marital status					
Married	39 (10.71%)	7 (6.31%)	21 (16.67%)	11 (8.66%)	0.024*
Unmarried	325 (89.29%)	104 (93.69%)	105 (83.33%)	116 (91.34%)	
Missing data	20	9	6	5	
Current academic level					
1–2	114 (31.32%)	38 (34.23%)	31 (24.60%)	45 (35.43%)	0.116
3–4	96 (26.37%)	25 (22.52%)	40 (31.75%)	31 (24.41%)	
5–6	39 (10.71%)	12 (10.81%)	11 (8.73%)	16 (12.60%)	
7–8	93 (25.55%)	34 (30.63%)	33 (26.19%)	26 (20.47%)	
Master's	9 (2.47%)	1 (0.90%)	3 (2.38%)	5 (3.94%)	
Ph.D. candidate	13 (3.57%)	1 (0.90%)	8 (6.35%)	4 (3.15%)	
Missing data	20	9	6	5	
Studies specialty					
Health-related	170 (46.70%)	44 (39.64%)	55 (43.65%)	71 (55.91%)	0.030*
Non-health-related	194 (53.30%)	67 (60.36%)	71 (56.35%)	56 (44.09%)	
Missing data	20	9	6	5	
Monthly income of the family					
< 1000 SAR	259 (71.15%)	83 (74.77%)	83 (65.87%)	93 (73.23%)	0.485
1000–2999 SAR	51 (14.01%)	12 (10.81%)	19 (15.08%)	20 (15.75%)	
3000–4999 SAR	25 (6.87%)	9 (8.11%)	10 (7.94%)	6 (4.72%)	
5000–10000 SAR	10 (2.75%)	1 (0.90%)	5 (3.97%)	4 (3.15%)	
> 10000 SAR	19 (5.22%)	6 (5.41%)	9 (7.14%)	4 (3.15%)	
Missing data	20	9	6	5	
Chronic diseases					
Missing data	32 (8.79%)	10 (9.01%)	15 (11.90%)	7 (5.51%)	0.199
Missing data	20	9	6	5	

Note: SAR: Saudi Arabian Riyal

range (55.06%). Marital status was significantly associated with knowledge level ($p = 0.024$), with unmarried participants predominating across all knowledge groups. Academic level did not reveal significant differences, though students in levels 1–2 and 3–4 were more prevalent (31.32%). The field of study was significantly associated with knowledge level ($p = 0.030$) with participants enrolled in health-related majors more likely to demonstrate higher knowledge (55.91% among health-related students versus 44.09% among non-related health students). Family monthly income and occurrence of chronic disease were not significantly associated with knowledge level.

3.2 UPF Consumption and Purchasing Habits

Table 2 summarizes the frequency of UPF consumption and purchasing habits according to knowledge level. Mean

consumption frequency varied significantly among knowledge groups ($p < 0.001$): participants in the low-knowledge group reported the highest intake (34.52 ± 14.19), followed by those with high knowledge (27.15 ± 11.36) and moderate knowledge (26.35 ± 13.66). Supermarkets represented the primary point of purchase for UPFs (44.8%), followed by food courts or restaurants (23.4%), with no significant differences observed across knowledge groups ($p = 0.109$). With respect to purchasing attributes, taste was the most frequently cited consideration overall (33.9%) followed by nutritional value (16.9%), while “other” factors, including availability and habitual purchase, accounted for 16.7%. Knowledge level significantly influenced the prioritization of these attributes ($p = 0.041$): participants with higher knowledge were more likely to prioritize nutritional value

Table 2. Frequency of Ultra-Processed Foods Consumption and Purchasing Patterns by the Level of Knowledge about Ultra-Processed Foods

	Total N = 384	Low Knowledge N=120	Moderate Knowledge N=132	High Knowledge N=132	P-value
Frequency of consumption	29.18 ± 13.55	34.52 ± 14.19	26.35 ± 13.66	27.15 ± 11.36	< 0.001*
Place of purchasing processed foods					0.109
Supermarkets	172 (44.79%)	56 (46.67%)	59 (44.70%)	57 (43.18%)	
Grocery stores	60 (15.63%)	22 (18.33%)	17 (12.88%)	21 (15.91%)	
Convenience stores	19 (4.95%)	11 (9.17%)	6 (4.55%)	2 (1.52%)	
Internet	43 (11.20%)	9 (7.50%)	16 (12.12%)	18 (13.64%)	
Food court/restaurants	90 (23.44%)	22 (18.33%)	34 (25.76%)	34 (25.76%)	
Important attributes when purchasing processed					
Taste	130 (33.85%)	41 (34.17%)	43 (32.58%)	46 (34.85%)	
Price	31 (8.07%)	16 (13.33%)	5 (3.79%)	10 (7.58%)	
Nutritional value	65 (16.93%)	21 (17.50%)	15 (11.36%)	29 (21.97%)	
Convenience	36 (9.38%)	7 (5.83%)	14 (10.61%)	15 (11.36%)	0.041*
Food additives	18 (4.69%)	7 (5.83%)	6 (4.55%)	5 (3.79%)	
Brands of company	23 (5.99%)	8 (6.67%)	9 (6.82%)	6 (4.55%)	
Advertisement	17 (4.43%)	3 (2.50%)	10 (7.58%)	4 (3.03%)	
Others	64 (16.67%)	17 (14.17%)	30 (22.73%)	17 (12.88%)	

Note: The frequency of consumption is measured by the following item: "How frequently do you consume the following food items? 0 = never, 1 = < 1 time/month, 2 = 2–3 times/month, 3 = 2–3 times/week, 4 = 4–6 times/week, and 5 = daily.

(21.9%) and convenience (11.36%), whereas those with lower knowledge placed greater emphasis on price (13.33%).

3.3 Theory of Planned Behavior Constructs by Knowledge Level

Table 3 presents variation in TPB constructs according to knowledge level regarding UPFs. Internal consistency for each construct was acceptable, with Cronbach's alpha values ranging from 0.78 to 0.84. Attitude towards UPFs differed significantly across knowledge groups ($p < 0.001$): participants with low knowledge expressed more favorable attitudes toward UPF consumption than those with high knowledge, particularly in terms of perceived safety of these food items ($p < 0.001$).

With regard to subjective norms, perceptions of social acceptance from friends, family, and social media yielded mixed results. Perceived acceptance from friends and family was not significantly associated with knowledge level, whereas perceived encouragement via social media ($p = 0.005$) and perceived community acceptance ($p < 0.001$) were both significantly stronger among participants with moderate and high knowledge. Perceived behavioral control did not vary significantly across groups, indicating comparable perceived control over UPF consumption irrespective of knowledge level. Behavioral intention likewise did not differ significantly across groups. In contrast, behavior—measured as frequency of consumption—exhibited a strong inverse association with knowledge level ($p < 0.001$), with participants in the low-knowledge group reporting higher consumption frequency

(34.52 ± 14.19) than those in the high-knowledge (27.15 ± 11.36).

3.4 Structural Equation Modeling

Table 4 summarizes the results of the structural equation model. Across all groups, the models predicting actual behavior demonstrated relatively weak explanatory power, accounting for a modest proportion of variance. In the total population, PBC was the only significant predictor of behavior, exerting a significant negative effect ($\beta = -0.22$, $p < 0.001$), indicating that participants reporting greater perceived control consumed UPFs less frequently. This effect of PBC on behavior remained significant only within the moderate-knowledge subgroup ($\beta = -0.20$, $p = 0.031$). Intention did not significantly predict behavior in any group after accounting for other model constructs (all $p > 0.05$), revealing a major intention-behavior gap, most pronounced among participants with high knowledge.

In contrast, the models predicting intention demonstrated considerably stronger explanatory power across all groups. Attitude emerged as the strongest and most consistent significant positive predictor of intention across knowledge levels ($\beta \approx 0.61$, $p < 0.01$), with this effect being particularly salient among participants with moderate and high knowledge. Among participants with moderate knowledge, both PBC and attitude were key drivers of intention ($\beta = 0.64$ and $\beta = 0.61$, respectively; $p < 0.05$). Among participants with high knowledge, attitude was the sole significant predictor of intention; social pressure (Subjective Norm) and PBC become irrelevant to the model.

Table 3. Constructs; Cronbach's Alpha, Mean Scores, and Standard Deviations by the Level of Knowledge about Ultra-Processed Foods

Construct items	Alpha	Total N = 384	Low knowledge N=120	Moderate knowledge N=132	High knowledge N=132	p-value
Attitude	0.83					
- Consuming UPFs is safe		2.60 ± 1.16	2.87 ± 1.20	2.64 ± 1.19	2.34 ± 1.04	<0.001*
- Consuming UPFs aligns with my dietary choices		2.87 ± 1.09	2.88 ± 1.15	2.93 ± 1.13	2.81 ± 1.00	0.663
- Consuming UPFs fits with my dietary preferences		2.82 ± 1.10	2.84 ± 1.14	2.87 ± 1.14	2.75 ± 1.04	0.649
- Consuming UPFs suits my lifestyle		2.79 ± 1.10	2.63 ± 1.15	2.93 ± 1.09	2.78 ± 1.05	0.099
Subjective Norm	0.81					
- My friends think that consuming UPFs is acceptable		3.02 ± 1.12	2.86 ± 1.18	3.04 ± 1.16	3.14 ± 1.01	0.138
- My family think that consuming UPFs is acceptable		2.94 ± 1.09	2.91 ± 1.16	3.05 ± 1.13	2.86 ± 0.97	0.316
- Social media encourages the consumption of UPFs		3.20 ± 1.17	2.99 ± 1.12	3.17 ± 1.22	3.46 ± 1.13	0.005*
- In my community, it is common for people to consume UPFs during social gatherings		3.22 ± 1.19	2.82 ± 1.18	3.32 ± 1.17	3.48 ± 1.13	<0.001*
Perceived Behavioral Control	0.78					
- I think that consumption of UPFs is under my control		3.08 ± 1.10	2.93 ± 1.12	3.13 ± 1.13	3.16 ± 1.05	0.217
- Whether I consume UPFs is a decision that depends entirely on me		3.18 ± 1.10	3.07 ± 1.12	3.10 ± 1.14	3.35 ± 1.04	0.088
- I am confident that I can consume UPFs safely		3.12 ± 1.11	3.11 ± 1.16	3.14 ± 1.14	3.12 ± 1.06	0.967
Intention	0.83					
- I intend to consume UPFs less than other foods		2.71 ± 1.07	2.67 ± 1.10	2.77 ± 1.09	2.67 ± 1.03	0.697
- I intend to consume UPFs that are advertised		2.85 ± 1.07	2.77 ± 1.07	2.98 ± 1.07	2.79 ± 1.07	0.211
- I intend to consume UPFs of regardless of their safety		2.79 ± 1.10	2.90 ± 1.15	2.87 ± 1.10	2.60 ± 1.03	0.052
Behavior	0.84					
Frequency of consumption		29.18 ± 13.55	34.52 ± 14.19	26.35 ± 13.66	27.15 ± 11.36	<0.001*

Note: The frequency of consumption is measured by the following item: "How frequently do you consume the following food items? 0 = never, 1 = < 1 time/month, 2 = 2-3 times/month, 3 = 2-3 times/week, 4 = 4-6 times/week, and 5 = daily. Behavior was measured as the sum of frequency-of-consumption scores across 13 UPF items, each scored 0 (never) to 5 (daily); possible total range 0–65. Higher scores indicate more frequent overall UPF consumption.

Table 4. Results of Structural Equation Models

	Total N = 384				Low Knowledge N=120				Moderate Knowledge N=132				High Knowledge N=132			
	R ²	r	b	p	R ²	r	b	p	R ²	r	b	p	R ²	r	b	p
Behavior Predictors	0.07				0.14				0.05				0.01			
Intention		-0.15*	-0.88	0.301		-0.32*	-0.18	0.319		-0.12	0.01	0.959		-0.01	0.02	0.884
Perceived Behavioral Control		-0.22*	-2.96	0.000		-0.35*	-0.24	0.185		-0.20*	-0.23	0.031		-0.07	-0.07	0.453
Intention Predictors:	0.49				0.53				0.64				0.54			
Attitude		0.59*	0.49	0.000		0.53*	0.13	0.507		0.61*	0.41	0.006		0.61*	0.58	0.000
Subjective Norm		0.47*	0.21	0.090		0.59*	0.35	0.335		0.50*	0.12	0.488		0.36*	0.29	0.120
Perceived Behavioral Control		0.40*	0.12	0.226		0.54*	0.32	0.322		0.64*	0.42	0.011		0.02	-0.23	0.131

Note: R²; coefficient of determination, r; correlations, b; standardized regression coefficients and p; p-values.

In the path diagram (Figure 1), solid arrows denote statistically significant relationship ($p < 0.05$), whereas dashed arrows represent relationships that did not reach statistical significance. In the total population, attitude was a strong, significant predictor of intention ($\beta = 0.59$, $p < 0.001$), and PBC exerted a significant direct effect on behavior ($\beta = -0.22$, $p < 0.001$) with the negative coefficient indicating that greater

perceived control was associated with reduced consumption. Within low-knowledge group, no significant relationships were identified among the examined constructs. Within the moderate-knowledge subgroup, both attitude ($\beta = 0.61$, $p < 0.01$) and PBC ($\beta = 0.64$, $p < 0.05$) were significant predictors of intention, and PBC additionally exerted a significant direct effect on behavior ($\beta = -0.20$, $p < 0.05$), again indicating that

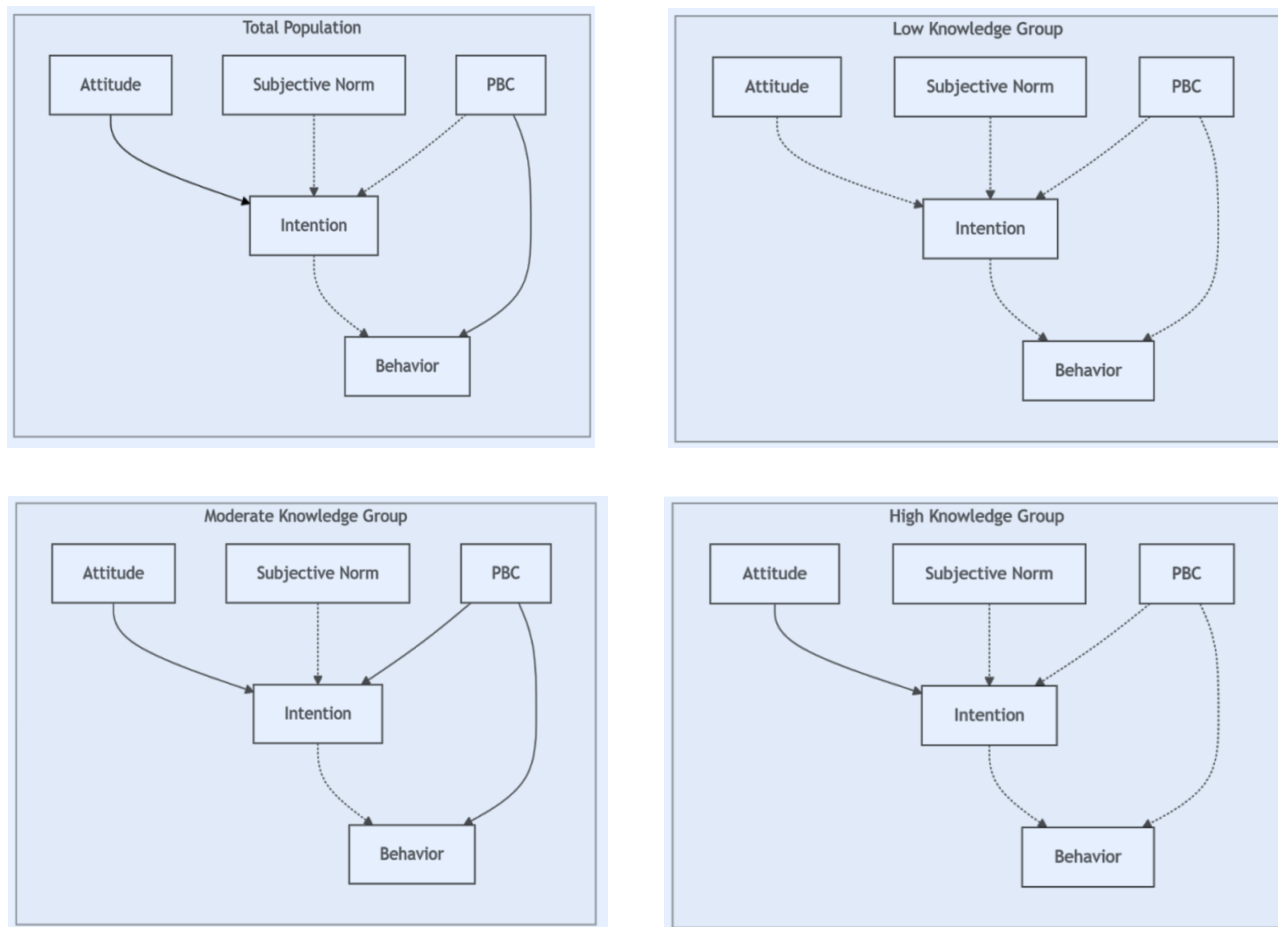


Figure 1. Schematic Representation of the Main Findings of the Structural Equation Model Results Predicting Intention and Behavior Regarding Ultra-Processed Food Consumption Across Knowledge Levels.

greater perceived control was associated with reduced consumption. Within the high- knowledge subgroup, attitude was the only significant predictor of intention ($\beta = 0.61, p < 0.001$), and neither intention nor PBC significantly predicted behavior.

4 DISCUSSION

The global shift towards the consumption of UPFS constitutes a major public health concern. This dietary trend is closely associated with increasing rates of obesity and non-communicable diseases (Chavez-Ugalde *et al.*, 2024; Jung *et al.*, 2024). Understanding the psychosocial determinants of this behavior is essential for the design of effective interventions aimed at reducing UPF consumption. Thus, the present study employed the TPB to examine how knowledge regarding UPFs shapes the relationships among attitude, subjective norm, perceived behavioural control (PBC), intention, and actual consumption among NBU students in Saudi Arabia.

The findings of this study underscore significant sociodemographic patterns associated with UPF knowledge among NBU Saudi students. Specifically, sex, marital status, and academic specialization emerged as significant determinants of UPF knowledge. The role of sex in shaping nutritional knowledge is well established, with numerous studies demonstrating that female students generally display higher levels of nutrition-related knowledge and adopt healthier dietary practices than their male counterparts (Kim *et al.*, 2012; Lee, 2003; Pirouznia, 2001). Similarly, academic specialization proved to be a strong predictor of health literacy. These findings highlight the relevance of academic discipline in shaping nutrition knowledge and suggest potential value in integrating food literacy content into non-health curricula to broaden student awareness.

The present study further revealed that purchasing locations (supermarkets and restaurants) did not differ significantly across knowledge levels; rather, differenced emerged in the choices made within these environments, with students possessing higher knowledge reporting healthier

decisions, a pattern consistent with that reported by O'Leary *et al.* (2025). Within this group, taste remained the primary driver of UPF consumption, with convenience and palatability outweighed health considerations. This finding suggests that knowledge can guide healthier decision-making within a given food environment, but that preference and convenience continue to sustain UPF consumption.

This study highlights the complex role of knowledge in shaping how NBU students perceive risk and behave toward UPFs. Students with greater UPF knowledge perceived a higher level of health risk, associating high consumption with adverse outcomes such as obesity, cardiovascular disease, and metabolic syndrome (Elizabeth *et al.*, 2020). This finding indicates that educational interventions can effectively modify perceived susceptibility, an important attitudinal construct (Suk *et al.*, 2024). However, knowledge did not significantly influence other attitudinal dimensions, such as taste preference or lifestyle fit, suggesting that factors related to enjoyment and practicality are more resistant to change through information provision alone. The relationship between knowledge and actual behavior is further shaped by environmental pressures: students with greater UPF knowledge were more sensitive to social media marketing and cultural influences promoting UPF consumption ($p < 0.05$). Consequently, intention and perceived control over consumption remained stable across knowledge levels, likely because competing factors, including convenience, taste, and established habit, frequently outweigh the influence of knowledge (Gardner, 2015; Monteiro *et al.*, 2019). Despite these constraints, knowledge remains a crucial determinant: individuals with higher knowledge reported significantly lower actual UPF consumption, suggesting that knowledge may influence behavior through indirect pathways, such as the promotion of mindful eating and modulation of automatic decision-making processes (Gardner, 2015). Taken together, these findings indicate that although education constitutes a key component of public health strategy, it is insufficient in isolation; effective interventions must also address environmental influences and offer practical tools to help individuals manage competing pressures and translate knowledge into sustained behavior change.

The structural equation models (Table 4) further illustrated this intention–behavior gap: models predicting intention demonstrated robust explanatory power ($R^2 = 0.49$ – 0.64), whereas models predicting behavior explained minimal variance ($R^2 = 0.01$ – 0.14), particularly within the high-knowledge group ($R^2 = 0.01$). Among these students, intention—driven primarily by attitude—proved a poor predictor of actual UPF consumption. This aligns with evidence indicating that knowledge and intentions frequently fail to translate into altered eating behavior when environmental and hedonic drivers predominate (Sheeran &

Webb, 2016). Barriers such as the strong hedonic appeal of UPFs, their convenience, their pervasive availability within social contexts, and their relatively lower cost—particularly salient considerations for students—likely override the influence of knowledge and intention (Monteiro *et al.*, 2019). Among students with low knowledge, no TPB constructs significantly predicted either behavior or intention, suggesting that dietary choices in this group may be more strongly influenced by external or unmeasured factors. In contrast, students with moderate knowledge emerged as the most psychologically predictable subgroup: their intentions were significantly influenced by both attitude ($\beta = 0.61$, $p < 0.01$) and PBC ($\beta = 0.64$, $p < 0.05$), while their behavior was significantly, negatively associated with PBC ($\beta = -0.20$, $p = 0.031$). This pattern suggests that interventions targeting this subgroup may be most effective if focused on strengthening self-regulatory skills and reinforcing positive attitudes. Among highly knowledgeable students, however, intention was strongly driven by attitude ($\beta = 0.61$, $p < 0.001$), yet actual consumption remained largely unpredictable by the TPB model ($R^2 = 0.01$), with neither intention nor PBC exerting significant effects. This pronounced intention–behavior gap suggests that, among knowledgeable individuals, behavior is instead shaped predominantly by situational, environmental, and habitual factors, including the convenience, palatability, and marketing of UPFs, their prevalence within social settings, and their lower cost. This finding is consistent with broader global evidence that awareness alone does not necessarily translate into behavior change (D'Angelo Campos *et al.*, 2024). The absence of a significant association between UPF knowledge and BMI in the present sample ($p = 0.294$) further supports this conclusion, indicating that knowledge alone is insufficient to alter health outcomes when the food environment does not promote healthier choices. This nuanced relationship between knowledge and dietary outcomes is consistent with recent evidence from other student populations; for instance, Elmskini *et al.* (2024) reported that greater nutrition knowledge and Mediterranean diet adherence were associated with lower BMI and more favorable self-rated general health among university students, suggesting that knowledge can, under certain conditions, translate into more favorable dietary patterns. The present findings, however, suggest that this translation is not guaranteed in the specific context of UPF consumption, where higher knowledge instead appears to widen the intention–behavior gap—highlighting that the knowledge–behavior relationship may differ according to dietary domain and behavioral context. Collectively, these findings indicate that although knowledge influences the psychological pathways within the TPB—shifting the locus of influence from social norms toward attitudes—it remains ultimately insufficient to overcome structural, cultural, and habitual barriers to behavior change. This underscores the

need for public health strategies that extend beyond education to address broader environmental factors affecting diet.

The present study is subject to several limitations. A primary consideration is its cross-sectional design, which prevents drawing causal inference regarding the relationships among knowledge, TPB constructs, and actual UPF consumption (Wang & Cheng, 2020). However, the use of the SEM enabled the examination of both the direct and indirect effects of knowledge on behavior within the TPB framework, and further supported multi-group analysis, facilitating comparison of pathways across knowledge levels. These methodological strengths render SEM a well-suited and effective approach for elucidating the complex determinants of UPF consumption among Saudi students (Kline, 2023); nonetheless, longitudinal or experimental designs would be required to confirm the directionality of these relationships. Furthermore, participants were recruited through a non-probability convenience sampling approach employing a voluntary online survey, which may introduce selection bias and limits the representativeness of the findings. Notably, the sample was predominantly female (82.3%), a skew likely reflecting differential willingness to participate rather than the true sex composition of the student population; this imbalance limits the generalizability of the findings to the broader, more sex-balanced university student population, particularly given prior evidence that psychosocial predictors of dietary behavior can differ by sex. A further limitation of this study concerns reliance on self-reported dietary data, which may be subject to recall bias and social desirability bias, potentially leading participants to underreport unhealthy eating or overreport healthier ones (Hebert *et al.*, 1995); such biases may compromise the accuracy of dietary assessments and attenuate the validity of associations between psychosocial predictors and eating behavior. Despite these limitations, the present study provides valuable insights into how knowledge moderates the psychosocial pathways underlying UPF consumption among NBU Saudi students. These findings underscore the necessity for future studies employing longitudinal designs and more representative sampling strategies to strengthen the evidence base and inform targeted interventions.

5 CONCLUSIONS

The current investigation demonstrates that knowledge regarding ultra-processed foods (UPFs) plays a central, yet complex, role in shaping dietary behavior among NBU Saudi students. Higher levels of knowledge were found not only to predict attitude and intention but also to shift the decision-making process from a socially driven basis toward one guided by personal attitudes. This shift, however, is accompanied by a persistent and significant intention–behavior gap, particularly among highly knowledgeable individuals, among

whom neither intention nor perceived behavioral control fully accounts for actual consumption. These findings suggest that, although knowledge fosters more critical perspectives toward UPFs, it remains insufficient, in isolation, to overcome the strong environmental, cultural, and habitual forces that sustain their consumption.

Public health strategies must therefore extend beyond cognitive and educational approaches to address contextual and structural barriers. Among students with moderate knowledge, interventions should focus on strengthening positive attitudes and perceived control through nutrition education and skills training. Among highly knowledgeable individuals, interventions should instead target the broader food environment by improving the availability, affordability, and appeal of healthier options on campus and within the community, implementing stronger regulations of UPF marketing (particularly on digital platforms), and employing behavioral nudges that establish healthier choices the default option. Social marketing initiatives may further reshape norms, positioning healthy eating as both attractive and socially rewarding.

Considered together, these findings underscore the necessity for multifaceted, knowledge-sensitive strategies that combine individual empowerment with supportive environments and policies to reduce UPF consumption among young adults effectively. Intervention-based design studies are recommended to assess how knowledge interacts with environmental modifications to promote healthy eating and reduced UPF consumption.

Ethical Approval

Ethical approval for this study was obtained from the Institutional Local Committee of Bioethics at Northern Border University on February 26, 2025 (Ref. No. 42/24/H).

Consent

Participants provided informed consent to participate in this study, and were offered the opportunity to pose questions regarding the research prior signing the consent form. Data collection commenced only after participant consent had been obtained. Respondents were asked to complete a questionnaire addressing their sociodemographic characteristics, knowledge, consumption patterns, and TPB construct items related to UPFs.

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