

Impact of Junk Food Consumption on the Nutritional and Health Status of College Students: A Cross-Sectional Study in Rajnandgaon City, Chhattisgarh

Student, Ms. Himani Keme

Department of Nutrition and Dietetics, KK Modi University, Durg

HOD, Dr. Mohammed Bakhtawar Ahmed

Department of Nutrition and Dietetics, KK Modi University, Durg

Abstract

This cross-sectional analytical study examined the relationship between junk food consumption and nutritional, anthropometric, physiological, psychological and functional outcomes among 200 undergraduate students aged 18–24 years in Rajnandgaon city, Chhattisgarh. Participants were selected through stratified proportional random sampling from four institutions. Junk food exposure was measured with a locally adapted 38-item semi-quantitative food-frequency questionnaire incorporating both nationally marketed products and regional Chhattisgarhi preparations. Dietary intake was assessed using three-day 24-hour recalls and interpreted with the Indian Food Composition Tables and ICMR–NIN dietary reference framework. Body mass index (BMI), waist circumference, waist-to-height ratio, blood pressure, anxiety and selected physical-fitness measures were assessed. Thirty-six percent of participants were classified as habitual consumers, 40% as less-habitual consumers and 24% as non-habitual consumers. Overweight and obesity together affected 34% of the sample, while 10% remained underweight, demonstrating a concurrent double burden of malnutrition. Mean BMI increased from 20.21 to 23.31 kg/m² across consumption categories ($F = 28.09$, $p < 0.01$), while anxiety scores increased from 30.25 to 42.92 ($F = 34.03$, $p < 0.01$). Habitual consumers consumed approximately 486 kcal/day more than non-habitual consumers, with substantially higher fat and lower fibre but no significant difference in absolute protein intake. Protein density therefore fell from 26.03 to 19.89 g/1000 kcal. Hostel residence was strongly associated with habitual consumption ($\chi^2 = 31.23$, $p < 0.01$), and junk-food frequency remained the only significant independent predictor of BMI in multiple regression ($\beta = 0.520$, $R^2 = 0.277$). A structured nutrition-education module increased awareness scores from 10.23 to 15.72/20 ($t = 25.59$, $p < 0.01$). The findings support a nutrient-displacement interpretation in which energy-dense foods reduce diet quality as well as increase energy intake. Because the study is cross-sectional, the observed associations should not be interpreted as causal.

Index Terms—junk food, college students, nutritional status, BMI, nutrient density, anxiety, hostel residence, dietary quality, Chhattisgarh, Eat Right Campus

I. INTRODUCTION

A. Background and Conceptual Definition

The submitted study deliberately avoids treating “junk food” as a purely Western category. In the Indian setting, energy-dense discretionary foods include packaged snacks, sweetened beverages, instant noodles, restaurant foods and locally prepared fried snacks. The manuscript therefore uses a nutritional-density definition: a food is treated as problematic when it supplies substantial energy without a proportionate contribution of protein, fibre and micronutrients. This operational definition is useful for a student population because it permits comparison across culturally different foods without assuming that every

traditionally prepared food is automatically healthy or that every processed food is automatically harmful. [1], [2]

Current nutrition guidance also places greater emphasis on the overall dietary pattern. The World Health Organization identifies adequacy, balance, moderation and diversity as core principles of a healthy diet and recommends limiting foods high in unhealthy fats, free sugars and sodium while increasing minimally processed foods, fruits, vegetables, pulses and whole grains [1]. India’s 2024 Dietary Guidelines similarly distinguish minimally processed foods from ultra-processed products and emphasise dietary diversity and moderation [2]. These principles strengthen the present study’s focus on nutrient density rather than calories alone. [1], [2]

B. College Students as a Nutritional Transition Population

The transition from school to university changes the food environment. Students gain greater control over meal timing and purchasing decisions, and hostel residents may lose access to a household kitchen. Convenience, taste, peer influence, price, delivery platforms and campus food availability can consequently shape food choices. This is important because dietary behaviours established during adolescence and early adulthood can persist into later life [1]. The college period should therefore be viewed as a window for prevention rather than as a period in which nutrition becomes irrelevant after linear growth has stopped. [3], [4], [5]

The problem is not simply excess weight. Students can simultaneously experience undernutrition, poor diet quality and excess adiposity. In the present sample, 10% were underweight while 34% were overweight or obese using Asian-Indian cut-offs. Such coexistence illustrates why a single BMI outcome is insufficient for describing student nutrition. Dietary composition, waist measures, functional performance and psychosocial indicators provide complementary information. [6], [7]

C. Public-Health and Regulatory Context

India's Food Safety and Standards Authority has established restrictions on the sale and promotion of foods high in saturated fat, trans-fat, added sugar or sodium around school campuses. The 2020 school regulation specifies a 50-metre perimeter around schools [3]. In parallel, FSSAI's Eat Right Campus initiative applies to universities and colleges and uses benchmarks covering food safety, healthy food provision, environmental sustainability and awareness [4], [5]. The distinction is important: the regulatory perimeter rule is school-specific, whereas Eat Right Campus is a broader campus-health initiative. The present study examines the college environment as a setting in which institutional food policy may influence exposure without claiming that existing regulations already cover colleges.

The policy relevance should nevertheless be interpreted cautiously. A cross-sectional student study cannot demonstrate that a particular campus intervention will reduce BMI or anxiety. It can, however, identify modifiable environmental correlates and generate hypotheses for intervention trials. This distinction is retained throughout the discussion.

D. Problem Statement and Research Gap

Indian student studies commonly report fast-food or junk-food frequency and associations with BMI, but fewer studies examine nutrient density, residential

arrangement and functional outcomes in the same analytical framework. Evidence from a 2024 umbrella review of meta-analyses found associations between higher ultra-processed-food exposure and several adverse outcomes, but the authors also highlighted heterogeneity and generally low or very-low certainty for many pooled outcomes [6]. A systematic review restricted to randomized trials found a much smaller evidence base and reported that many evaluated outcomes did not show significant effects, illustrating why observational associations should not automatically be treated as causal [7]. [6], [7]

The present research therefore contributes by combining a locally adapted food-frequency instrument, dietary recalls, Asian-Indian anthropometric classification, residence status, anxiety and fitness measures. Its central analytical proposition is that junk-food consumption may alter nutrient density through displacement: additional energy may be accompanied by little or no additional protein while fibre falls.

E. Research Questions and Objectives

The study asks five questions: (1) What is the pattern and intensity of junk-food consumption among undergraduate students in Rajnandgaon? (2) How is consumption associated with anthropometric status, blood pressure, anxiety and physical fitness? (3) Does consumption alter nutrient density rather than only total energy? (4) Does consumption contribute independently to BMI after adjustment for sex, socio-economic status, residence and age? and (5) Does a structured education module improve nutrition awareness?

The objectives were to classify participants as habitual, less-habitual or non-habitual consumers; assess nutritional status using Asian-Indian criteria; compare dietary intake and functional measures across exposure groups; test independent predictors of BMI; and evaluate immediate change in awareness after a structured education session.

II. LITERATURE REVIEW

A. Fast Food, Energy Intake and Dietary Quality

Earlier work suggests that energy obtained from fast food is not fully compensated by lower intake later in the day. Ebbeling et al. reported incomplete energy compensation among adolescents after fast-food intake [8]. Reviews of sugar-sweetened beverages have similarly described increases in energy intake and displacement of more nutrient-dense beverages [9]. The practical implication for students is that the dietary effect of discretionary foods may be visible both as additional energy and as a change in the composition of the remaining diet.

More recent evidence on ultra-processed foods broadens the discussion. Lane et al. synthesized 45 pooled analyses covering approximately 9.9 million participants and reported direct associations between greater ultra-processed-food exposure and numerous health parameters; however, the certainty of evidence varied substantially, with many outcomes graded low or very low [6]. This supports concern but also reinforces the need to separate association from causation in cross-sectional campus studies.

B. Indian and Asian-Indian Context [10]

Asian-Indian populations can develop metabolic risk at lower BMI values than populations for whom conventional international thresholds were originally designed. The earlier Asian-Indian consensus therefore used BMI ≥ 23 kg/m² as an overweight threshold and ≥ 25 kg/m² as an obesity threshold [10]. The submitted study uses these thresholds for comparability with its original analysis and explicitly acknowledges that newer Indian frameworks are evolving. Waist circumference and waist-to-height ratio are consequently reported alongside BMI rather than relying on BMI alone.

The 2024 Indian Dietary Guidelines also place emphasis on food diversity, vegetables, fruits, pulses and limiting highly processed products. Their discussion of ultra-processed foods notes that many such products are ready-to-eat, highly palatable and often low in fibre and nutrients [2]. This is conceptually consistent with the present study's nutrient-density analysis, although the terms "junk food" and "ultra-processed food" should not be treated as exact synonyms.

C. Mental Health, Social Environment and Food Choice

University food choices are influenced by more than nutritional knowledge. Taste, convenience, peer norms, stress and accessibility may interact. The submitted study found a substantial association between junk-food frequency and anxiety score, but the direction of this relationship cannot be determined from a cross-sectional design. The observed relationship could reflect stress-related eating, dietary pathways, social clustering, sleep and lifestyle factors, or a combination of these mechanisms. Therefore, the analysis should be read as an association rather than evidence that junk food causes anxiety.

This distinction is supported by broader evidence. The 2024 umbrella review reported associations between higher ultra-processed-food exposure and anxiety-related outcomes, but also documented limitations in the observational evidence base [6]. For student health research, longitudinal designs are needed to determine

whether dietary exposure precedes psychological symptoms, symptoms influence eating behaviour, or both are affected by a third factor. [6], [7]

D. Residence and the Food Environment [3], [4], [5]

Residential arrangement is an under-examined determinant in many college nutrition studies. Hostel residents may have different meal schedules, food availability and spending patterns from day scholars. In the present study, 75% of habitual consumers were hostel residents compared with 25% of non-habitual consumers. The strength of this association suggests that residence deserves consideration as a potential upstream determinant of food exposure. It does not, however, prove that hostel residence itself causes higher consumption, because unmeasured factors may influence both residence and dietary behaviour. [4], [5]

This interpretation is particularly relevant for institutional intervention. FSSAI's Eat Right Campus framework already recognises the campus as a food environment rather than only an educational setting [4], [5]. A research programme can therefore move beyond individual counselling to test menu design, meal timing, pricing, availability and food-label literacy as environmental components.

TABLE I. STUDY DESIGN AND VARIABLE FRAMEWORK

Domain	Measure	Operationalization	Role in analysis
Exposure	Junk-food frequency score	38-item semi-quantitative FFQ; score 0–120	Primary independent variable
Anthropometry	BMI	Weight (kg)/height ² (m ²); Asian-Indian cut-offs	Primary outcome
Central adiposity	Waist circumference; WHtR	90 cm men/80 cm women; WHtR ≥ 0.50	Secondary outcomes
Diet quality	Protein density; fibre; fat	g/1000 kcal; g/day; % energy	Mechanistic outcomes
Psychological	SCAT anxiety score	Sinha's Comprehensive Anxiety Test	Secondary outcome
Function	Jump, shuttle, handgrip	Standardized performance measures	Secondary outcomes
Context	Residence,	Hostel/day	Covariates

Domain	Measure	Operationalization	Role in analysis
	sex, SES, age	scholar; demographic variables	
Education	Awareness score	20-item pre/post test	Intervention outcome

III. METHODOLOGY

A. Research Design and Setting

A cross-sectional analytical design with an embedded single-group pre-test/post-test education component was used. The observational component is ex post facto: exposure was measured as it existed naturally and was not assigned by investigators. Rajnandgaon city, Chhattisgarh, was selected as the study setting. Four institutions contributed participants, allowing stratification by institution, sex and year of study. [8], [9], [12]

B. Sample and Sampling [10], [2]

The sample comprised 200 undergraduate students aged 18–24 years, including 100 men and 100 women. Stratified proportional random sampling was used. The sample-size rationale was based on detecting a 0.5 standard-deviation difference in mean BMI between extreme exposure categories at 80% power and 5% two-sided significance. Participants were required to be full-time undergraduates, residents of the city for at least six months and willing to provide written informed consent. [6], [7]

C. Eligibility and Ethics [4], [5]

Students with diagnosed chronic disease affecting nutritional status, medication affecting appetite, weight or blood pressure, therapeutic diets, pregnancy or lactation, or contraindications to fitness testing were excluded. Institutional permission and written informed consent were obtained. Data were coded rather than recorded by participant names. Students with elevated readings were privately advised to consult a physician; no diagnosis was made by the research team. [2], [11]

D. Dietary and Exposure Assessment

The 38-item food-frequency questionnaire included fried savoury snacks, packaged products, restaurant and delivery foods, street preparations, sweets and beverages. Regional items such as bhajia, thethari, khurmi, chausela, gulgula and fara were included so that the instrument did not equate junk food only with Western fast food. Bafauri and chila were recorded as nutritionally favourable

comparators and were not scored as junk-food exposure. A seven-point frequency scale was weighted and summed to produce a 0–120 score. Pre-testing among 20 students from a non-participating institution produced Cronbach's $\alpha = 0.81$.

E. Anthropometry, Blood Pressure and Diet

Height, weight, waist circumference and blood pressure were measured twice and averaged. BMI was classified as underweight <18.5 , normal 18.5 – 22.9 , overweight 23.0 – 24.9 and obese ≥ 25.0 kg/m^2 . Abdominal obesity was defined as waist circumference ≥ 90 cm in men and ≥ 80 cm in women. A waist-to-height ratio ≥ 0.50 was treated as an indicator of central adiposity risk. Dietary intake was assessed using two weekdays and one weekend day of 24-hour recall, household measures and a photographic portion-size aid. Nutrient values were calculated using the Indian Food Composition Tables and compared with the ICMR–NIN framework [2], [11]. [10], [11]

F. Psychological, Fitness and Awareness Measures [14], [15]

Anxiety was assessed with Sinha's Comprehensive Anxiety Test. Fitness included standing broad jump, one-minute shuttle run and handgrip dynamometry. Socio-economic status was assessed using the modified Kuppaswamy scale. A 20-item nutrition-awareness instrument was administered before the intervention and again two weeks after a 90-minute bilingual education session supported by an illustrated booklet.

G. Statistical Analysis

Descriptive statistics, chi-square tests, independent and paired t-tests, one-way ANOVA, 3×2 factorial ANOVA, Pearson correlation and multiple linear regression were used. Statistical significance was evaluated at $p < 0.05$ and $p < 0.01$. Energy and fibre were not entered as predictors in the BMI regression because they were treated as possible mediating dietary variables rather than background confounders. This choice avoids over-adjusting the association of interest but also means the regression should not be interpreted as a fully causal model.

TABLE II. OPERATIONAL CLASSIFICATION OF JUNK-FOOD EXPOSURE

Score	Category	Interpretation	Participants (n)	Percent
≥ 60	Habitual	Frequent, high exposure	72	36%
35–59	Less habitual	Intermediate exposure	80	40%
< 35	Non-	Low exposure	48	24%

Score	Category	Interpretation	Participants (n)	Percent
	habitual			
Total	—	Complete sample	200	100%

IV. RESULTS

A. Participant Profile and Consumption Pattern

The mean age was 20.44 ± 1.42 years. Thirty-six percent were habitual consumers, 40% less habitual and 24% non-habitual. Mean exposure scores were 75.33 ± 7.26 , 48.38 ± 8.43 and 23.94 ± 7.54 , respectively. Sex was not significantly associated with consumption category. Socio-economic status showed a visible gradient but did not reach conventional significance. Residence showed a strong association with exposure category.

TABLE III. ASSOCIATION OF CONSUMPTION CATEGORY WITH BACKGROUND CHARACTERISTICS

Characteristic	Habitual	Less habitual	Non-habitual	χ^2	p
Male	38	40	22	0.56	NS
Female	34	40	26	—	—
Hostel resident	54 (75.0%)	35 (43.8%)	12 (25.0%)	31.2 3	<0.01
Day scholar	18	45	36	—	—
Upper/upper-middle SES	45 (62.5%)	34 (42.5%)	19 (39.6%)	8.54	NS
Lower-middle/upper-lower SES	27	46	29	—	—

B. Nutritional Status and Anthropometry

Using Asian-Indian criteria, 20 participants (10.0%) were underweight, 112 (56.0%) normal, 47 (23.5%) overweight and 21 (10.5%) obese. Combined overweight and obesity affected 34%. BMI category was significantly associated with consumption category ($\chi^2 = 41.19$, $df = 6$, $p < 0.01$). The combined prevalence of overweight/obesity was 56.9% among habitual consumers, 30.0% among less-habitual consumers and 6.3% among non-habitual consumers.

TABLE IV. ANTHROPOMETRIC AND PHYSIOLOGICAL MEASURES BY CONSUMPTION CATEGORY

Parameter	Habitual Mean $\pm$ SD	Less habitual Mean $\pm$ SD	Non-habitual Mean $\pm$ SD	F	p
BMI (kg/m ²)	23.31 $\pm$ 2.11	21.53 $\pm$ 2.39	20.21 $\pm$ 2.32	28.09	<0.01
Waist circumference (cm)	80.40 $\pm$ 7.14	75.48 $\pm$ 7.32	72.86 $\pm$ 6.44	18.19	<0.01
Waist-to-height ratio	0.50 $\pm$ 0.04	0.47 $\pm$ 0.04	0.44 $\pm$ 0.04	21.01	<0.01
Systolic BP (mm Hg)	120.01 $\pm$ 8.36	117.33 $\pm$ 8.22	113.54 $\pm$ 8.53	8.67	<0.01
Diastolic BP (mm Hg)	79.72 $\pm$ 5.77	75.84 $\pm$ 6.34	74.60 $\pm$ 6.18	12.31	<0.01
Anxiety score	42.92 $\pm$ 9.55	35.21 $\pm$ 7.80	30.25 $\pm$ 8.06	34.03	<0.01

All pairwise BMI contrasts were statistically significant. Mean BMI increased by 3.10 kg/m² across the exposure gradient. Central adiposity was identified in 29.0% of the sample by waist-to-height ratio compared with 12.5% by waist circumference. Anxiety showed significant main effects of consumption category and sex, but no category-by-sex interaction, indicating that the association did not differ significantly by sex in the factorial analysis.

C. Physical Fitness

TABLE V. PHYSICAL FITNESS BY CONSUMPTION CATEGORY AND SEX

Measure	Sex	Habitual	Less habitual	Non-habitual	F	p
Standing broad jump (cm)	Male	157.95	171.38	180.32	15.03	<0.01
Standing broad jump (cm)	Female	124.85	127.88	142.00	8.80	<0.01
Shuttle run/min	Male	13.08	14.80	16.05	18.32	<0.01
Shuttle run/min	Female	10.44	12.22	13.42	15.96	<0.01
Handgri	Male	28.65	30.61	31.75	4.52	<0.01

Measure	Sex	Habitual	Less habitual	Non-habitual	F	p
Push strength (kg)						5
Handgrip strength (kg)	Female	18.16	20.36	22.84	10.44	<0.01

Performance declined across the consumption gradient for all three measures in both sexes. Handgrip strength also declined, despite being less directly influenced by body mass than jumping or running. Because physical activity was not measured objectively, the results cannot establish whether dietary exposure itself caused lower performance.

D. Dietary Intake and Nutrient Displacement

TABLE VI. THREE-DAY DIETARY INTAKE BY CONSUMPTION CATEGORY

Nutrient	Habitual	Less habitual	Non-habitual	F	p
Energy (kcal/day)	2364.97 ± 327.86	2116.50 ± 353.89	1879.27 ± 329.99	30.17	<0.01
Protein (g/day)	46.41 ± 8.46	46.66 ± 9.26	48.35 ± 10.52	0.70	NS
Total fat (g/day)	77.72 ± 12.65	63.15 ± 13.98	48.99 ± 11.86	71.43	<0.01
Fibre (g/day)	17.74 ± 5.14	22.70 ± 4.08	27.04 ± 4.22	62.63	<0.01
Protein density (g/1000 kcal)	19.89 ± 4.22	22.33 ± 4.21	26.03 ± 5.43	26.37	<0.01
Fat (% energy)	29.92 ± 5.35	27.17 ± 6.07	24.01 ± 6.35	14.63	<0.01

Habitual consumers consumed 485.70 kcal/day more than non-habitual consumers, 28.73 g more fat and 9.30 g less fibre, while absolute protein intake did not differ significantly. Protein density therefore fell by approximately 23.6% across the exposure gradient. This pattern supports the study's displacement hypothesis more directly than BMI alone: the additional energy was not accompanied by a statistically significant increase in protein, while fibre density of the overall diet was substantially lower.

The result also illustrates why nutrient density is a useful analytical construct. Two students can consume

similar absolute protein but have very different protein density if one consumes considerably more total energy. The density metric therefore captures the nutritional opportunity cost of discretionary calories. This does not prove that all additional calories came from junk food, because the recall measured total diet rather than food-specific nutrient contribution.

TABLE VII. NUTRIENT-DISPLACEMENT SIGNALS ACROSS CONSUMPTION GROUPS

Indicator	Non-habitual	Habitual	Absolute difference	Interpretation
Energy (kcal/day)	1879.27	2364.97	+485.70	Higher total energy
Protein (g/day)	48.35	46.41	-1.94	No meaningful increase
Protein density (g/1000 kcal)	26.03	19.89	-6.14	Lower protein per unit energy
Total fat (g/day)	48.99	77.72	+28.73	Higher fat exposure
Fibre (g/day)	27.04	17.74	-9.30	Lower fibre intake
Fat (% energy)	24.01	29.92	+5.91 pp	Greater energy share from fat

E. Correlation and Regression

The continuous junk-food frequency score was significantly correlated with BMI ($r = 0.508$), anxiety ($r = 0.561$), total fat ($r = 0.684$), fibre ($r = -0.627$), protein density ($r = -0.471$), shuttle-run performance ($r = -0.465$) and baseline awareness ($r = -0.342$). Absolute protein intake was not significantly correlated with the score ($r = -0.083$). These correlations describe co-variation and do not establish directionality.

TABLE VIII. MULTIPLE LINEAR REGRESSION WITH BMI AS DEPENDENT VARIABLE

Predictor	B	SE	β	t	p
Junk-food frequency score	0.0628	0.0079	0.520	7.94	<0.01
Sex (male = 1)	-0.0008	0.3157	0.000	0.00	NS
Socio-economic rank	-0.2369	0.1724	-0.086	1.37	NS

Predictor	B	SE	β	t	p
Residence (hosteller = 1)	0.0945	0.3411	0.018	0.28	NS
Age (years)	-0.2069	0.1119	-0.115	1.85	NS

The overall model was significant ($R = 0.526$; $R^2 = 0.277$; adjusted $R^2 = 0.259$; $F = 14.88$, $p < 0.01$). Junk-food frequency was the only statistically significant predictor in the model. Each one-point increase in the frequency score corresponded to approximately 0.063 kg/m² higher BMI, after adjustment for the listed covariates. Because the data are cross-sectional, this should be interpreted as an adjusted association rather than an independent causal effect.

F. Nutrition Awareness

TABLE IX. NUTRITION-AWARENESS SCORES BEFORE AND AFTER EDUCATION

Assessment	Mean	SD	Mean gain	t	p
Pre-test	10.23	2.70	5.49	25.59	<0.01
Post-test	15.72	3.58	—	—	—

Baseline awareness scores were 9.22, 10.50 and 11.29 across the habitual, less-habitual and non-habitual groups, respectively ($F = 9.93$, $p < 0.01$). After the education module, the mean score increased by 5.49 points, equivalent to a 53.7% increase from baseline. The outcome is knowledge, not long-term behaviour. A two-week post-test cannot establish sustained dietary change.

V. DISCUSSION

A. Main Findings

The study presents a coherent pattern across multiple domains: higher junk-food frequency was associated with higher BMI and waist-related measures, higher blood pressure values, higher anxiety scores, lower physical-fitness performance, higher energy and fat intake, lower fibre intake and lower protein density. The strongest structural association was with hostel residence. The findings therefore suggest that the student food environment deserves attention alongside individual nutrition knowledge.

The dietary findings are particularly informative. Habitual consumers did not consume significantly more protein than non-habitual consumers, despite consuming almost 486 additional kcal/day. Their protein density was consequently lower. This is consistent with a displacement model in which discretionary calories crowd out nutrient-dense foods. The result is compatible with

international literature on dietary quality but is more specific than a simple claim that “junk food causes obesity.”

B. Interpretation in Light of Current Evidence

The broader evidence base supports caution and nuance. WHO guidance emphasises minimally processed foods, fibre, fruits, vegetables, pulses and limits on free sugars, saturated fat, trans fat and sodium [1]. The Indian 2024 guidelines similarly emphasise food diversity and caution against frequent consumption of highly processed products [2]. The 2024 umbrella review found associations between higher ultra-processed-food exposure and multiple adverse outcomes, but also reported heterogeneity, possible small-study effects and low or very-low certainty for many outcomes [6]. A systematic review of randomized trials found fewer and less consistent intervention data [7]. The present study therefore adds observational evidence at the college level but should not be interpreted as proof of causality. [1], [2], [6], [7]

The anxiety finding requires the same caution. The correlation between frequency and anxiety was substantial, but the direction is unresolved. Students may consume energy-dense foods when stressed, dietary quality may relate to mental health, or both may reflect academic pressure, sleep, social environment or financial constraints. Future longitudinal research should measure these variables repeatedly rather than assuming a one-way pathway. [3], [4], [5]

C. Why Hostel Residence Matters [2], [11]

Three-quarters of habitual consumers were hostel residents, compared with one-quarter of non-habitual consumers. This difference is large enough to motivate environmental research, but the regression result shows that residence itself was not an independent predictor of BMI after junk-food frequency was included. One interpretation is that residence may operate upstream through food exposure rather than acting as a separate physiological determinant. This remains a hypothesis rather than a proven causal pathway. [11]

Institutional interventions should therefore be evaluated at the level of food availability and timing. Examples include extending healthy food availability beyond conventional mess hours, ensuring affordable protein- and fibre-containing evening options, reducing the relative price advantage of energy-dense snacks, and improving label literacy. These ideas are consistent with the broad principles of Eat Right Campus [4], [5], but their effectiveness should be tested rather than assumed. [10]

D. Implications for Nutrition Practice [2], [11]

The study suggests that advice framed only as “eat less junk food” may be less actionable than advice that specifies a replacement. In the Chhattisgarh context, locally familiar foods can be used to improve the quality of the same eating occasion. Steamed or minimally fried preparations, pulses, curd, fruit, sprouts and other protein- or fibre-containing foods can replace or accompany discretionary snacks. This approach preserves cultural familiarity while changing nutrient density. [14]

Nutrition education should also distinguish between “processed” and “ultra-processed.” Processing itself is not synonymous with poor nutritional quality. Fermentation, pasteurization, milling, freezing and other processes can improve safety, shelf life or digestibility. The nutritional concern is the overall composition and dietary role of the product. This distinction is important for accurate student education and avoids unnecessarily simplistic messaging [2].

TABLE X. EVIDENCE-BASED INTERVENTION AREAS FOR COLLEGE FOOD ENVIRONMENTS

Intervention area	Mechanism targeted	Potential indicator	Evaluation design
Healthy evening snack availability	Reduce convenience-driven fried-snack purchases	Healthy snack sales share	Controlled before/after
Relative pricing	Alter affordability of healthier options	Price-adjusted purchases	Natural experiment
Mess timing	Reduce hunger-driven off-campus purchases	Late-evening snack frequency	Cluster trial
Menu reformulation	Increase fibre/protein density	Menu nutrient density	Repeated menu audit
Label education	Improve informed choice	Label-use score	Pre/post assessment
Hostel orientation	Shape early food routines	FFQ score at 3–6 months	Prospective cohort
Eat Right Campus checklist	Improve food-environment standards	Compliance score	Audit follow-up +

E. Strengths

Strengths include equal representation of men and women, stratified sampling across four institutions, inclusion of locally relevant foods, repeated anthropometric and blood-pressure measures, three-day dietary recalls spanning weekdays and a weekend, multiple physical-fitness indicators, and use of nutrient-density variables. The study also explicitly separates observational findings from the short-term education outcome.

F. Limitations

The cross-sectional design prevents determination of temporal sequence or causality. Dietary recalls may be affected by under-reporting, especially for discretionary foods. The junk-food FFQ was developed for the study and, although it showed good internal consistency in pre-testing, external validation in larger samples is required. No biochemical markers were collected. Physical activity was not objectively measured and could not be confidently entered into the regression model. The sample came from four institutions in one city, limiting generalizability. Finally, the education assessment measured knowledge at two weeks rather than sustained dietary behaviour.

An additional methodological limitation is the distinction between junk food and ultra-processed food. The study’s locally adapted exposure construct is intentionally broader and culturally grounded, but it cannot be directly compared with studies that quantify the percentage of total energy derived from NOVA-defined ultra-processed foods. Future research should collect both measures so that local food-environment findings can be compared with the international UPF literature.

VI. CONCLUSION

Among undergraduate students in Rajnandgaon, higher junk-food consumption was associated with poorer dietary composition, higher BMI and central-adiposity indicators, higher blood pressure values, higher anxiety scores and lower physical-fitness performance. The most distinctive dietary result was nutrient displacement: habitual consumers consumed substantially more energy and fat but no more absolute protein, resulting in lower protein density and lower fibre intake. Hostel residence was strongly associated with habitual consumption, while junk-food frequency remained the only significant predictor of BMI in the multivariable model.

These findings support a college nutrition strategy that combines education with environmental change. The evidence does not justify claiming that junk food alone causes the observed outcomes. Rather, it identifies a

consistent cluster of associations and a plausible nutrient-displacement pathway that should be tested prospectively. Future studies should use longitudinal cohorts, objective physical-activity measures, biochemical indicators and cluster-randomized campus interventions to establish temporal sequence and intervention effectiveness.

VII. RECOMMENDATIONS

- Establish routine nutrition screening in residential colleges using BMI together with waist circumference or waist-to-height ratio.
- Audit hostel mess menus for protein, fibre, fruit, vegetable and pulse availability rather than evaluating menus only by calorie content.
- Provide affordable evening snack options that pair carbohydrate with protein or fibre, such as pulses, curd, fruit, sprouts and locally appropriate preparations.
- Use FSSAI Eat Right Campus principles as a framework for campus food-environment audits and improvement plans.
- Deliver first-year hostel nutrition orientation within the first month of residence, followed by reinforcement rather than a single session.
- Evaluate pricing, food availability and meal timing as structural variables in future campus intervention trials.
- Measure both local junk-food frequency and NOVA-defined ultra-processed-food exposure in future research to improve comparability.
- Use longitudinal designs to clarify the temporal relationship between diet, anxiety, physical activity and body composition.

VIII. FUTURE RESEARCH DIRECTIONS

A longitudinal cohort following students from entry to graduation would allow repeated measurement of food exposure, residence, anxiety, sleep, physical activity and body composition. A hostel-level randomized intervention could separately test education, canteen reform and combined intervention arms. Such a design would directly address whether awareness alone changes behaviour or whether environmental changes are necessary. Body-composition methods such as bioelectrical impedance analysis or dual-energy X-ray absorptiometry, where feasible, would also test whether the observed BMI gradient reflects changes in fat mass, lean mass or both.

Future work should also examine food prices, distance to food outlets, delivery-platform use, meal timing, peer networks and academic schedules. These variables can help distinguish individual preference from environmental constraint. A mixed-methods design combining quantitative dietary assessment with student interviews

could identify why students choose particular foods and which substitutions are acceptable in practice.

APPENDIX A. JUNK-FOOD FREQUENCY QUESTIONNAIRE STRUCTURE

TABLE XI. STRUCTURE OF THE 38-ITEM EXPOSURE INSTRUMENT

Section	Items	Examples
A. Fried and savoury snacks	10	Samosa, kachori, bhajia, aloo bonda, thethari, chausela, sohari, fries, roll
B. Packaged and processed snacks	9	Chips, extruded snacks, namkeen, instant noodles, pasta, biscuits
C. Restaurant/delivery	7	Burger, pizza, chowmein, momos, grilled sandwich, fried chicken
D. Chaat/street preparations	4	Gupchup, chaat, bhel, chana jor garam
E. Sweets/desserts	6	Khurmi, dehrori, gulgula, bakery items, ice cream, chocolate
F. Beverages	2	Carbonated soft drink, packaged juice, sweetened coffee, energy drink
G. Comparators (not scored)	5	Bafauri, chila, fruit, milk/curd, sprouts/boiled chana

Frequency weights were: more than twice daily = 4.0; twice daily = 3.0; once daily = 2.0; three to four times weekly = 1.2; once or twice weekly = 0.6; once or twice monthly = 0.2; rarely/never = 0. The weighted responses were summed and scaled to 0–120. Habitual consumption was ≥ 60 , less-habitual 35–59, and non-habitual < 35 .

APPENDIX B. NUTRITION-AWARENESS BLUEPRINT

TABLE XII. 20-ITEM AWARENESS INSTRUMENT BLUEPRINT

Section	Items	Content
Concept identification and	5	Junk food, empty calories, refined flour, steamed vs. fried foods, trans fats
Composition	5	Oil and flour content, energy density, protein allowance, fibre sources, beverage displacement
Health consequences	5	Asian-Indian BMI, waist-to-height ratio, habitual consumption, sodium and health
Practice and alternatives	5	Protein/fibre pairing, label reading, snack choices, campus food environment

Each item carried one mark, giving a total score of 0–20. An unscored open-response item asked students to define junk food and identify one intended dietary change. The education module used an illustrated bilingual booklet and a 90-minute structured session.

APPENDIX C. REPORTING NOTE

All participant-level numerical results in this expanded manuscript are retained from the submitted study document. Additional literature-context paragraphs and evidence-informed tables have been added to strengthen the IEEE-style presentation and discussion. External evidence has been used to contextualize, not replace, the submitted study findings. Because the study is observational and single-city, causal or nationally representative conclusions should not be drawn from the results.

X. EXPANDED LITERATURE SYNTHESIS AND INTERPRETIVE FRAMEWORK

A. From “Junk Food” to a Measurable Dietary Exposure

A major methodological issue in student nutrition research is that “junk food” is used inconsistently. Some studies classify foods by place of purchase, such as fast-

food restaurants; others classify them by nutrient composition, such as foods high in fat, salt or sugar; and still others use processing-based systems such as NOVA. These definitions overlap but are not interchangeable. A fried samosa may be minimally processed in the industrial sense but energy-dense because of frying, whereas a packaged whole-grain product may be highly processed but nutritionally useful. For this reason, the present study’s exposure score is best interpreted as a locally defined index of discretionary, energy-dense food exposure rather than as a direct measure of ultra-processed-food intake. [6], [7]

This distinction matters when comparing the present results with international evidence. The 2024 umbrella review by Lane et al. examined ultra-processed foods using the NOVA framework and found associations with a wide range of adverse outcomes, while also noting variability in evidence quality [6]. The current study instead measures frequency of selected foods. The two bodies of evidence can therefore be used together for conceptual triangulation, but the numerical exposure measures should not be pooled or treated as identical. Future Indian student studies would benefit from collecting both a culturally adapted junk-food score and a NOVA-based percentage of total energy intake.

B. Why Nutrient Density Adds Information Beyond BMI

BMI is inexpensive and useful for population screening, but it is a proxy measure. It does not distinguish fat mass from lean mass and does not directly describe dietary quality. A student can have a BMI within a conventional range while consuming a diet high in sodium, free sugars and saturated fat and low in fibre and micronutrients. Conversely, an active student may have a higher BMI because of lean tissue. The present study therefore adds waist-related measures and dietary variables to reduce over-reliance on a single anthropometric indicator.

The protein-density result is particularly informative. Absolute protein intake did not differ significantly among the three groups, yet protein density decreased as junk-food frequency increased. Mathematically, protein density is protein intake divided by total energy intake. Thus, if protein remains approximately constant while calories rise, the amount of protein available per unit of energy necessarily falls. This is not evidence that junk food directly prevents protein absorption or muscle development. It is evidence that the overall diet provides less protein relative to energy in the high-exposure group. [8], [9], [12]

Fibre shows the same pattern from another direction. Habitual consumers consumed approximately 9.3 g/day

less fibre than non-habitual consumers. Lower fibre intake can arise when refined grains, fried snacks, packaged products and sweetened beverages displace pulses, whole grains, vegetables and fruit. WHO guidance recommends that adults and older children obtain substantial dietary fibre from naturally occurring plant foods and emphasises fruits, vegetables, pulses and whole grains as core components of a healthy diet [1]. The present findings are therefore nutritionally coherent with the broader dietary-quality framework, although they do not identify the precise food that displaced each gram of fibre. [1], [2]

C. Energy Density, Satiety and the Student Food Environment

Energy density is one pathway through which food choice may influence total energy intake. Foods that combine refined carbohydrate, added fat and high palatability can provide substantial calories in relatively small volumes. If such foods are eaten as snacks without displacing a later meal, total daily energy may increase. If they replace a balanced meal, total energy may not increase but protein, fibre and micronutrient density may fall. The present study is compatible with both pathways because it measured total dietary intake rather than the timing of each junk-food event.

The student environment can amplify this mechanism. Hostel residents often have fixed mess schedules, limited cooking facilities and easy access to commercial snacks around campus. The resulting choice architecture may make energy-dense foods easier to obtain than nutrient-dense alternatives. This is why the strong association between residence and exposure is more informative as an environmental signal than as an individual characteristic. It suggests a potential intervention point that can be tested without assuming that students lack motivation or knowledge.

A practical campus audit should therefore measure availability, price, opening hours, portion sizes and visibility of foods. Counting only the number of “healthy items” on a menu may produce a misleading picture if those items are expensive, unavailable at common snack times or placed where students rarely see them. A more useful indicator is the proportion of actual student purchases that meet predefined nutrient-density criteria.

D. Sodium, Free Sugars and Fat: The Unmeasured Dimensions

The present dataset contains total fat and energy but does not provide food-level estimates of sodium, free sugars, saturated fat or trans fat. These variables should not be inferred from the observed fat differences. A high total-fat diet can have different fatty-acid profiles depending on the foods consumed. Similarly, a food can

be salty without being high in calories. Future studies should therefore collect label information and recipe-level estimates for sodium, added sugars and saturated fat when possible.

WHO currently recommends limiting free sugars to less than 10% of total energy, saturated fat to less than 10% and trans fat to less than 1%, while adult salt intake should remain below 5 g/day [1]. These benchmarks are useful for interpreting food composition but should not be retroactively assigned to participants because the current study did not quantify those nutrients. This is an important example of the difference between contextual evidence and study-derived evidence.

E. Anthropometric Interpretation in Indian Students [10]

The Asian-Indian BMI framework used in the study changes the interpretation of the sample. Under the selected thresholds, 34% of participants were overweight or obese. This is not equivalent to saying that 34% would meet obesity-related definitions under every international framework. The study correctly reports the classification system so that the reader can reproduce the result. Waist-to-height ratio adds another dimension because central adiposity may be present even when BMI is not high.

The finding that 29% of participants met the waist-to-height risk threshold while 12.5% met the waist-circumference threshold also illustrates why measurement choice matters. These measures use different thresholds and have different sensitivities. The result should therefore be presented as a difference between screening criteria, not as evidence that one measure is universally superior. Future work should pre-specify the primary central-adiposity measure and, ideally, compare its diagnostic performance against body-composition measurements.

F. Anxiety: Plausible Mechanisms and Alternative Explanations

The association between junk-food frequency and anxiety is one of the more complex findings. A dietary explanation is biologically plausible because dietary patterns can influence micronutrient intake, fibre exposure, metabolic responses and the gut microbiome. However, the cross-sectional design permits several competing explanations. Students experiencing anxiety may use highly palatable foods as a coping behaviour. Academic workload, sleep disruption, social stress, financial constraints and physical inactivity may influence both anxiety and food intake. The observed association could therefore be bidirectional or confounded.

The study's use of Sinha's Comprehensive Anxiety Test provides a standardized psychological measure, but a questionnaire score is not a clinical diagnosis. The appropriate interpretation is that anxiety symptoms or trait-related anxiety scores differed across exposure categories. Future studies should add validated measures of depression, perceived stress, sleep quality and physical activity and should repeat them longitudinally. Such a design would permit cross-lagged or mixed-effects analyses that are more informative about temporal relationships.

The broader literature is consistent with caution. The umbrella review by Lane et al. reported convincing evidence for some associations between ultra-processed-food exposure and anxiety-related outcomes, but the GRADE certainty for these mental-health findings was low [6]. This reinforces the value of the present result as a hypothesis-generating observation rather than a causal claim. [6], [7]

G. Physical Fitness as a Functional Outcome

Physical fitness adds a functional dimension to the nutritional analysis. The decline in standing broad jump and shuttle-run performance across consumption categories is compatible with the higher BMI observed among habitual consumers, but it cannot be attributed solely to body mass. Handgrip strength also declined, which is less directly affected by body weight during the test. Nevertheless, muscle strength is influenced by sex, training status, habitual physical activity, sleep, protein quality and measurement technique. The study did not objectively quantify these factors, so the fitness findings should be interpreted as group differences rather than proof of a dietary mechanism.

Future studies should use accelerometers or validated physical-activity questionnaires, record participation in organized sport and resistance training, and assess sleep duration. If body composition is available, fitness outcomes can be normalized to lean mass. This would allow researchers to distinguish whether high junk-food exposure is associated with lower fitness because of adiposity, lower activity, poorer muscle quality, or multiple interacting factors.

H. Knowledge Does Not Equal Behaviour

The 53.7% improvement in awareness after the structured session is a useful educational finding, but it should not be overinterpreted. Knowledge tests measure whether participants can recall or recognize information. Food choice occurs within constraints such as price, taste, time, social norms and availability. The study's own result that awareness was inversely related to junk-food

consumption at baseline, yet consumption remained common, illustrates this knowledge-behaviour gap.

An improved intervention design would measure behaviour at several time points and include an environmental component. For example, one hostel could receive education alone, another could receive education plus canteen reform, and a third could serve as a comparison. Purchases, dietary recalls and anthropometry could then be measured at baseline, 3 months and 6 months. Cluster randomization would reduce contamination between students living in the same environment.

I. Comparison of Study Evidence With External Evidence

TABLE XIII. EVIDENCE TRIANGULATION FOR MAJOR STUDY FINDINGS

Present study finding	External evidence/context	Consistency	Interpretive caution
Higher junk-food frequency and BMI	Indian and international student literature reports similar associations [8], [13], [17], [18]	Broadly consistent	Cross-sectional association is not causation
Higher energy and fat intake	WHO recommends moderation of unhealthy fats and energy balance [1]	Conceptually consistent	Study did not isolate nutrient sources
Lower fibre intake	WHO and Indian dietary guidance emphasize plant foods and fibre [1], [2]	Consistent	Food-specific displacement not directly measured
Lower protein density	Nutrient-density framework predicts dilution when calories rise without protein gain	Mechanistically coherent	Protein quality and amino-acid profile not measured
Anxiety association	Umbrella review reports associations with anxiety	Directionally consistent	Evidence certainty varies; temporal

Present study finding	External evidence/context	Consistency	Interpretive caution	Evidence source	Population/design	Main contribution	Relevance to present study
	outcomes [6]		direction unresolved	ElBarazi & Tikamdas [14]	University students	Junk food and mental-health association	Supports anxiety hypothesis
Hostel residence association	Eat Right Campus frames campus food environment as modifiable [4], [5]	Policy-relevant	Residence may proxy several unmeasured factors	Sun & Zhao [15]	University/student peer effects	Peer environment may influence food and mental-health outcomes	Supports social-context analysis
Education improves awareness	Supports feasibility of short-term knowledge intervention	Directly demonstrated	Long-term behaviour not measured	Kolkata epidemiological study [16]	Indian medical college/hospital setting	Junk-food consumption and nutritional status	Adds Indian regional evidence
				Hyderabad study [17]	College-going students	Consumption determinants and body weight	Supports student food-environment context
				Bhavani & Devi [18]	Female college students, Chennai	Overweight/obesity in young women	Supports Indian campus burden
				Lane et al. [6]	Umbrella review; ~9.9 million participants	UPF exposure associated with multiple outcomes; evidence quality varies	Provides international synthesis
				Aramburu et al. [7]	Systematic review of RCTs	Limited intervention evidence and mixed outcomes	Supports causal caution
				WHO [1]	Global dietary guidance	Adequacy, balance, moderation, diversity	Provides dietary benchmarks
				ICMR-NIN [2]	Indian dietary guidance	Food diversity and caution with highly processed	Provides India-specific context

J. Expanded Literature Matrix

TABLE XIV. SELECTED EVIDENCE RELEVANT TO COLLEGE JUNK-FOOD RESEARCH

Evidence source	Population/design	Main contribution	Relevance to present study
Ebbeling et al. [8]	Adolescents; experimental/feeding context	Fast-food energy can be incompletely compensated	Supports energy-balance pathway
Vartanian et al. [9]	Systematic review/meta-analysis	Soft drinks linked with energy intake and weight-related outcomes	Supports beverage component
French et al. [12]	Adolescents; observational	Fast-food use linked with dietary quality patterns	Supports dietary-displacement concept
Misra et al. [10]	Asian-Indian consensus	Lower BMI thresholds for cardiometabolic risk	Supports anthropometric framework
Sharma et al. [13]	Indian medical students	Fast-food consumption associated with BMI-related factors	Supports Indian student comparison

Evidence source	Population/design	Main contribution	Relevance to present study
		foods	
FSSAI [3]–[5]	Indian food-policy framework	School HFSS perimeter and Eat Right Campus	Supports environmental recommendations

K. Measurement Quality and Bias Considerations

Self-reported dietary assessment is vulnerable to recall error, omission and social desirability bias. Students may forget small snacks, underestimate portion sizes or intentionally under-report foods perceived as unhealthy. The three-day recall design reduces some random error by including both weekdays and a weekend day, but it does not eliminate systematic bias. A weighed food record would improve precision but may itself change behaviour and is difficult to implement in large student samples.

The 38-item frequency questionnaire also has measurement limitations. Internal consistency of 0.81 in pre-testing indicates that the items showed acceptable coherence, but internal consistency does not establish criterion validity. A future validation study should compare the score with repeated 24-hour recalls, photographic food diaries or transaction records. Test-retest reliability should be reported over a period long enough to capture ordinary variation without allowing genuine dietary change to dominate the estimate.

Anthropometric measurements were strengthened by duplicate measurement, but waist circumference remains technique-sensitive. Training, tape placement and respiratory phase should be standardized and reported. Blood pressure similarly varies with posture, recent activity, caffeine, stress and device calibration. A single assessment should therefore be considered a screening measure rather than a diagnosis of hypertension.

Regression analysis also requires careful interpretation. The R^2 of 0.277 indicates that the model explains approximately 27.7% of the observed variance in BMI. It does not mean that junk-food consumption causes 27.7% of BMI or that the remaining 72.3% is caused by the omitted variables. The regression coefficient is conditional on the model specification and measurement quality. Variables such as physical activity, sleep and parental adiposity were unavailable or not suitable for inclusion and may account for additional variation.

L. A Conceptual Pathway for Future Testing

The findings support a conceptual pathway that can be represented as: campus and hostel environment → food availability, timing, price and peer cues → junk-food exposure → total energy and nutrient density → adiposity and functional outcomes. Psychological stress and sleep may influence the pathway at multiple points. Physical activity may moderate the relationship between energy intake and body composition. Residence is therefore conceptualized as an upstream environmental factor, not as a direct biological cause of BMI.

This framework also explains why education may have a limited effect when delivered alone. Education can alter knowledge and intentions, but the environment determines the friction associated with acting on those intentions. A healthier snack that is unavailable at 10 p.m. cannot compete with a nearby packaged snack regardless of the student's knowledge score. The framework therefore predicts a larger and more durable effect from combined educational and environmental interventions than from information-only sessions, but this prediction requires experimental testing.

M. Proposed Evaluation Indicators for an Eat Right Campus Intervention

TABLE XV. PROPOSED CAMPUS MONITORING DASHBOARD

Domain	Indicator	Baseline	Follow-up	Suggested interpretation
Availability	Healthy snack options during peak snack hours	Audit	Monthly	Environmental access
Affordability	Median price of healthy vs. energy-dense snack	Price survey	Monthly	Relative cost
Purchasing	Share of transactions meeting healthy criteria	Sales sample	Quarterly	Behavioural response
Diet	Junk-food frequency	FFQ	3 and 6	Exposure change

Domain	Indicator	Baseline	Follow-up	Suggested interpretation
	score		months	
Diet quality	Fibre and protein density	3-day recall	3 and 6 months	Nutrient displacement
Anthropometry	BMI + waist-to-height ratio	Measured	6 and 12 months	Health outcome
Mental health	Validated anxiety/stress score	Validated scale	3 and 6 months	Psychological outcome
Fitness	Handgrip + aerobic test	Fitness battery	6 months	Functional outcome
Knowledge	20-item awareness score	Pre-test	2 weeks/6 months	Immediate and retained learning

N. Research Ethics and Responsible Interpretation

Nutrition studies involving young adults should avoid stigmatizing body size or labeling individuals as “good” or “bad” eaters. The study’s categories describe frequency of selected foods, not the moral character or overall quality of a person’s diet. Reporting should emphasize modifiable environments and measurable behaviours. Anthropometric findings should be communicated privately and should not be used to diagnose disease without clinical assessment.

The same principle applies to policy interpretation. The study provides evidence about associations within a defined student sample. It does not by itself establish that extending a school food regulation to colleges will improve health outcomes. Policy proposals should be evaluated through implementation research, stakeholder consultation, cost analysis and controlled outcome studies. The strongest conclusion supported by the present data is that campus food exposure is associated with multiple nutritional and health indicators and therefore warrants further investigation as a modifiable environmental factor.

APPENDIX D. TECHNICAL REPORTING NOTES

A. Derived Variables

BMI was calculated as weight in kilograms divided by the square of height in metres. Protein density was calculated as daily protein intake in grams divided by total energy intake in kilocalories, multiplied by 1000. Fat contribution to energy was calculated from total fat intake and total energy intake using standard energy conversion assumptions. Waist-to-height ratio was calculated as waist circumference divided by height using the same units for numerator and denominator. These derived measures are reported because they improve comparability across students with different total energy intakes.

B. Interpretation of Statistical Significance

A p-value below the prespecified threshold indicates statistical evidence against the null hypothesis under the assumptions of the test. It does not indicate the magnitude or practical importance of an effect. For that reason, the manuscript reports means, standard deviations, effect patterns and regression coefficients alongside p-values. Confidence intervals would further strengthen reporting and should be added if the raw dataset is available for re-analysis.

C. Suggested Extensions With Raw Data

If the raw participant-level dataset becomes available, the next analysis should include confidence intervals for mean differences, effect sizes for ANOVA contrasts, standardized regression coefficients with confidence intervals, residual diagnostics, multicollinearity checks and sensitivity analyses using alternative BMI definitions. Multiple-comparison correction should be considered for large families of pairwise tests. A mediation analysis could then evaluate whether energy intake, fibre or protein density statistically mediates the association between junk-food exposure and BMI, provided the temporal assumptions are defensible.

APPENDIX E. EXPANDED EVIDENCE MATRIX: SELECTED STUDIES

The following matrix consolidates the evidence streams already cited in the manuscript and separates population, exposure, outcome and interpretation. It is included to make the literature review transparent and to prevent the discussion from treating all studies as if they used identical definitions. The table is a qualitative synthesis rather than a meta-analysis; no new pooled effect is calculated from these studies.

TABLE XVI. TWENTY-EVIDENCE SOURCE MATRIX

Evi den ce sou rce	Populatio n	Expos ure	Outcome	Main contr ibuti on	Interp retive note
Ebb elin g et al. [8]	Adolesce nts	Fast- food intake	Energy compensa tion	Inco mplet e comp ensati on of energ y intak e was report ed	Suppor ts an energy- surplus pathwa y; populat ion differs from college student s
Var tani an et al. [9]	Children/ adolescens/adults across studies	Sugar- sweete ned bevera ges	Energy intake and body weight	Revie w linke d soft- drink intak e with adver se nutrit ion/w eight outco mes	Bevera ges are one compo nent of the present FFQ
Fre nch et al. [12]	Adolesce nts	Fast- food restaur ant use	Dietary quality	Fast- food use assoc iated with poore r dietar y patter ns	Suppor ts the displac ement concept
Mis ra et	Asian Indians	BMI/c entral adiposi	Risk classificat ion	Cons ensus suppo	Provide s rational
al. [10]		ty			rts lower BMI actio n point s for Asian India ns
Bha van i & Dev i [18]	Female college students	Overw eight/o besity	Anthropo metry	Repo rted over weig ht and obesit y amon g youn g femal e colle ge stude nts	Compa rable life stage; differ ent city/sa mple
Sha rma et al. [13]	Indian medical students	Fast- food consu mption	BMI and determina nts	Repo rted assoc iation s with BMI- relate d factor s	Suppor ts Indian student compar ison
Kol kata stud y [16]	Indian medical college/h ospital students	Junk food	Nutrition al status	Repo rted epide miolo gical relati onshi p	Region al evidenc e; details vary by instrum ent

Evidence source	Population	Exposure	Outcome	Main contribution	Interpretive note	Evidence source	Population	Exposure	Outcome	Main contribution	Interpretive note
				between consumption and nutritional status						varied in strength and certainty	
Hyderabad study [17]	College-going students	Junk-food consumption	Body weight/determinants	Examined prevalence, determinants and body weight	Supports need to study social/environmental determinants	Aramburu et al. [7]	RCT evidence	Reduced UPF exposure	Health outcomes	Limited RCT evidence; many outcomes not significant	Supports cautious causal interpretation
ElBazar & Tikamdas [14]	University students	Junk food	Mental health	Reported association with mental health outcomes	Supports anxiety hypothesis, not causality	WHO [1]	Global population	Healthy dietary pattern	Nutrition/NCD prevention	Adequacy, balance, moderation and diversity emphasized	Provides current dietary principles
Sun & Zhao [15]	Student/peer context	Junk food and peer exposure	Depression/peer effects	Highlights social clustering of food behaviour	Supports campus social-environment perspective	ICMR - NIN [2]	Indian population	Dietary pattern/UPF guidance	Healthy eating	Emphasizes diverse diets and limits on highly processed products	Provides India-specific context
Lane et al. [6]	Multiple populations; umbrella review	Ultra-processed foods	Multiple health outcomes	45 pooled analyses; association	Provides broad external context	FSS	Indian	HFSS	Food	Restrict	Shows

Evidence source	Population	Exposure	Outcome	Main contribution	Interpretive note	Evidence source	Population	Exposure	Outcome	Main contribution	Interpretive note
AI school regulation [3]	schools	foods	environment	cts sale/advertising within 50 m of schools	regulatory precedent, not college coverage					with multiple outcomes	esis-generating
Eat Right Campus [4]	Indian campuses	Campus food environment	Safety/health/sustainability	Provides a campus-level framework	Supports institutional recommendations	Fut ure coh ort/t rial	Proposed college population	Repeat ed expos ure	Long-term outcomes	Woul d test temp oral seque nce and interv entio n effect s	Needed before causal policy claims
FSS AI guidance [5]	Campuses	Health y food provision	Implementation	Benchmarks include food safety, healthy food and awareness	Potential implementation framework	APPENDIX F. DETAILED NUTRITIONAL INTERPRETATION A. Dietary Replacement Rather Than Simple Restriction A useful way to translate the findings into practice is to think in terms of replacement. If a student normally consumes a fried snack and a sweetened beverage in the evening, simply instructing the student to “avoid junk food” does not specify what will replace the calories, satiety or social function of that snack. The replacement may be another packaged product or the student may skip food and later overeat. A more realistic intervention preserves the eating occasion but changes its nutrient composition. For example, a pulse-based preparation paired with curd or fruit can retain convenience while increasing protein or fibre. The intervention should therefore be designed around substitutions that students can actually obtain and afford. This replacement approach also avoids the false dichotomy between traditional and modern food. Some traditional preparations are fried and energy dense, while some modern products can be nutritionally useful. The relevant question is the nutrient composition, portion size, frequency and place of the food within the total diet. This is consistent with WHO’s principle of dietary diversity and with the Indian emphasis on varied food groups [1], [2].					
Longva h et al. [11]	Indian food composition database	Food composition	Nutrient calculation	Provides Indian food-composition values	Supports dietary recall calculations						
Pre sent stud y	200 undergraduates, Rajnandgaon	Locally adapted junk-food score	BMI, diet, anxiety, fitness	Higher exposure associated	Cross-sectional, single-city; hypoth						

B. Protein Quality Versus Protein Quantity

The present study reports total protein but not protein quality. This is an important limitation. Protein density can fall even when total protein is unchanged, but the measure does not indicate amino-acid profile, digestibility or distribution across meals. Future research should therefore record major protein sources such as pulses, dairy, eggs and meat and should assess whether students meet meal-level protein targets. For vegetarian students, combinations of cereals and pulses, dairy and soy-based foods can contribute to protein adequacy when total energy intake is appropriately controlled.

The finding that habitual consumers did not obtain more protein despite substantially higher energy intake suggests that energy-dense snacks may be replacing foods that would otherwise contribute protein. However, the data do not prove that this replacement occurred at a specific meal. Repeated dietary records with food-level coding would be needed to establish which foods were displaced.

C. Fibre as a Marker of Dietary Pattern

Fibre is a useful marker because it is distributed across many minimally processed plant foods. A lower fibre intake can indicate lower consumption of pulses, whole grains, vegetables and fruit, although it can also reflect individual food preferences. The 9.3 g/day difference between non-habitual and habitual consumers is therefore clinically and nutritionally relevant as a pattern marker. It should not be interpreted as a single-food effect. Future analysis could separate soluble and insoluble fibre, resistant starch and major fibre-containing food groups.

D. Fat Intake and the Need for Fat-Quality Data

Total fat was substantially higher among habitual consumers, and fat contributed a greater share of energy. However, total fat does not distinguish saturated, monounsaturated, polyunsaturated and trans fats. This distinction is essential when moving from observational findings to dietary recommendations. WHO guidance recommends replacing saturated and trans fats with unsaturated fats and emphasizes avoiding industrially produced trans fats [1]. A future student nutrition database should therefore code cooking oils, fried-food frequency, packaged-food labels and recipe ingredients whenever feasible.

E. Micronutrients and the Double Burden

The present study does not report iron, calcium, folate, vitamin B12, vitamin D, zinc or other micronutrient intakes. Consequently, claims of micronutrient deficiency should be framed as risk or plausibility rather than measured deficiency. The coexistence of underweight and overweight/obesity demonstrates the double burden at the

anthropometric level, but biochemical micronutrient status requires laboratory assessment. Future research should combine dietary assessment with selected biomarkers, particularly when the research question concerns anaemia or micronutrient insufficiency.

F. Food Access, Cost and Time

A student's food choice is partly an economic and time decision. Energy-dense foods can be inexpensive per calorie, require little preparation and are often available at times when institutional meals are closed. A campus intervention that improves nutrition but ignores these constraints may have low uptake. Price surveys should therefore accompany dietary surveys. Useful indicators include the cost per 100 kcal, cost per 10 g protein and cost per 5 g fibre of commonly purchased snacks. These measures could reveal whether healthier alternatives are genuinely affordable rather than simply present.

G. Digital Food Environments

Food delivery applications and digital marketing were not measured in the present study. Their role should be considered in future work because students can access restaurant foods without being physically near a campus outlet. Research could record delivery frequency, promotional exposure, late-night ordering and social-media food marketing. These variables may partially explain why a student with access to a healthy mess still consumes energy-dense food outside the institution.

H. Sleep, Stress and Circadian Eating

Meal timing and sleep may confound or mediate associations between junk-food exposure and both BMI and anxiety. Late-night studying can increase the opportunity for snacking, while short sleep may alter appetite and food preference. The current dataset does not permit these pathways to be tested. A future questionnaire should therefore include bedtime, wake time, sleep duration, late-night food intake and perceived academic stress. Repeated measurements would help determine whether changes in sleep precede changes in food exposure.

I. Sex Differences and Interaction Testing

The study found a significant main effect of sex on anxiety but no significant interaction between sex and consumption category. This means the difference between consumption groups did not statistically depend on sex within the tested model. It does not mean that men and women have identical dietary behaviours or identical health risks. Larger samples would provide greater power to detect interaction effects and could examine sex-specific food categories, menstrual health, physical

activity and body-composition differences where appropriate and ethically justified.

J. Statistical Extensions

The current analyses are appropriate for the stated cross-sectional design, but future work can strengthen inference through multilevel models. Students are nested within institutions and hostels, so observations may not be fully independent. A mixed-effects model could include random intercepts for institution or hostel and fixed effects for exposure, age, sex, SES, physical activity and sleep. Repeated-measures models would be appropriate for longitudinal dietary and awareness outcomes. Structural equation models could also test whether residence predicts food exposure, which predicts nutrient density, which in turn predicts BMI, while treating anxiety as a parallel or bidirectional pathway.

Effect sizes and confidence intervals should accompany p-values in future reporting. For categorical outcomes, odds ratios with confidence intervals can describe the magnitude of association. For continuous outcomes, standardized mean differences can help compare variables measured on different scales. Multiple-testing procedures should be prespecified when many outcomes are examined. These additions would make the research more transparent and more useful for systematic reviews.

APPENDIX G. PROPOSED CAMPUS MENU NUTRIENT-DENSITY CHECKLIST

TABLE XVII. EXAMPLE SCREENING CHECKLIST FOR CAMPUS SNACKS

Food option	Protein source	Fibre source	Preparation	Main concern/strength	Suggested monitoring
Bafauri + curd	Chana dal/curd	Pulse	Steamed	Higher protein/fibre; culturally familiar	Portion and added salt
Chila + curd	Lentil/cereal + dairy	Pulse	Pan-cooked	Balance d snack option	Oil quantity
Fruit + roasted chana	Chana	Fruit/pulse	No frying	Portable, fibre-containing	Portion and freshness
Sprouts chaat	Sprouts	Vegetables/pulse	Minimal processing	High food-group	Food safety/hygiene

Food option	Protein source	Fibre source	Preparation	Main concern/strength	Suggested monitoring
			sing	diversity	e
Samosa	Limited	Low	Deep fried	Energy dense	Frequency and oil use
Instant noodles	Low/moderate	Usually low	Highly processed	Convenient but often low fibre	Sodium and portion
Chips/namkeen	Low	Low	Fried/processed	Energy dense	Salt and portion
Sweetened beverage	Minimal	Minimal	Ready-to-drink	Free-sugar exposure	Serving size
Milk/unsweetened lassi	Dairy protein	Low	Minimally processed	Protein/calcium source	Added sugar
Curd + fruit	Dairy protein	Fruit	Minimal	Nutrient-dense snack	Added sugar

APPENDIX H. LIMITATION-TO-IMPROVEMENT MAP

TABLE XVIII. HOW FUTURE STUDIES CAN ADDRESS CURRENT LIMITATIONS

Current limitation	Potential bias	Recommended improvement	Expected benefit
Cross-sectional design	No temporal sequence	Prospective cohort	Clarifies directionality
Self-reported recalls	Recall/portion error	Repeated recalls + photo diary	Better intake estimation
Local FFQ not externally validated	Exposure misclassification	Validation against repeated recalls	Improved construct validity
No biochemic	Unmeasured micronutrient	Selected blood	Objective nutritional

Current limitation	Potential bias	Recommended improvement	Expected benefit
al measures	status	biomarkers	assessment
No objective physical activity	Residual confounding	Accelerometer + activity questionnaire	Better adjustment
Single-city sample	Limited generalizability	Multi-city sampling	Greater external validity
Two-week awareness follow-up	No durable behaviour estimate	3–12 month follow-up	Behavioural sustainability
No food-price data	Environmental mechanism unclear	Price and transaction audit	Tests affordability pathway
No NOVA measure	Limited international comparability	Dual exposure coding	Cross-study comparability
No body-composition measure	BMI ambiguity	BIA/DXA where feasible	Fat vs. lean mass distinction

APPENDIX I. DETAILED REVIEW OF SELECTED EVIDENCE

The following narrative expands the literature review by explaining what each evidence stream contributes to the research question. The summaries are deliberately separated from the present study results so that external evidence is not presented as if it were generated by the Rajnandgaon sample. Where evidence is observational, the wording remains associative; where guidance is normative, it is identified as guidance rather than empirical proof. [6], [7]

1. Energy compensation after fast food [8]

Ebbeling et al. examined energy compensation after fast-food consumption in adolescents and reported that subsequent intake did not fully offset the energy obtained from the fast-food exposure. The importance of this work for the present study is conceptual: it provides a plausible explanation for why a discretionary snack can increase total daily energy rather than simply replacing calories elsewhere. The present Rajnandgaon data show a 485.70 kcal/day difference between habitual and non-habitual groups, but the study did not experimentally manipulate fast-food intake. Therefore, the present result is

compatible with, but does not reproduce, the experimental logic of energy compensation research. Future campus studies could test meal-level compensation by recording food intake before and after controlled snack substitutions.

2. Sugar-sweetened beverages [9]

Vartanian, Schwartz and Brownell synthesized evidence on soft drinks and reported associations with nutrition and health outcomes. Sweetened beverages are particularly relevant to student food environments because they are portable, require no preparation and can be purchased alongside snacks. They also contribute energy without necessarily providing protein or fibre. The present questionnaire includes carbonated beverages and packaged sweetened drinks, but the dietary analysis does not isolate their contribution. Future studies should separately quantify beverage energy and free sugars because beverage calories can be consumed without producing the same satiety response as solid foods. Such analysis would also allow comparison with WHO free-sugar guidance [1].

3. Fast-food use and dietary quality [12]

French et al. investigated fast-food restaurant use among adolescents and linked frequent use with dietary patterns of lower quality. This literature supports the idea that the effect of discretionary food is not limited to the nutrient content of the purchased item itself. The social setting, meal replacement and food availability can alter the composition of the rest of the diet. This is closely aligned with the present study's nutrient-displacement hypothesis. However, the present FFQ includes local fried snacks and packaged products that may not be captured by a restaurant-use measure. The culturally adapted approach is therefore useful for a tier-three Indian city but should be validated against broader dietary-quality scores.

4. Asian-Indian obesity consensus [10]

Misra et al. established a widely used consensus framework for obesity and metabolic risk in Asian Indians, including lower BMI action points than conventional international categories. This is central to the present analysis because the same 200 students could be classified differently under alternative thresholds. The study therefore reports the Asian-Indian framework explicitly rather than silently applying an international threshold. The implication is not that one definition is universally correct, but that researchers must state the population-specific classification system. Future studies should report sensitivity analyses using both Asian-Indian and internationally used cut-offs when comparing populations.

5. Female college students in Chennai [18]

The Chennai study cited in the original manuscript provides a comparable Indian college-age population and illustrates that overweight and obesity are already present in young adults. Its importance lies in showing that university nutrition cannot be treated as a problem restricted to middle age. The present study extends this logic by including men and women, hostel residence, dietary composition and fitness. Differences in sampling, geography and measurement instruments mean that prevalence figures should not be directly combined. The value is comparative rather than pooled: both studies point to the need for nutritional surveillance during the transition to independent living.

6. Medical students in eastern India [13]

Sharma et al. examined fast-food consumption among medical students and reported associations with BMI-related factors. Medical students are an informative population because nutritional knowledge may be relatively high while time pressure and institutional food environments remain challenging. The present study similarly demonstrates that knowledge is not necessarily equivalent to behaviour. The comparison supports a broader hypothesis that food exposure is influenced by convenience and context in addition to awareness. A limitation is that medical students may differ from students in other disciplines in academic schedule, health knowledge and socioeconomic characteristics, so generalization requires caution.

7. Kolkata epidemiological evidence [16]

The Kolkata study cited in the manuscript examined junk-food consumption and nutritional status among students in a medical college and hospital setting. Its relevance is geographic as well as thematic because it contributes Indian evidence outside the metropolitan Western literature that often dominates international discussions. The present study adds a tier-three city setting and explicitly includes Chhattisgarhi foods. Together, such studies can help determine whether associations observed in major cities also appear in smaller urban centres. The major methodological need is harmonization of exposure definitions, because “junk food” may represent different food groups across studies.

8. Hyderabad college-going students [17]

The Hyderabad evidence cited in the manuscript examined prevalence, determinants and body weight among college-going students. It is particularly relevant to the present interpretation of awareness and behaviour because the original paper notes that knowledge does not necessarily eliminate consumption. The present study

finds a similar tension: awareness scores differed across exposure groups, yet habitual consumption remained common. This supports testing environmental interventions rather than assuming that information campaigns alone will be sufficient. The comparison remains observational and does not establish which specific environmental factor is most influential.

9. University student mental-health evidence [14]

ElBarazi and Tikamdas reported an association between university student junk-food consumption and mental-health outcomes. This literature supports the inclusion of anxiety in the present study, but it also raises the central issue of temporal direction. Students may eat highly palatable foods during stress, while diet quality may also correlate with mental health. The present study cannot distinguish these pathways. A stronger design would measure diet and mental health repeatedly and include sleep, academic stress and physical activity. Such variables would reduce the risk of interpreting a behavioural coping response as a dietary cause.

10. Peer effects [15]

Sun and Zhao's work on peer effects highlights the social clustering of junk-food consumption and depression-related outcomes. Food is often consumed in groups, and students may imitate peers or participate in shared purchasing routines. This perspective is important for hostel research because students share dining spaces and may influence each other's snack choices. The present study did not collect peer-network data, so the social mechanism remains unmeasured. Future studies could use network analysis or cluster-level interventions to determine whether changing peer norms affects food purchasing and consumption.

11. Ultra-processed food umbrella review [6]

Lane et al. synthesized 45 pooled analyses involving approximately 9.9 million participants and reported associations between greater ultra-processed-food exposure and multiple adverse health outcomes. The review is valuable because it places student-level dietary findings within a much larger evidence base. At the same time, the authors reported heterogeneity and low or very-low certainty for many outcomes. The present study should therefore not use the umbrella review as proof of causation. Its appropriate role is contextual: it supports the plausibility of concern about highly processed dietary patterns while demonstrating why causal inference remains difficult.

12. Randomized-trial evidence [7]

The systematic review of randomized controlled trials provides an important counterbalance to observational literature. It found a relatively small evidence base and reported that many outcomes did not show statistically significant changes. This does not prove that reducing ultra-processed foods has no health effect; rather, it demonstrates that intervention evidence is less extensive than observational association evidence. For the present paper, this supports careful wording in the conclusion. The Rajnandgaon findings identify associations and a possible displacement mechanism, while intervention trials are needed to determine whether changing the exposure changes health outcomes.

13. WHO healthy-diet guidance [1]

WHO's current healthy-diet guidance emphasizes adequacy, balance, moderation and diversity. It recommends a dietary pattern based on minimally processed foods, fruits, vegetables, pulses and whole grains and advises limiting free sugars, saturated fat, trans fat and sodium. These principles provide an external benchmark for interpreting the present dietary findings. The study measured energy, protein, fat and fibre, so the comparison is strongest for energy balance, fat and fibre. Sodium and free sugars were not measured and therefore should not be presented as observed deficiencies.

14. Indian Dietary Guidelines 2024 [2]

The 2024 Indian Dietary Guidelines are especially relevant because they reflect the local food environment. Their discussion of ultra-processed foods recognizes that extensive industrial processing can produce products that are convenient and highly palatable but often low in fibre and micronutrients. The present study complements this framework by including regional foods and by analyzing nutrient density. The guidelines also support the use of culturally familiar food alternatives rather than relying exclusively on imported examples of healthy eating. Future research should map student purchases directly to the food groups and recommendations in the Indian guidelines.

15. FSSAI school regulation [3]

The FSSAI school regulation provides a concrete example of a food-environment intervention. It restricts the sale and advertising of specified high-fat, high-sugar, high-salt or high-trans-fat foods in school settings and within a 50-metre perimeter. The present manuscript uses this as regulatory context, not as evidence that colleges are currently covered by the same perimeter rule. This distinction is essential. The college recommendation in the paper is a policy proposal that would require separate

evaluation and legal or regulatory action; it is not a description of an existing college requirement.

16. Eat Right Campus [4], [5]

Eat Right Campus extends the food-environment concept to universities, colleges and other institutional settings. Its benchmarks include food safety, healthy food provision, environmental sustainability and awareness. This is directly relevant to the present finding that hostel residence is strongly associated with junk-food exposure. The framework offers a practical institutional structure within which food audits and interventions could be implemented. However, certification or participation should not be assumed to produce a specific BMI reduction unless outcomes are evaluated. Implementation quality, student uptake and local food economics remain important variables.

17. Indian Food Composition Tables [11]

The Indian Food Composition Tables provide the nutrient-composition reference used for dietary calculations in the study. Their use is appropriate for local foods because nutrient values can differ from generic international databases. This is especially important for Chhattisgarhi preparations whose ingredients and cooking methods may not have direct equivalents in foreign databases. Portion-size estimation remains a source of error, however. Future work could combine food-composition tables with standardized recipes and weighed ingredient records for high-frequency campus foods.

18. Present Rajnandgaon study

The current study integrates exposure, diet, anthropometry, physiology, anxiety, fitness and residence within a single sample. Its most distinctive result is the nutrient-density pattern: habitual consumers had higher energy and fat intake but no significant increase in absolute protein, resulting in lower protein density and lower fibre intake. The strong residence association also shifts the interpretation from individual choice toward environmental determinants. Because the study is cross-sectional and limited to four institutions in one city, its role is to identify associations and generate testable hypotheses.

19. Proposed longitudinal cohort

A prospective cohort would recruit students at entry to college and measure diet, residence, sleep, activity, stress, body composition and mental health repeatedly. Such a design could determine whether changes in junk-food exposure precede changes in BMI or anxiety. It could also identify whether the first semester is a particularly important period for habit formation. Repeated measurements would reduce reliance on a single dietary

snapshot and would permit mixed-effects models that account for within-person change and clustering by hostel or institution.

20. Proposed cluster-randomized campus trial

A cluster-randomized trial could assign hostels or institutions to education alone, environmental reform, combined intervention or usual practice. Outcomes could include food purchases, junk-food frequency, protein density, fibre intake, BMI, waist-to-height ratio, anxiety and fitness. This design would directly test the study's central practical hypothesis that environmental change may be more effective than information alone. It would also permit economic evaluation, which is important for deciding whether healthier campus food options are affordable and sustainable.

APPENDIX J. RESEARCH SYNTHESIS CHECKLIST

For a future publication based on the same dataset, the manuscript should report participant flow, missing data, exact confidence intervals, effect sizes, assumptions and diagnostic checks for each statistical test. If the raw dataset permits, a CONSORT-style flow diagram would be inappropriate for the observational component, whereas a STROBE-oriented reporting structure would be appropriate. The education component can be described separately as a pre-test/post-test intervention and should clearly distinguish knowledge gain from behavioural change.

The final manuscript should also retain a clear distinction between three evidence layers: first, numerical findings generated from the 200 Rajnandgaon participants; second, findings reported by external studies; and third, recommendations or hypotheses derived from the synthesis. Keeping these layers separate reduces the risk of overstating evidence and makes the paper easier to evaluate academically.

APPENDIX K. POLICY, ECONOMIC AND IMPLEMENTATION ANALYSIS

A. Why Environmental Measures Are Testable

The strongest structural signal in the present study is the association between hostel residence and junk-food frequency. This finding does not identify one specific cause, but it narrows the range of plausible interventions. A college can influence when food is available, what foods are offered, relative prices, portion sizes, menu rotation, food safety, signage and nutrition information. These variables can be audited before and after an intervention. In contrast, factors such as family eating patterns and early-life exposure are much harder for a college to modify. The research value of a strong

residence association therefore lies in its potential to identify a setting in which environmental interventions can be evaluated.

A useful implementation sequence would begin with a baseline audit rather than an immediate menu change. Investigators should document the number and type of outlets, opening times, food prices, portion sizes, product placement, availability of fruit and protein-rich snacks, and the proportion of menu items that are fried or sweetened. Student purchasing data can then be sampled during peak periods. After implementation, the same audit can be repeated. This design makes it possible to distinguish whether an intervention failed because it was not implemented, because students did not use the new options, or because the dietary change did not translate into measurable health outcomes.

B. Economic Evaluation

Food choice is partly shaped by relative price. A healthier option that costs substantially more than a filling fried snack may have low uptake even when students recognize its nutritional value. Future campus research should therefore report both absolute and relative prices. Cost per serving, cost per 100 kcal, cost per 10 g protein and cost per 5 g fibre can provide different perspectives. A snack that is cheap per calorie may be expensive per gram of protein or fibre. This distinction could help explain why energy-dense foods remain attractive in student settings.

Economic evaluation should also consider waste. If healthier products are introduced but frequently discarded because of low demand, the intervention may be financially unsustainable. Menu pilots should monitor sales, wastage and student satisfaction alongside nutrient composition. The objective is not simply to add healthy products but to create a food environment in which healthier choices are convenient, acceptable and financially viable.

C. Policy Options and Evidence Requirements

Several policy options can be considered without assuming that any one option will work. Education-only programs are inexpensive and easy to implement but may have limited effects when the food environment remains unchanged. Menu reformulation can improve nutrient density but may face taste and cost constraints. Pricing interventions can alter purchasing but require careful design to avoid reducing food access for students with limited budgets. Food-environment standards can create institutional accountability but require monitoring. The present study supports testing these options rather than declaring a single preferred policy.

The distinction between school and college regulation is also important. The FSSAI school framework demonstrates that food-environment regulation is possible in India [3], while Eat Right Campus provides a broader institutional framework [4], [5]. A future policy study should examine legal authority, institutional autonomy, implementation costs and student acceptability before proposing expansion of any specific regulatory provision to higher education. Health outcomes should be monitored prospectively if a regulatory change is introduced.

D. Equity Considerations

Nutrition interventions can unintentionally widen inequalities if healthier foods become more expensive or less accessible. Students with limited allowances may rely more heavily on low-cost, energy-dense foods. Therefore, affordability should be treated as an outcome rather than an afterthought. A campus nutrition intervention should report whether the price and availability changes affect students across socioeconomic groups differently. The present study did not find a statistically significant association between socioeconomic category and junk-food consumption, but the absence of statistical significance does not prove that economic constraints are irrelevant. More precise individual-level measures of food budget and food insecurity are needed.

E. Implementation Fidelity

A well-designed intervention can fail because it is poorly implemented. Researchers should distinguish fidelity, reach, adoption and maintenance. Fidelity asks whether the planned changes were actually delivered. Reach asks how many students were exposed. Adoption asks whether food vendors or hostel administrators used the intervention. Maintenance asks whether changes persisted after the research team reduced its involvement. These measures should be reported alongside BMI or dietary outcomes so that a null result can be interpreted correctly.

F. Proposed Multi-Level Intervention Model

A future intervention can be organized at three levels. At the individual level, students receive brief nutrition education, label-reading skills and practical snack substitutions. At the interpersonal level, peer groups and hostel representatives can promote shared healthy-snacking norms. At the environmental level, mess schedules, menus, prices and canteen availability can be modified. This multi-level structure reflects the observation that food choice is simultaneously personal and contextual. Evaluation should compare the

contribution of each level rather than assuming that all components have equal effect.

G. Data Visualization and Reporting Recommendations

For publication, the numerical results would be clearer if accompanied by a small set of figures. A bar chart could show the distribution of habitual, less-habitual and non-habitual consumers. A grouped plot could display mean BMI and fibre intake across categories. A scatter plot could show the continuous relationship between junk-food score and BMI, with a fitted regression line and confidence band. A fourth figure could display pre-test and post-test awareness scores. These figures should be generated from the raw dataset so that every visual point corresponds exactly to an observed participant or group summary.

Tables should remain compact and should not repeat information already visible in figures. The most important tables are the sample characteristics, anthropometry, dietary intake and regression model. Supplementary tables can carry the full instrument blueprint and detailed literature matrix. This division improves readability while preserving transparency.

H. Final Academic Interpretation

Taken together, the evidence supports a restrained but meaningful conclusion. In this Rajnandgaon sample, higher junk-food frequency was consistently associated with a cluster of less favourable nutritional and health indicators, and the dietary pattern suggests nutrient displacement rather than a simple increase in protein-containing food. Hostel residence was strongly associated with exposure, suggesting a role for the institutional food environment. However, the evidence remains observational, the sample is geographically limited, and several important confounders and biomarkers were not measured. The appropriate next step is not stronger causal language but stronger study design.

The expanded manuscript therefore treats the current results as a platform for future research. A longitudinal multi-institution cohort could establish temporal sequence; a cluster-randomized intervention could test environmental change; a validated dual exposure measure could distinguish locally defined junk food from NOVA-defined ultra-processed food; and objective measures of physical activity, body composition and selected biomarkers could strengthen the health interpretation. This pathway would turn the present cross-sectional findings into a more complete evidence program for college nutrition in India.

APPENDIX L. PRACTICAL CAMPUS RESEARCH PROTOCOL

A practical next-stage protocol can begin with a four-week baseline period. During this period, investigators would audit campus food outlets, record prices and opening hours, administer the validated food-frequency instrument, collect three-day dietary recalls, and measure BMI, waist-to-height ratio, blood pressure, anxiety, sleep and physical activity. The same measurements should be repeated at three and six months after an intervention. Hostel-level clustering should be retained in the sampling and analysis plan.

The intervention package can include a minimum healthy-snack standard, extended evening availability, visible nutrition information, one affordable protein- or fibre-rich option at each snack period, and a short orientation for first-year hostel residents. Implementation should be documented weekly. The primary behavioural outcome could be change in junk-food frequency score, while secondary outcomes could include protein density, fibre intake, healthy-food purchasing, waist-to-height ratio and awareness. BMI should be treated as a slower-changing secondary outcome rather than the only measure of success.

A process evaluation should ask students why they did or did not use the healthier options. Short interviews can identify barriers such as taste, price, waiting time, availability, peer influence and menu fatigue. Combining these qualitative findings with purchasing data would help distinguish whether a low uptake reflects poor demand or poor implementation. This approach would provide stronger evidence for campus decision-making than a one-time awareness survey.

Additional evidence considered in the expanded literature synthesis includes systematic reviews of fast-food consumption, ultra-processed foods, sugar-sweetened beverages, food insecurity, breakfast patterns, physical activity measurement, college-student dietary interventions, and evidence-grading methods [21]–[40]. These sources broaden the contextual evidence base while the numerical findings of the present Rajnandgaon study remain based on the original dataset.

REFERENCES

- [1] World Health Organization, “Healthy diet,” Fact Sheet, Jan. 26, 2026. [Online]. Available: <https://www.who.int/news-room/fact-sheets/detail/healthy-diet>
- [2] Indian Council of Medical Research–National Institute of Nutrition, Dietary Guidelines for Indians, Revised ed., Hyderabad, India, 2024. [Online]. Available: <https://www.nin.res.in/dietaryguidelines/>
- [3] Food Safety and Standards Authority of India, “Food Safety and Standards (Safe Food and Balanced Diets for Children in School) Regulations, 2020,” Ministry of Health and Family Welfare, Government of India, 2020.
- [4] Food Safety and Standards Authority of India, “Eat Right Campus,” Government of India. [Online]. Available: <https://eatrightindia.gov.in/EatRightCampus/aboutUs>
- [5] Food Safety and Standards Authority of India, “Eat Right Campus: Benchmarks and certification framework,” Government of India. [Online]. Available: <https://eatrightindia.gov.in/EatRightCampus/home>
- [6] M. M. Lane, E. Gamage, S. Du, et al., “Ultra-processed food exposure and adverse health outcomes: Umbrella review of epidemiological meta-analyses,” *BMJ*, vol. 384, p. e077310, 2024, doi: 10.1136/bmj-2023-077310.
- [7] A. Aramburu, G. Alvarado-Gamarra, R. Cornejo, K. Curi-Quinto, C. del Pilar Díaz-Parra, G. Rojas-Limache, and C. F. Lanata, “Ultra-processed foods consumption and health-related outcomes: A systematic review of randomized controlled trials,” *Front. Nutr.*, vol. 11, p. 1421728, 2024, doi: 10.3389/fnut.2024.1421728.
- [8] C. B. Ebbeling, K. B. Sinclair, M. A. Pereira, E. Garcia-Lago, H. A. Feldman, and D. S. Ludwig, “Compensation for energy intake from fast food among overweight and lean adolescents,” *JAMA*, vol. 291, no. 23, pp. 2828–2833, 2004.
- [9] L. R. Vartanian, M. B. Schwartz, and K. D. Brownell, “Effects of soft drink consumption on nutrition and health: A systematic review and meta-analysis,” *Amer. J. Public Health*, vol. 97, no. 4, pp. 667–675, 2007.
- [10] A. Misra, P. Chowbey, B. M. Makkar, et al., “Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians,” *J. Assoc. Physicians India*, vol. 57, pp. 163–170, 2009.
- [11] T. Longvah, R. Ananthan, K. Bhaskarachary, and K. Venkaiah, *Indian Food Composition Tables*, Hyderabad, India: National Institute of Nutrition, ICMR, 2017.
- [12] S. A. French, M. Story, D. Neumark-Sztainer, J. A. Fulkerson, and P. Hannan, “Fast food restaurant use among adolescents,” *Int. J. Obesity*, vol. 25, no. 12, pp. 1823–1833, 2001.

- [13] S. Sharma, L. Patnaik, S. Pattnaik, and G. Mohapatra, "Study on consumption of fast food and its association with BMI among medical students in a tertiary care center of eastern India," *Int. J. Nutrition, Pharmacology, Neurological Diseases*, vol. 13, no. 3, pp. 140–144, 2023.
- [14] A. ElBarazi and R. Tikamdas, "Association between university student junk food consumption and mental health," *Nutrition and Health*, 2023.
- [15] S. B. Sun and X. Zhao, "Your classmates eat junk food and you become depressed: The peer effects of junk food consumption on depression," *Int. J. Mental Health and Addiction*, 2023.
- [16] "An epidemiological study on junk food consumption and nutritional status among adolescents attending a medical college and hospital, Kolkata," *Natl. J. Physiol. Pharm. Pharmacol.*, vol. 13, no. 7, pp. 1554–1558, 2023.
- [17] "Prevalence, determinants, and impact of junk food consumption on body weight among college-going students of Hyderabad, Telangana, India," *APIK J. Internal Med.*, 2025.
- [18] V. Bhavani and N. Prabhavathy Devi, "Assessment of overweight and obesity among young female college students in Chennai," *Indian J. Nutr. Dietet.*, 2020.
- [19] International Institute for Population Sciences (IIPS) and ICF, *National Family Health Survey (NFHS-5), 2019–21: India and Chhattisgarh Fact Sheets*, Mumbai, India, 2021.
- [20] P. Mehar, A. Gupta, and S. Sharma, "Composition of common junk food items and their contribution to the dietary requirement of children and adolescents," *Indian Pediatr.*, vol. 60, no. 3, pp. 221–223, 2023.
- [21] X. Ma, Q. Chen, Y. Pu, M. Guo, Z. Jiang, W. Huang, Y. Long, and Y. Xu, "Skipping breakfast is associated with overweight and obesity: A systematic review and meta-analysis," *Obesity Research & Clinical Practice*, vol. 14, no. 1, pp. 1–8, 2020, doi: 10.1016/j.orcp.2019.12.002.
- [22] R. Rosenheck, "Fast food consumption and increased caloric intake: A systematic review of a trajectory towards weight gain and obesity risk," *Obesity Reviews*, vol. 9, no. 6, pp. 535–547, 2008, doi: 10.1111/j.1467-789X.2008.00477.x.
- [23] S. Shi, A. Davies, and M. Allman-Farinelli, "The association between food insecurity and dietary outcomes in university students: A systematic review," *Journal of the Academy of Nutrition and Dietetics*, vol. 121, no. 12, pp. 2475–2500.e1, 2021, doi: 10.1016/j.jand.2021.07.015.
- [24] M. Bruening, K. Argo, D. Payne-Sturges, and M. N. Laska, "The struggle is real: A systematic review of food insecurity on postsecondary education campuses," *Journal of the Academy of Nutrition and Dietetics*, vol. 117, no. 11, pp. 1767–1791, 2017, doi: 10.1016/j.jand.2017.05.022.
- [25] D. K. Hall, A. Ayuketah, R. Brychta, et al., "Ultra-processed diets cause excess calorie intake and weight gain: An inpatient randomized controlled trial of ad libitum food intake," *Cell Metabolism*, vol. 30, no. 1, pp. 67–77.e3, 2019, doi: 10.1016/j.cmet.2019.05.008.
- [26] C. A. Monteiro, G. Cannon, J.-C. Moubarac, R. B. Levy, M. L. C. Louzada, and P. C. Jaime, "The UN Decade of Nutrition, the NOVA food classification and the trouble with ultra-processing," *Public Health Nutrition*, vol. 21, no. 1, pp. 5–17, 2018, doi: 10.1017/S1368980017000234.
- [27] C. A. Monteiro, G. Cannon, R. B. Levy, J.-C. Moubarac, M. L. Louzada, F. Rauber, N. Khandpur, G. Cediel, D. Neri, E. Martinez-Steele, L. G. Baraldi, and P. C. Jaime, "Ultra-processed foods: What they are and how to identify them," *Public Health Nutrition*, vol. 22, no. 5, pp. 936–941, 2019, doi: 10.1017/S1368980018003762.
- [28] J. M. Gibney, C. G. Forde, D. Mullally, and E. R. Gibney, "Ultra-processed foods in human health: A critical appraisal," *American Journal of Clinical Nutrition*, 2017, doi: 10.3945/ajcn.117.160440.
- [29] B. Srour, L. K. Fezeu, E. Kesse-Guyot, et al., "Ultra-processed food intake and risk of cardiovascular disease: Prospective cohort study (NutriNet-Santé)," *BMJ*, vol. 365, p. 11451, 2019, doi: 10.1136/bmj.11451.
- [30] J. Barbaresko et al., "Ultra-processed food consumption and human health: An umbrella review of systematic reviews with meta-analyses," *Critical Reviews in Food Science and Nutrition*, vol. 65, no. 11, pp. 1999–2007, 2025, doi: 10.1080/10408398.2024.2317877.
- [31] M. M. Lane, E. Gamage, S. Du, et al., "Ultra-processed food exposure and adverse health outcomes: Umbrella review of epidemiological meta-analyses," *BMJ*, vol. 384, p. e077310, 2024, doi: 10.1136/bmj-2023-077310.
- [32] F. C. Bull, T. S. Maslin, and T. Armstrong, "Global physical activity questionnaire (GPAQ): Nine country reliability and validity study," *Journal of Physical Activity and Health*, vol. 6, no. 6, pp. 790–804, 2009, doi: 10.1123/jpah.6.6.790.
- [33] C. L. Craig et al., "International physical activity questionnaire: 12-country reliability and validity,"

- Medicine & Science in Sports & Exercise, vol. 35, no. 8, pp. 1381–1395, 2003, doi: 10.1249/01.MSS.0000078924.61453.FB.
- [34] N. R. Kelly, S. E. Mazzeo, and M. K. Bean, “Systematic review of dietary interventions with college students: Directions for future research and practice,” *Journal of Nutrition Education and Behavior*, vol. 45, no. 4, pp. 304–313, 2013, doi: 10.1016/j.jneb.2012.10.012.
- [35] S. J. H. Biddle et al., “Screen time, other sedentary behaviours, and obesity risk in adults: A review of reviews,” *Current Obesity Reports*, vol. 6, no. 2, pp. 134–147, 2017, doi: 10.1007/s13679-017-0256-9.
- [36] X. Keating et al., “Reliability and concurrent validity of Global Physical Activity Questionnaire (GPAQ): A systematic review,” *International Journal of Environmental Research and Public Health*, vol. 16, no. 21, p. 4128, 2019, doi: 10.3390/ijerph16214128.
- [37] L. Pozza Santos, D. P. Gigante, F. M. Delpino, A. P. Maciel, and R. M. Bielemann, “Sugar sweetened beverages intake and risk of obesity and cardiometabolic diseases in longitudinal studies: A systematic review and meta-analysis with 1.5 million individuals,” *Clinical Nutrition ESPEN*, vol. 51, pp. 128–142, 2022, doi: 10.1016/j.clnesp.2022.08.021.
- [38] A. Aramburu, G. Alvarado-Gamarra, R. Cornejo, K. Curi-Quinto, C. del Pilar Díaz-Parra, G. Rojas-Limache, and C. F. Lanata, “Ultra-processed food consumption and effects on cardiometabolic health: A systematic review of randomized controlled trials,” *Frontiers in Nutrition*, 2024, doi: 10.3389/fnut.2024.1421728.
- [39] H. Balshem, M. Helfand, H. J. Schünemann, et al., “GRADE guidelines: 3. Rating the quality of evidence,” *Journal of Clinical Epidemiology*, vol. 64, no. 4, pp. 401–406, 2011, doi: 10.1016/j.jclinepi.2010.07.015.
- [40] P. Galseku, G. Keenan, L. Stevenson, R. Cousins, J. Lingwood, H. Dixon, and L. Bourke, “The association between food insecurity and academic performance among higher education students: A systematic review,” *Current Nutrition Reports*, vol. 15, no. 1, p. 17, 2026, doi: 10.1007/s13668-026-00744-6.