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ULTRA-PROCESSED FOOD CONSUMPTION AND METABOLIC HEALTH RISKS AMONG ADOLESCENTS IN PAKISTAN

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Abstract

The increasing consumption of ultra-processed foods (UPFs) among adolescents has emerged as a major public health concern due to its association with obesity and other metabolic disorders. This study examined the relationship between ultra-processed food consumption and metabolic health risks among adolescents in Pakistan, with dietary quality serving as a mediating variable. A quantitative cross-sectional research design was employed, and data were collected from 500 adolescents enrolled in public and private secondary schools and colleges across Pakistan using a multistage stratified random sampling technique. Ultra-processed food consumption and dietary quality were assessed using validated questionnaires based on the NOVA food classification system and food frequency measures, while metabolic health was evaluated through anthropometric and biochemical indicators, including body mass index, waist circumference, blood pressure, fasting blood glucose, and lipid profile. Data were analyzed using IBM SPSS Statistics 29 and SmartPLS 4.0. The findings revealed that ultra-processed food consumption significantly reduced dietary quality and increased metabolic health risks. Dietary quality partially mediated the relationship between ultra-processed food consumption and adverse metabolic outcomes, indicating that unhealthy dietary patterns play a critical role in the development of obesity and cardiometabolic disorders among adolescents. The study concludes that reducing ultra-processed food intake and promoting healthier dietary behaviors are essential for preventing metabolic disorders and improving adolescent health in Pakistan. The findings provide important evidence for nutrition policy, school-based health promotion programs, and public health interventions aimed at reducing the burden of non-communicable diseases among adolescents.

INTRODUCTION

The global consumption of ultra-processed foods (UPFs) has increased dramatically over the past two decades, becoming one of the most significant contributors to poor dietary quality and the growing burden of non-communicable diseases (NCDs). According to the NOVA food classification system, ultra-processed foods are industrial formulations manufactured using refined ingredients, additives, preservatives, artificial flavors, colorings, and emulsifiers, with little or no whole foods. Common examples include carbonated soft drinks, packaged snacks, confectionery, instant noodles, processed meats, fast foods, sugary breakfast cereals, and

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commercially baked products (Monteiro et al., 2019).

Adolescence is a critical stage of growth and development during which dietary habits are established and often persist into adulthood. Adequate nutrition during this period is essential for physical growth, cognitive development, hormonal regulation, and metabolic health. However, rapid urbanization, globalization, aggressive food marketing, changing lifestyles, and increased availability of convenience foods have substantially increased the consumption of ultra-processed foods among adolescents worldwide (World Health Organization [WHO], 2024).

Growing evidence indicates that excessive consumption of ultra-processed foods is associated with obesity, insulin resistance, hypertension, dyslipidemia, type 2 diabetes mellitus, metabolic syndrome, cardiovascular diseases, and chronic inflammation. These foods are typically characterized by high concentrations of added sugars, sodium, unhealthy fats, and energy density, while containing low amounts of dietary fiber, vitamins, minerals, and other essential nutrients. Consequently, frequent consumption contributes to unhealthy weight gain, impaired glucose metabolism, and adverse cardiometabolic outcomes (Elizabeth et al., 2020).

Pakistan is currently experiencing a nutritional transition characterized by increasing consumption of processed and fast foods, particularly among urban adolescents. Changing dietary behaviors, sedentary lifestyles, limited nutrition awareness, socioeconomic disparities, and widespread availability of inexpensive processed foods have contributed to rising rates of overweight, obesity, and metabolic disorders among young people. National public health reports indicate increasing prevalence of childhood obesity, hypertension, and impaired glucose tolerance, suggesting an urgent need to investigate dietary determinants of metabolic health in Pakistani adolescents (National Institute of Health Pakistan, 2024).

Although international studies have consistently demonstrated associations between ultra-processed food consumption and metabolic health risks, empirical evidence from Pakistan remains limited. Most local research has focused on general dietary patterns or nutritional deficiencies, with relatively few studies specifically examining the metabolic consequences of ultra-processed food intake among adolescents. Furthermore, limited research has simultaneously assessed multiple metabolic health indicators, including body mass index (BMI), waist circumference, blood pressure, fasting blood glucose, and lipid profiles within the Pakistani context.

Therefore, the present study investigates the relationship between ultra-processed food consumption and metabolic health risks among adolescents in Pakistan. The findings are expected to provide evidence supporting nutrition policies, school-based dietary interventions, and public health strategies aimed at reducing non-communicable disease risk and promoting healthier eating behaviors among adolescents.

Problem Statement

The increasing consumption of ultra-processed foods among Pakistani adolescents has become a growing public health concern due to its potential contribution to obesity, insulin resistance, hypertension, dyslipidemia, and other metabolic disorders. Despite the rapid expansion of processed food markets and changing dietary behaviors, limited empirical evidence exists regarding the association between ultra-processed food consumption and metabolic health risks among adolescents in Pakistan. Existing studies have primarily focused on nutritional deficiencies or general dietary habits without comprehensively evaluating the metabolic consequences of ultra-processed food intake. Consequently, policymakers and healthcare professionals lack sufficient evidence to design targeted nutritional interventions and effective public health policies. This study addresses this gap by examining the relationship between ultra-processed food consumption and metabolic health risks among Pakistani adolescents.

Research Questions

How prevalent is ultra-processed food consumption among adolescents in Pakistan?

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What is the relationship between ultra-processed food consumption and metabolic health risks among Pakistani adolescents?

How does ultra-processed food consumption influence obesity, blood pressure, fasting blood glucose, and lipid profiles among adolescents?

Which metabolic health indicators are most strongly associated with frequent consumption of ultra-processed foods?

How can reducing ultra-processed food consumption contribute to improving adolescent metabolic health in Pakistan?

Research Objectives

To determine the prevalence of ultra-processed food consumption among adolescents in Pakistan.

To examine the relationship between ultra-processed food consumption and metabolic health risks.

To assess the effects of ultra-processed food consumption on obesity, blood pressure, fasting blood glucose, and lipid profiles.

To identify the metabolic health indicators most strongly associated with frequent ultra-processed food consumption.

To provide evidence-based recommendations for improving adolescent nutrition and preventing metabolic disorders in Pakistan.

Significance of the Study

The study contributes significantly to the fields of nutrition, public health, epidemiology, and adolescent medicine by examining the association between ultra-processed food consumption and metabolic health risks in a developing-country context.

From a theoretical perspective, the study expands the evidence on the nutritional transition and dietary determinants of metabolic health among adolescents. It contributes to the growing body of literature examining the health consequences of ultra-processed foods and their role in the development of non-communicable diseases.

From a practical perspective, the findings will assist nutritionists, pediatricians, dietitians, school administrators, and public health practitioners in identifying dietary behaviors associated with adverse metabolic outcomes. The results can inform school nutrition programs, dietary counseling, and adolescent health promotion initiatives.

From a policy perspective, the study provides valuable evidence for the Ministry of National Health Services, provincial health departments, educational authorities, and nutrition policymakers to develop strategies aimed at reducing ultra-processed food consumption among adolescents. The findings may support policies related to food labeling, taxation of unhealthy foods, restrictions on marketing to children, and promotion of healthier school food environments.

Furthermore, the study establishes a foundation for future longitudinal and intervention-based research investigating dietary behaviors, metabolic health, and non-communicable disease prevention among Pakistani adolescents.

Literature Review

Ultra-Processed Food Consumption among Adolescents

Ultra-processed foods (UPFs) have become a dominant component of modern diets, particularly among adolescents. According to the NOVA food classification, ultra-processed foods are industrial formulations manufactured primarily from refined ingredients and additives, containing little or no whole foods (Monteiro et al., 2019). These products include carbonated beverages, fast foods, processed meats, confectionery, instant noodles, packaged snacks, sugary cereals, and commercially baked goods. Their convenience, affordability, aggressive marketing, long shelf life, and appealing taste have contributed to a substantial increase in consumption worldwide.

Adolescence represents a critical developmental stage during which lifelong dietary habits are established. Increased autonomy, peer influence, urbanization, digital media exposure, and changing lifestyles have encouraged adolescents to consume energy-dense, nutrient-poor foods. Recent international studies indicate that ultra-processed foods contribute between 30% and 60% of total daily energy intake among adolescents in many countries, raising concerns regarding future

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metabolic health (Lane et al., 2024). In Pakistan, rapid urbanization, expansion of fast-food outlets, increasing availability of packaged foods, and changing family eating patterns have accelerated the transition toward diets rich in ultra-processed foods.

Ultra-Processed Foods and Obesity

Obesity is one of the most widely reported health consequences associated with excessive ultra-processed food consumption. These foods typically contain high levels of refined carbohydrates, added sugars, saturated fats, sodium, and food additives while providing low amounts of dietary fiber, protein, vitamins, and minerals. Their high energy density and low satiety value often promote excessive caloric intake and weight gain.

Hall et al. (2019) demonstrated through a randomized controlled feeding trial that participants consuming ultra-processed diets consumed significantly more calories and experienced greater weight gain than those consuming minimally processed diets. Similarly, Elizabeth et al. (2020) concluded that frequent consumption of ultra-processed foods substantially increases the risk of overweight and obesity among children and adolescents. Recent meta-analyses further confirm that higher ultra-processed food intake is positively associated with increased body mass index (BMI), waist circumference, and body fat percentage (Lane et al., 2024).

Ultra-Processed Foods and Metabolic Health Risks

Growing evidence suggests that ultra-processed food consumption is strongly associated with several metabolic disorders beyond obesity. High dietary intake of refined sugars, trans fats, sodium, and artificial additives contributes to insulin resistance, hypertension, dyslipidemia, chronic inflammation, impaired glucose metabolism, and metabolic syndrome.

Large prospective cohort studies have demonstrated significant associations between higher ultra-processed food intake and increased risks of type 2 diabetes mellitus, cardiovascular diseases, hypertension, and premature mortality (Srour et al., 2019). Recent systematic reviews have also linked frequent ultra-processed food consumption with elevated fasting blood glucose, increased triglyceride levels, reduced high-density lipoprotein (HDL) cholesterol, and higher blood pressure among adolescents and young adults (Lane et al., 2024). These findings indicate that unhealthy dietary patterns established during adolescence may substantially increase long-term risks of chronic non-communicable diseases.

Ultra-Processed Food Consumption in Pakistan

Pakistan is experiencing a nutritional transition characterized by increasing consumption of processed and convenience foods. Urbanization, globalization, changing lifestyles, aggressive food marketing, socioeconomic development, and greater accessibility to fast-food restaurants have transformed dietary behaviors among adolescents. Recent national health reports indicate increasing prevalence of overweight, obesity, hypertension, and impaired glucose tolerance among Pakistani adolescents (National Institute of Health Pakistan, 2024). School-aged children increasingly consume sugar-sweetened beverages, packaged snacks, fried foods, and processed bakery products, while fruit, vegetable, and whole-grain consumption remains inadequate. Despite these emerging public health concerns, relatively few empirical studies have comprehensively examined the relationship between ultra-processed food consumption and metabolic health indicators within Pakistan.

Given the country's growing burden of non-communicable diseases and limited adolescent nutrition research, investigating the health consequences of ultra-processed food consumption has become an important public health priority.

Metabolic Health Indicators among Adolescents

Metabolic health encompasses physiological indicators associated with energy metabolism and cardiovascular function. Common metabolic risk indicators include body mass index (BMI), waist circumference, blood pressure, fasting blood glucose, total cholesterol, low-density lipoprotein

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(LDL), high-density lipoprotein (HDL), and triglyceride concentrations.

Adolescents consuming diets high in ultra-processed foods frequently exhibit increased adiposity, insulin resistance, elevated blood pressure, dyslipidemia, and chronic low-grade inflammation. Recent epidemiological studies suggest that these metabolic abnormalities often develop during adolescence and persist into adulthood, substantially increasing lifetime risks of cardiovascular disease and diabetes (Pagliai et al., 2021). Early identification of dietary risk factors is therefore essential for preventing future chronic diseases.

Although extensive international evidence has demonstrated associations between ultra-processed food consumption and metabolic disorders, several research gaps remain. First, most existing studies have been conducted in high-income countries, while evidence from South Asian populations, particularly Pakistan, remains limited.

Second, previous Pakistani studies have primarily investigated general dietary habits or nutritional deficiencies rather than specifically examining ultra-processed food consumption using standardized NOVA classification criteria. Third, relatively few studies have simultaneously evaluated multiple metabolic health indicators—including obesity, blood pressure, fasting blood glucose, and lipid profiles—in relation to ultra-processed food intake among adolescents.

Finally, limited evidence exists to support evidence-based nutritional policies and school-based dietary interventions targeting adolescent populations in Pakistan. The present study addresses these gaps by comprehensively investigating the relationship between ultra-processed food consumption and metabolic health risks among Pakistani adolescents.

Underpinning Theory

Social Cognitive Theory (SCT)

The present study is underpinned by Social Cognitive Theory (SCT) developed by Albert Bandura (1986). Social Cognitive Theory proposes that health behaviors are influenced through reciprocal interactions among personal factors, environmental influences, and behavioral practices. Individuals learn dietary behaviors by observing family members, peers, media advertisements, and their surrounding food environments.

Within the context of this study, adolescents' consumption of ultra-processed foods is influenced by environmental factors such as food availability, marketing, school food environments, family dietary habits, and socioeconomic conditions. These dietary behaviors subsequently affect metabolic health outcomes, including obesity, hypertension, insulin resistance, dyslipidemia, and other cardiometabolic risk factors.

Social Cognitive Theory provides an appropriate theoretical foundation because it explains how environmental and behavioral factors contribute to unhealthy dietary patterns and subsequent metabolic health risks. The theory also supports interventions aimed at improving nutrition knowledge, strengthening self-regulation, promoting healthy food choices, and creating supportive food environments for adolescents.

Research Hypotheses

H1: Ultra-processed food consumption has a significant negative effect on dietary quality among adolescents in Pakistan.

H2: Ultra-processed food consumption has a significant positive effect on metabolic health risks among adolescents.

H3: Dietary quality has a significant negative effect on metabolic health risks among adolescents.

H4: Dietary quality significantly mediates the relationship between ultra-processed food consumption and metabolic health risks among adolescents in Pakistan.

Methodology

Research Design

The study employed a quantitative, cross-sectional, analytical research design to examine the relationship between Ultra-Processed Food (UPF) Consumption and Metabolic Health Risks among adolescents in Pakistan, with Dietary Quality serving as the mediating variable. The study was grounded in the positivist research paradigm and

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adopted a deductive approach to test the proposed hypotheses. Primary data and clinical measurements were collected from adolescents, and the hypothesized relationships were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) in SmartPLS 4.0. Descriptive and inferential statistical analyses were conducted using IBM SPSS Statistics Version 29.

Population

The target population comprised adolescents aged 12–19 years enrolled in public and private secondary schools and colleges across the provinces of Pakistan. Participants represented both urban and rural settings to ensure adequate demographic and socioeconomic diversity. Adolescents with diagnosed chronic illnesses, endocrine disorders, or medical conditions affecting metabolism were excluded to minimize potential confounding effects.

Sampling Technique

A multistage stratified random sampling technique was employed. In the first stage, provinces and administrative regions were stratified into urban and rural areas. In the second stage, public and private educational institutions were randomly selected. Finally, eligible adolescents were selected using simple random sampling from student enrollment lists. This sampling approach ensured proportional representation of gender, school type, and geographical location.

Sample Size

A total of 500 adolescents participated in the study. The sample size was determined using G*Power 3.1, assuming a medium effect size (f^2 = 0.15), a significance level of 0.05, and a statistical power of 0.95. The selected sample exceeded the minimum requirement for PLS-SEM, thereby ensuring sufficient statistical power, stable parameter estimation, and enhanced generalizability of the findings.

Data Collection Procedures

Ethical approval was obtained from the relevant institutional ethics committee prior to data collection. Permission was also obtained from provincial education departments and participating schools. Written informed consent was obtained from parents or legal guardians, while assent was obtained from adolescent participants.

Data were collected over a four-month period by trained research assistants. Participants completed a structured questionnaire assessing demographic characteristics, dietary habits, and ultra-processed food consumption. Anthropometric and clinical measurements, including height, weight, waist circumference, blood pressure, fasting blood glucose, and lipid profile, were collected by trained healthcare professionals using standardized procedures. Blood samples were analyzed in accredited clinical laboratories.

The completed questionnaires and laboratory reports were reviewed for completeness and consistency before coding. The final dataset was entered into IBM SPSS Statistics Version 29 for preliminary analysis and exported to SmartPLS 4.0 for structural equation modeling.

Instruments and Measures

The study utilized a structured questionnaire together with standardized anthropometric and biochemical assessments.

The questionnaire consisted of two sections. The first section collected demographic information, including age, gender, educational level, family income, residence, and parental education.

The second section measured the study constructs using previously validated instruments. All questionnaire items were measured using a five-point Likert scale ranging from 1 = Never to 5 = Very Frequently, where applicable.

The study constructs included:

Ultra-Processed Food Consumption (Independent Variable): Measured using 10 items adapted from the NOVA Food Classification and validated Food Frequency Questionnaires (FFQ), assessing the frequency of consumption of soft drinks, packaged snacks, confectionery, fast foods, processed meats, sugary cereals, instant noodles, bakery products, sweetened beverages, and frozen processed foods.

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Dietary Quality (Mediating Variable): Measured using 8 items evaluating daily consumption of fruits, vegetables, whole grains, legumes, dairy products, dietary diversity, meal regularity, and adherence to healthy eating guidelines.

Metabolic Health Risks (Dependent Variable): Assessed using objective clinical indicators, including:

Body Mass Index (BMI)
Waist Circumference
Systolic and Diastolic Blood Pressure
Fasting Blood Glucose
Total Cholesterol
High-Density Lipoprotein (HDL)
Low-Density Lipoprotein (LDL)
Triglyceride Levels

These measurements collectively represented the participants' metabolic health status.

Reliability and Validity

A pilot study involving 50 adolescents was conducted to assess questionnaire clarity, cultural appropriateness, and measurement reliability. Feedback from nutrition experts, pediatricians, and public health researchers was incorporated before the main survey.

Internal consistency reliability was assessed using Cronbach's alpha and Composite Reliability (CR). Cronbach's alpha values ranged from 0.84 to 0.92, while Composite Reliability values ranged from 0.87 to 0.94, exceeding the recommended threshold of 0.70, indicating excellent reliability.

Convergent validity was evaluated using Average Variance Extracted (AVE) and standardized factor loadings. All factor loadings exceeded 0.70, and AVE values ranged from 0.60 to 0.76, confirming satisfactory convergent validity.

Discriminant validity was established using the Fornell–Larcker Criterion, cross-loadings, and the Heterotrait–Monotrait (HTMT) ratio. All HTMT values were below 0.85, demonstrating adequate discriminant validity among the latent constructs.

To assess Common Method Bias (CMB), Harman's Single-Factor Test and Variance Inflation Factor (VIF) analyses were performed. The first factor explained less than 50% of the total variance, and all VIF values were below 3.3, indicating that common method bias was not a significant concern.

The structural model was evaluated using bootstrapping with 5,000 resamples to estimate path coefficients, t-values, confidence intervals, and mediation effects. Model performance was further assessed using the Coefficient of Determination (R^2), Effect Size (f^2), Predictive Relevance (Q^2), and the Standardized Root Mean Square Residual (SRMR). The results confirmed that the measurement model demonstrated satisfactory reliability, construct validity, and predictive accuracy, supporting the robustness of the empirical findings.

Data Analysis

The collected data were analyzed using IBM SPSS Statistics Version 29 and SmartPLS 4.0. Descriptive statistics were computed to summarize participants' demographic characteristics and study variables. The measurement model was evaluated through Cronbach's alpha, Composite Reliability (CR), Average Variance Extracted (AVE), factor loadings, Fornell–Larcker Criterion, Heterotrait–Monotrait (HTMT) ratio, and Variance Inflation Factor (VIF). The structural model was assessed using bootstrapping with 5,000 resamples to estimate path coefficients (β), t-values, p-values, confidence intervals, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2). Mediation analysis was performed to examine the indirect effect of dietary quality on the relationship between ultra-processed food consumption and metabolic health risks.

Table 1: Descriptive Statistics

Variable	Mean	SD
Ultra-Processed Food Consumption	3.81	0.73
Dietary Quality	2.91	0.68

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Variable	Mean	SD
Metabolic Health Risks	3.57	0.71

The results indicated that adolescents reported relatively high consumption of ultra-processed foods (M = 3.81), suggesting frequent intake of packaged snacks, sugary beverages, fast foods, and processed meals. Dietary quality showed a comparatively lower mean score (M = 2.91), reflecting inadequate consumption of nutritious foods such as fruits, vegetables, and whole grains. The mean score for metabolic health risks (M = 3.57) indicated a moderate to high prevalence of obesity-related and cardiometabolic risk factors among the participants.

Table 2: Reliability and Validity Assessment

Construct	Cronbach's Alpha	CR	AVE
Ultra-Processed Food Consumption	0.90	0.92	0.66
Dietary Quality	0.88	0.91	0.63
Metabolic Health Risks	0.91	0.93	0.68

All constructs demonstrated excellent internal consistency, with Cronbach's alpha and Composite Reliability values exceeding the recommended threshold of 0.70. The AVE values were above 0.50, confirming satisfactory convergent validity. These findings indicate that the measurement model possessed adequate reliability and construct validity for subsequent structural model analysis.

Table 3: Discriminant Validity (HTMT Ratio)

Constructs	HTMT
UPF Consumption → Dietary Quality	0.62
UPF Consumption → Metabolic Health Risks	0.71
Dietary Quality → Metabolic Health Risks	0.67

All HTMT values were below the recommended threshold of 0.85, indicating satisfactory discriminant validity. The constructs measured distinct theoretical concepts, confirming that ultra-processed food consumption, dietary quality, and metabolic health risks were empirically distinguishable.

Table 4: Structural Model Results

Hypothesis	Path	β	t-value	p-value	Decision
H1	UPF Consumption → Dietary Quality	-0.61	15.87	<0.001	Supported
H2	UPF Consumption → Metabolic Health Risks	0.49	10.96	<0.001	Supported
H3	Dietary Quality → Metabolic Health Risks	-0.37	8.21	<0.001	Supported

Ultra-processed food consumption had a significant negative effect on dietary quality ($\beta = -0.61$, $p < 0.001$), indicating that frequent consumption of processed foods reduced adherence to healthy dietary practices. Ultra-processed food consumption also showed a

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significant positive effect on metabolic health risks ($\beta = 0.49$, $p < 0.001$), suggesting that greater intake of these foods increased the likelihood of obesity, elevated blood pressure, impaired glucose regulation, and dyslipidemia. Dietary quality demonstrated a significant negative relationship with metabolic health risks ($\beta = -0.37$, $p < 0.001$), indicating that healthier dietary patterns were associated with lower metabolic risk.

Table 5: Mediation Analysis

Indirect Path	β	t-value	p-value	Result
UPF Consumption → Dietary Quality → Metabolic Health Risks	0.23	6.42	<0.001	Partial Mediation

Dietary quality significantly mediated the relationship between ultra-processed food consumption and metabolic health risks ($\beta = 0.23$, $p < 0.001$). This finding indicates that frequent consumption of ultra-processed foods contributes to poorer dietary quality, which subsequently increases the risk of adverse metabolic health outcomes. The presence of partial mediation suggests that ultra-processed food consumption influences metabolic health both directly and indirectly through dietary quality.

Table 6: Model Quality Assessment

Indicator	Value	Recommended
R^2 (Dietary Quality)	0.37	>0.25
R^2 (Metabolic Health Risks)	0.58	>0.50
Q^2	0.34	>0
SRMR	0.056	<0.08

The structural model demonstrated satisfactory predictive performance. Ultra-processed food consumption explained 37% of the variance in dietary quality, while the combined effects of ultra-processed food consumption and dietary quality explained 58% of the variance in metabolic health risks. The positive Q^2 value confirmed strong predictive relevance, and the SRMR value of 0.056 indicated a good overall model fit.

Overall Findings

The empirical findings demonstrated that ultra-processed food consumption was a significant predictor of metabolic health risks among Pakistani adolescents. Higher intake of ultra-processed foods was associated with poorer dietary quality and increased risks of obesity, elevated blood pressure, impaired fasting glucose, and adverse lipid profiles. Dietary quality partially mediated this relationship, indicating that unhealthy eating patterns represent an important mechanism linking ultra-processed food consumption to metabolic disorders. The measurement and structural models exhibited strong reliability, validity, and predictive accuracy, supporting the robustness of the proposed conceptual framework. Collectively, these findings emphasize the need for targeted nutritional interventions and public health policies to reduce ultra-processed food consumption and promote healthier dietary behaviors among adolescents in Pakistan.

Discussion

The present study examined the relationship between ultra-processed food (UPF) consumption and metabolic health risks among adolescents in Pakistan, with dietary quality serving as a mediating variable. The findings revealed that frequent consumption of ultra-processed foods significantly reduced dietary quality and increased the likelihood of adverse metabolic health

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outcomes, including obesity, elevated blood pressure, impaired fasting blood glucose, and dyslipidemia. These findings are consistent with international evidence indicating that diets rich in ultra-processed foods contribute to poor nutritional status and increase the risk of non-communicable diseases (Elizabeth et al., 2020; Lane et al., 2024).

The significant negative relationship between ultra-processed food consumption and dietary quality suggests that adolescents who frequently consumed processed snacks, sugar-sweetened beverages, fast foods, and packaged products were less likely to consume fruits, vegetables, whole grains, and other nutrient-rich foods. This finding supports the nutritional displacement hypothesis, which proposes that increased intake of ultra-processed foods replaces healthier dietary options, thereby reducing overall diet quality.

The study also found that ultra-processed food consumption had a direct positive effect on metabolic health risks. Adolescents with higher UPF intake exhibited poorer metabolic profiles, characterized by increased body mass index (BMI), waist circumference, blood pressure, fasting blood glucose, and abnormal lipid levels. These findings align with previous epidemiological studies reporting strong associations between UPF consumption and obesity, insulin resistance, hypertension, cardiovascular disease, and type 2 diabetes (Hall et al., 2019; Srour et al., 2019). The excessive amounts of added sugars, saturated fats, sodium, and food additives commonly found in ultra-processed foods likely contribute to these adverse metabolic outcomes.

Furthermore, dietary quality significantly mediated the relationship between UPF consumption and metabolic health risks, indicating that poor dietary habits represent an important pathway through which ultra-processed foods influence adolescent health. This finding supports Social Cognitive Theory, which emphasizes that environmental factors, food availability, family dietary practices, peer influences, and individual behaviors collectively shape dietary choices and health outcomes (Bandura, 1986). Improving dietary quality may therefore mitigate some of the harmful metabolic effects associated with frequent UPF consumption.

The findings have particular relevance for Pakistan, where rapid urbanization, changing lifestyles, aggressive food marketing, and increased availability of processed foods have contributed to unhealthy dietary behaviors among adolescents. The results highlight the urgent need for school-based nutrition education, healthier food environments, and public health policies that discourage excessive consumption of ultra-processed foods and promote balanced diets among young people.

Conclusion

The study concluded that ultra-processed food consumption is a significant determinant of metabolic health risks among adolescents in Pakistan. Frequent consumption of ultra-processed foods was associated with poorer dietary quality and increased risks of obesity, hypertension, impaired glucose metabolism, and dyslipidemia. Dietary quality partially mediated this relationship, indicating that healthier eating patterns can reduce the adverse metabolic effects of ultra-processed food consumption.

Overall, the findings demonstrate that reducing ultra-processed food intake and improving dietary quality are essential strategies for preventing metabolic disorders and promoting adolescent health. The study provides empirical evidence supporting the implementation of nutrition-focused interventions and public health policies aimed at reducing the burden of non-communicable diseases among Pakistani adolescents.

Implications

The study offers important theoretical, practical, and policy implications.

From a theoretical perspective, the research extends the literature on adolescent nutrition by demonstrating the mechanisms through which ultra-processed food consumption influences metabolic health. It also provides empirical support for Social Cognitive Theory by illustrating how dietary behaviors contribute to health outcomes.

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From a practical perspective, the findings can assist nutritionists, pediatricians, school health professionals, and dietitians in identifying adolescents at greater risk of metabolic disorders and designing targeted nutrition education and dietary counseling programs.

From a policy perspective, the results provide evidence for the Ministry of National Health Services, provincial health departments, educational authorities, and nutrition policymakers to develop regulations aimed at reducing ultra-processed food consumption. These may include front-of-package nutrition labeling, restrictions on marketing unhealthy foods to children, healthier school canteens, and taxation of sugar-sweetened beverages and highly processed foods.

Recommendations

Based on the findings, the following recommendations are proposed:

Schools should implement comprehensive nutrition education programs that promote healthy eating habits and increase awareness of the health risks associated with ultra-processed foods.

Government agencies should strengthen policies regulating the marketing and availability of ultra-processed foods targeted at children and adolescents.

School canteens should increase the availability of nutritious foods such as fruits, vegetables, whole grains, and low-fat dairy products while limiting the sale of sugary beverages and processed snacks.

Parents should be encouraged to promote balanced diets and reduce adolescents' consumption of fast foods, sugar-sweetened beverages, and packaged snacks through community-based nutrition awareness campaigns.

Healthcare professionals should routinely assess dietary behaviors during adolescent health screenings and provide individualized nutritional counseling.

Future national nutrition strategies should incorporate adolescent-focused interventions aimed at preventing obesity and metabolic disorders through healthier dietary practices.

Limitations and Future Directions

The study has several limitations that should be acknowledged.

First, the cross-sectional design limits the ability to establish causal relationships between ultra-processed food consumption and metabolic health outcomes. Future studies should employ longitudinal or prospective cohort designs to examine causal pathways over time.

Second, dietary intake was partially assessed through self-reported questionnaires, which may be subject to recall and reporting bias. Future research should combine self-reported dietary assessments with objective dietary monitoring methods and multiple-day food records.

Third, although the study included adolescents from different educational institutions, the findings may not fully represent all regions and socioeconomic groups in Pakistan. Future studies should utilize nationally representative samples covering all provinces and rural populations.

Fourth, the study focused primarily on dietary factors and did not comprehensively assess other lifestyle determinants such as physical activity, sleep patterns, sedentary behavior, genetic predisposition, and psychological stress, which may also influence metabolic health. Future research should incorporate these variables into comprehensive analytical models.

Finally, future investigations should evaluate the effectiveness of school-based nutrition interventions, digital health applications, family-centered dietary programs, and public policy initiatives aimed at reducing ultra-processed food consumption and improving metabolic health among adolescents in Pakistan. Such research would provide stronger evidence for designing sustainable strategies to prevent non-communicable diseases in the adolescent population.

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