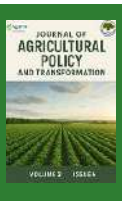

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Junk Food Consumption and Child Health in Khyber Pakhtunkhwa, Pakistan: A Cross-Sectional Econometric Analysis with Agricultural and Food Policy Implications

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ABSTRACT
Rising consumption of energy-dense, nutrient-poor junk food among Pakistani children is increasing public health risks and contributing to the burden of undernutrition and overnutrition. Evidence on behavioral and socioeconomic factors influencing junk food consumption in Pakistan remains limited, particularly its connection with agricultural and food-systems policy. This study examines associations between junk food consumption, media and advertising exposure, parental nutritional awareness, and caregiver-reported health outcomes among children aged 3–14 years in Swabi District, Khyber Pakhtunkhwa. Using primary data from 100 caregivers recruited through convenience sampling at a single clinic, Probit and Logit models were estimated for a binary health-outcome indicator based on caregiver-reported overweight/obesity, dental problems, or persistent fatigue. Model diagnostics indicated adequate fit and specification. Frequent junk food consumption, defined as more than three times weekly, was associated with a 27.6 percentage-point higher probability of health issues ($p<0.01$). Each additional junk food advertisement viewed increased this probability by 7.4 percentage points ($p<0.05$), while higher parental nutritional awareness reduced it by 13.1 percentage points ($p<0.05$). Urban residence was not significant. Given the cross-sectional, single-site, convenience-sampled design, findings represent associations rather than causal effects. Policy implications include healthier school food environments, responsible marketing, nutrition-sensitive agriculture, healthy food value chains, and nutrition education.

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1. INTRODUCTION

The consumption of junk food, defined as energy-dense, nutrient-poor food high in refined sugars, unhealthy fats, and sodium, has escalated into a global public health concern, with children disproportionately affected. The World Health Organization identifies ultra-processed and junk food consumption as a significant contributor to childhood obesity, metabolic disorders such as type 2 diabetes, and adverse cognitive outcomes (WHO, 2023). Globally, ultra-processed food consumption has risen sharply since 2000, with developing countries, Pakistan among them, experiencing the steepest increases, driven by rapid urbanization, aggressive marketing of unhealthy food products, and shifting dietary habits (Global Nutrition Report, 2022).

While regulatory interventions such as sugar taxes and advertising restrictions have moderated some of these risks in high-income countries, South Asia faces a distinct and more complex challenge: a rapid displacement of traditional diets by processed foods, leaving children exposed to a dual burden of persistent undernutrition and rising overweight/obesity. Pakistan exemplifies this transition, with a substantial share of children under five affected by stunting alongside a growing share of school-aged children who are overweight, a paradox that underscores the

severity of the nutritional transition under way (Ataullahjan et al., 2025; Ahmed et al., 2024). Related patterns of early-onset diet-related conditions have also been documented elsewhere in South Asia (Shrestha & Adhikari, 2023).

National survey evidence points to a pronounced urban-rural divide in children's junk food consumption, with urban children consuming carbonated beverages, packaged savory snacks, and instant noodles considerably more often than their rural counterparts, and with consumption concentrated among children aged 8-12 years (National Nutrition Survey (NNS), 2019; Tanveer et al., 2024).

Conceptual and Theoretical Framework

This study is guided by the Food Environment Framework (High Level Panel of Experts on Food Security and Nutrition [HLPE], 2017), read alongside the Social Ecological Model of health behavior (McLeroy et al., 1988). Together, these frameworks conceptualize a child's diet as the outcome of nested layers of influence: (i) individual/child characteristics (age, gender); (ii) household and caregiver behavior, including parental nutritional awareness and monitoring; (iii) the immediate food environment, school canteens, retail food outlets, and advertising/media exposure, which determines the availability, affordability, convenience, and desirability of different foods; and (iv) macro-level agricultural, food-system, and regulatory structures that ultimately shape what is grown, marketed, and sold.

Within this framework, junk food consumption is treated as a proximate behavioral outcome of a food environment in which ultra-processed products are widely available, heavily marketed, and often cheaper or more convenient than fresh alternatives, while parental awareness is modelled as a household-level protective factor that can partially offset environmental risk. This framing motivates the study's joint focus on household-level correlates (media exposure, parental awareness) and its extension, in Section 5, to the food-systems and agricultural-policy levers that shape the wider food environment.

Research Gap and Novelty

The health consequences of junk food consumption among children are well documented globally and increasingly so in South Asia, but Pakistani evidence remains largely descriptive or focused on urban, tertiary-care populations. Comparatively few studies apply a formal binary-choice econometric framework, jointly estimating Probit and Logit models with marginal effects and full diagnostic testing, to weigh the relative contribution of consumption frequency, advertising exposure, and parental awareness to child health outcomes in a semi-rural district of Khyber Pakhtunkhwa, a province that is underrepresented in the nutrition literature relative to Punjab and Sindh.

Moreover, much existing work treats junk food consumption purely as a public-health issue, in isolation from the agricultural and food-systems drivers, retail food environments, food marketing, agricultural diversification, and value-chain development, that determine what foods are actually available and affordable to children. By explicitly connecting the empirical, household-level findings to food-systems and agricultural-policy levers (Section 5), this study aims to contribute evidence of interest to both public-health and agricultural-policy audiences.

Objectives of the Research Study

This study seeks to:

1. Describe urban-rural and socioeconomic patterns of junk food consumption frequency among children aged 3-14 years in Swabi District, Khyber Pakhtunkhwa;
2. Estimate the association between junk food consumption frequency, media/advertising exposure, and parental nutritional awareness and a caregiver-reported child health-issue indicator, using Probit and Logit regression with associated diagnostic and robustness checks; and
3. Discuss the implications of these findings for school food environments, food-marketing regulation, and agricultural and nutrition policy in Pakistan, including nutrition-sensitive agriculture and food-systems transformation.

These objectives correspond to what the study instrument was designed to measure: child health status is captured through caregiver-reported outcomes via a structured questionnaire rather than independent clinical measurement or academic-performance assessment, and the study discusses policy implications rather than evaluating policy efficacy in a causal sense, consistent with its cross-sectional design.

Significance

With tens of millions of Pakistani children facing nutrition-related health risks, this research provides evidence that can help to inform national and provincial policy dialogue, guide targeted school-based nutritional interventions, and

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contribute, alongside the agricultural and food-policy discussion in Section 5, to a more integrated, food-systems view of childhood nutrition in Pakistan.

2. LITERATURE REVIEW

The proliferation of junk food, commercially processed products characterized by high concentrations of refined sugars, unhealthy fats, and sodium, and deficient in essential nutrients (WHO, 2023), constitutes a pressing global pediatric public health challenge. Rapid dietary transitions from traditional diets to ultra-processed alternatives, driven by urbanization, globalized food systems, and marketing targeted at children (Popkin, 1998), warrant continued empirical scrutiny. This review synthesizes evidence on the physical, cognitive, and behavioral impacts of junk food consumption in children, with emphasis on Pakistan and comparable South Asian contexts, before turning to the agricultural and food-systems literature that motivates Section 5.

Global and Regional Patterns

Ultra-processed food consumption has risen sharply worldwide over the past two decades, with the steepest growth in developing countries (Global Nutrition Report, 2022). This shift disproportionately affects children in low- and middle-income countries, where commercial, structural, and socio-cultural factors converge to heighten vulnerability, including weaker regulatory oversight of digital and broadcast food advertising and urban food-retail expansion that increases the accessibility of convenience foods (Popkin, 1998). Socioeconomic constraints compound the problem, as lower-income households often rely on ultra-processed, calorie-dense foods for their low cost despite poor nutritional quality (Shrestha & Adhikari, 2023).

Regional comparisons show substantial junk food consumption across South Asia, with country- and district-level variation. Pakistan shows a marked urban-rural divide, with urban children consuming junk food considerably more frequently than rural children (PNNS, 2018), a pattern broadly consistent with reported trends in India and Bangladesh (Nguyen et al., 2024; Hossain & Simi, 2024).

Physical Health Consequences

Junk food consumption is linked to childhood overweight and obesity in Pakistan, with a Lahore-based study reporting that over a quarter of children exceeded healthy weight parameters, with junk food identified as a contributing factor (Shahid et al., 2022). Frequent junk food consumers also show a markedly higher prevalence of insulin resistance than infrequent consumers, a risk factor for early-onset type 2 diabetes (Basit et al., 2023). Despite high caloric intake, junk food consumption is also associated with micronutrient malnutrition, including iron deficiency and vitamin D insufficiency among Pakistani children (PNNS, 2018), and with a substantially elevated incidence of dental caries among daily consumers relative to minimal consumers (Zafar et al., 2021).

Cognitive and Behavioral Consequences

Beyond physical health, junk food consumption has been associated with cognitive and behavioral difficulties. Children with high junk food intake have been reported to score lower on standardized academic assessments than peers with more balanced diets (Falak et al., 2025), and teacher-reported hyperactivity and attentional difficulties have been linked to frequent junk food consumption, suggesting a possible association with ADHD-like symptomatology (Ahmad et al., 2021 and Hemmingsson, 2018). Proposed mechanisms include synthetic food additives and glycemic variability that may influence adrenergic activity and cortisol regulation (Hemmingsson, 2018).

Socioeconomic, Regulatory, and Awareness Constraints

Pakistan's regulatory landscape for curbing childhood junk food consumption remains fragmented. Only Punjab currently enforces a school canteen junk food prohibition, and monitoring gaps have limited compliance (Punjab Food Authority [PFA], 2017). A federal excise duty on sugar-sweetened beverages has had limited impact on consumption due to enforcement gaps (Drope & Powell, 2024; Ramić, 2024). At the household level, nutritional misinformation is common, a substantial share of rural mothers reportedly consider packaged savory snacks to be a “safe” option for children while structured nutrition education programs struggle with low attendance due to marketing pressure, geographic and linguistic barriers, and scheduling conflicts with caregivers' labor demands (Carducci, 2022).

Food Systems, Nutrition-Sensitive Agriculture, and Agricultural Policy

Growing literature situates children's diets within the wider food system rather than treating consumption as an isolated behavioral choice. In Pakistan, food-systems assessments indicate that although national dietary energy availability is broadly adequate, the food supply falls short of what is needed to support diverse, healthy diets, with persistent shortfalls in fruits, vegetables, and legumes relative to national dietary guidelines, an access and availability

problem rooted in agricultural production and value chains rather than household behavior alone (UNSDG, 2024). This is compounded by an institutional architecture that has historically treated food security primarily as an agricultural production problem rather than a multisectoral nutrition issue (UNSDG, 2024).

Evidence from nutrition-sensitive agricultural interventions elsewhere in South Asia and in comparable low-resource rural settings suggests that agricultural interventions such as homestead food production, nutrition-linked agricultural extension, and support for dietary diversification can measurably improve household dietary diversity and, in some cases, child nutritional and developmental outcomes (Ch et al., 2024; Grant et al., 2025). Political-economy research in Pakistan similarly links water insecurity, food insecurity, and weak multisectoral nutrition governance to child malnutrition outcomes, underscoring that improving children's diets requires coordinated agricultural, water, and social-protection policy rather than health-sector action alone (Ahmed et al., 2024).

At the same time, school food systems are increasingly recognized as a scalable entry point linking agriculture, education, and nutrition policy: government- and NGO-led school meal initiatives in Pakistan illustrate how locally sourced food procurement can simultaneously advance nutrition, education, and food-systems goals (UN Network for SUN, 2025). These strands of literature, nutrition-sensitive agriculture, food environments, and school food systems, inform the Agricultural and Food Policy Implications discussed in Section 6.

Knowledge Gaps

Three gaps motivate this study. First, there is a lack of longitudinal data on the long-term health and developmental consequences of childhood junk food consumption in Pakistan, particularly for cardiometabolic and neurocognitive outcomes. Second, spatial disparities in dietary risk within Pakistan, across rural, peri-urban, and urban settings, remain under-studied outside Punjab and Sindh, limiting the design of regionally tailored interventions. Third, the influence of digital and algorithmic food advertising on children's food preferences remains poorly understood and represents a frontier for future research. This study addresses the second gap directly and speaks to the first and third in its discussion of limitations and future research.

3. MATERIALS AND METHODS

The study adopts a quantitative, observational, cross-sectional design grounded in applied econometrics, based on primary data collected through a structured caregiver questionnaire. Because the dependent variable is binary, the presence or absence of a caregiver-reported health issue, Probit and Logit models are used in place of linear regression, as both predict probabilities bounded between 0 and 1 and accommodate the non-linear relationship between explanatory variables and the likelihood of a reported health issue.

Study Design

The research design is cross-sectional, quantitative, and observational, based on a structured survey administered to parents or guardians. Cross-sectional designs are well suited to capturing associations between variables at a single point in time but cannot, by themselves, establish the direction or causal nature of those associations (see Section 4). The study is non-experimental and relies on naturally occurring variation, an approach commonly used in public health and economic research where randomized designs are not feasible. Data were collected using a 23-item, close-ended questionnaire covering five domains: demographic information, parental awareness and nutritional attitudes, junk food consumption patterns, media exposure and advertising influence, and health and behavioral outcomes. Responses were coded for quantitative analysis using binary or ordinal scales as appropriate.

Study Population and Sampling

The study focuses on children aged 3-14 years; data were collected indirectly via their parents or guardians, who are the primary observers and decision-makers regarding children's diets and health. Data collection took place at a Homeopathic Clinic in Swabi District, Khyber Pakhtunkhwa, a setting frequented by caregivers from a range of socioeconomic backgrounds, which allowed both urban and rural households to be represented in the sample.

A convenience sampling method was used: all caregivers attending the clinic during the data collection period were approached voluntarily. Convenience sampling lacks the rigor of probability-based techniques and carries a material risk of selection bias for example, caregivers attending a homeopathic clinic may differ systematically from the general population in health-seeking behavior, health beliefs, or socioeconomic status. This method was adopted because it was feasible within the resource constraints of the study, and results should be interpreted with this limitation explicitly in mind.

Out of 101 responses collected, 100 valid observations were retained after data cleaning; this sample size (n = 100) is used consistently throughout the manuscript. The sample size was considered adequate under the conventional rule of thumb for Probit/Logit models of 10-15 observations per predictor; with 7 independent variables in the estimated

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models, this threshold is met, though we note in Section 4 that a sample of this size limits statistical power for detecting smaller effects (e.g., gender, age, urban residence) and precludes subgroup or interaction analysis.

Ethical Considerations

This research adhered to standard ethical guidelines. Informed consent was obtained from all participants, who were informed of the study's purpose and procedures and of their right to withdraw at any time without penalty. No personally identifiable data were recorded, and responses were used exclusively for academic research and stored securely.

Questionnaire and Data Collection

The survey instrument captured five domains: (i) Demographic Section (child's age, gender, parental education, household income); (ii) Junk Food Section (frequency and type of junk food consumed (e.g., chips, carbonated drinks, instant noodles)); (iii) Health Section (whether the child experienced any adverse health issue); (iv) Awareness Section (the caregiver's nutritional knowledge and awareness of junk food risks); and (v) Media Exposure Section (the number of junk food advertisements seen per day).

The health-outcome variable was defined as follows: caregivers were asked whether their child had experienced any of a specified set of diet-related health concerns in the preceding period including overweight/obesity, dental caries, or persistent fatigue/low energy based on caregiver observation and, where available, prior clinical consultation. The variable was coded 1 if the caregiver reported any such issue and 0 if none was reported. This measure relies on caregiver reports rather than independent clinical confirmation and is discussed as a limitation in Section 4.

Econometric Model Specification

The purpose of the study was explained to all participants before administering the questionnaire, which took approximately 15 minutes to complete; confidentiality of personal information was maintained throughout.

Both Probit and Logit models were estimated for the binary health-outcome indicator yi, coded so that yi = 1 when the child has a caregiver-reported health issue and yi = 0 when no health issue was reported.

The latent-variable specification underlying both models is:

$$y^*i = xi\beta + \varepsilon i$$

where y*i is an unobserved latent propensity for a health issue, and we observe yi = 1 if y*i > 0 and yi = 0 otherwise. In the Probit model εi is assumed standard normal; in the Logit model εi follows a standard logistic distribution. The marginal effect of a continuous regressor xi in the Probit model is given by:

$$\partial \text{Prob}(y=1)/\partial xi = f(xi\beta)\cdot\beta$$

Both specifications were estimated because they rely on different link functions (cumulative normal versus logistic) but are expected to yield qualitatively similar results; joint estimation therefore serves as a check on sensitivity to functional-form assumptions rather than as two independent hypotheses. The Logit specification is treated as the primary model for substantive interpretation in Section 4 (its coefficients have a direct odds-ratio interpretation, and it is the model for which full diagnostics, Hosmer-Lemeshow, linktest, ROC-AUC, are reported), with the Probit model serving as a robustness check. Marginal effects (Section 4) are interpreted throughout as percentage-point changes in the predicted probability of a reported health issue, evaluated at sample means, and not as percentage changes in that probability for example, a marginal effect of 0.276 for junk food frequency means the predicted probability of a reported health issue is 27.6 percentage points higher for frequent consumers, not that the risk is "27.6% higher." Because the design is cross-sectional and observational, all reported relationships are associations, not estimates of causal effect; potential omitted-variable bias, recall bias (given caregiver self-report), common-source/reporting bias, and reverse causality cannot be ruled out.

Description of Variables

The study variables were categorized into one dependent variable, five independent variables, and two control variables. The dependent variable, Health Issue, is measured as a binary indicator, taking a value of 1 when the caregiver reported a health issue such as overweight/obesity, dental caries, or fatigue, and 0 otherwise. The independent variables capture key behavioral, informational, and socioeconomic factors associated with child health. Junk Food Frequency is a binary measure indicating whether the child consumes junk food more than three times per week. Media Exposure measures the number of junk food advertisements viewed daily, while Parental Awareness is measured using a 0–5 nutrition-awareness index. Household Income represents monthly household income in Pakistani Rupees, and Urban Residence distinguishes urban households from rural households. The analysis also controls for Child Age, measured in completed years, and Gender, coded as 1 for male and 0 for female. These

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variables collectively allow the study to examine the association of junk food consumption and related behavioral and socioeconomic factors with reported health outcomes among children.

4. Table 1: Description of variables

Variable	Type	Description
Health Issue (dependent)	Binary (0/1)	1 = Caregiver-reported health issue (e.g., overweight/obesity, dental caries, fatigue); 0 = No health issue reported
Junk Food Frequency (independent)	Binary (0/1)	1 = Consumes junk food more than 3 times/week, 0 = Less frequently
Media Exposure (independent)	Numeric	Number of junk food advertisements seen daily
Parental Awareness (independent)	Index (0-5 scale)	Score based on nutrition awareness-related questions
Household Income (independent)	Numeric	Monthly income in Pakistani Rupees
Urban Residence (independent)	Binary (0/1)	1 = Urban, 0 = Rural
Age of Child (control)	Numeric (years)	Child's age in completed years
Gender (control)	Binary (0/1)	1 = Male, 0 = Female

Data Analysis Techniques

The collected data were analyzed using a combination of descriptive and inferential statistical techniques to summarize the characteristics of the sampled households and examine the factors associated with reported health issues among children. Descriptive statistics were first used to present the distribution of categorical variables through frequencies and percentages, while continuous variables were summarized using means and standard deviations. Appropriate graphical presentations, including pie charts, bar graphs, and histograms, were also used to illustrate the distribution and patterns of key variables.

For inferential analysis, Probit and Logit regression models were estimated using the Maximum Likelihood Estimation (MLE) approach because the dependent variable, health issue, is binary. The estimated coefficients were interpreted in terms of their direction, magnitude, and statistical significance. To facilitate practical interpretation, marginal effects were calculated and reported as changes in the predicted probability, expressed in percentage points. Results from the Probit and Logit models were compared to assess the consistency and robustness of the estimated relationships.

Several diagnostic measures were employed to evaluate model adequacy and reliability. The Likelihood Ratio (LR) test was used to assess the overall significance of the estimated model, while Pseudo R^2 was reported as an approximate measure of model fit for the binary-response models. The Hosmer–Lemeshow test was used to assess goodness-of-fit for the Logit specification. Variance Inflation Factors (VIFs) were examined to identify potential multicollinearity among explanatory variables.

All statistical and econometric analyses were conducted using Stata 17.

A Priori Expectations

Based on the conceptual framework presented in Section 1, the study expected higher junk food consumption frequency and greater media exposure to be positively associated with the probability of reported child health issues, whereas higher parental nutritional awareness was expected to reduce this probability. Urban residence and lower household income were also expected to be associated with a higher likelihood of reported health problems. These relationships were specified as directional a priori expectations to be empirically tested and were not treated as predetermined findings.

5. RESULTS

Table 2 presents the results of the Probit regression model estimating the association between selected behavioral, socioeconomic, and demographic factors and the probability of a reported health issue among children. The results indicate that junk food consumption frequency has a positive and statistically significant association with reported health issues ($\beta = 0.812$, $p = 0.006$), suggesting that children who consume junk food more frequently are more likely to experience a reported health issue. Media exposure also shows a positive and statistically significant association ($\beta = 0.212$, $p = 0.048$), indicating that greater exposure to junk food advertisements is associated with a higher probability of reported health problems. In contrast, parental nutritional awareness has a negative and statistically significant coefficient ($\beta = -0.370$, $p = 0.031$), suggesting a potentially protective association between greater parental awareness and reported child health outcomes.

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The variable "How often consumed" has a positive coefficient (β = 0.156) and is marginally significant at the 10% level (p = 0.069). Age also shows a negative and marginally significant association (p = 0.080). However, gender (p = 0.546) and urban residence (p = 0.199) are not statistically significant at conventional levels. The constant is negative and statistically significant (β = −1.974, p = 0.003).

Because Probit coefficients are expressed on an underlying latent-index scale, they should not be interpreted directly as percentage-point changes in probability. Marginal effects should therefore be used to quantify the practical magnitude of these associations. Overall, the findings are consistent with the hypothesized relationships between junk food exposure, parental awareness, and child health, but they represent associations rather than causal effects, particularly given the cross-sectional design and sampling approach.

Table 2: Probit Regression Results

Variable	Coefficient (β)	z-value	p-value	95% CI
Junk food frequency (binary)	+0.812	2.75	0.006	0.233 to 1.391
Media exposure score	+0.212	1.98	0.048	0.002 to 0.422
Parental awareness score	-0.370	-2.15	0.031	-0.707 to -0.033
How often consumed	+0.156	1.82	0.069	-0.012 to 0.324
Gender (male = 1)	+0.120	0.60	0.546	-0.272 to 0.512
Age	-0.081	-1.75	0.080	-0.172 to 0.010
Urban residence	+0.265	1.28	0.199	-0.141 to 0.671
Constant	-1.974	-3.00	0.003	-3.264 to -0.684

Table 3 presents the results of the Logit regression model examining the association between behavioral, socioeconomic, and demographic factors and the likelihood of a reported health issue among children. The findings are broadly consistent with those obtained from the Probit specification. Junk food consumption frequency has a positive and statistically significant association with the likelihood of a reported health issue (β = 1.487, p = 0.004). Similarly, media exposure is positively and significantly associated with reported health issues (β = 0.395, p = 0.045), suggesting that greater exposure to junk food advertisements is associated with a higher likelihood of an adverse health outcome. In contrast, parental nutritional awareness has a negative and statistically significant coefficient (β = −0.682, p = 0.029), indicating a protective association between greater parental awareness and the likelihood of reported child health issues.

The variable "How often consumed" has a positive coefficient (β = 0.292) and is marginally significant at the 10% level (p = 0.065). Age has a negative coefficient and is also marginally significant (p = 0.078). However, gender (p = 0.540) and urban residence (p = 0.196) are not statistically significant at conventional levels. The constant is negative and statistically significant (β = −3.618, p = 0.002).

As with the Probit model, the Logit coefficients represent changes in the log-odds of the reported health outcome and should not be interpreted directly as percentage-point changes in probability. Marginal effects should therefore be used to assess the practical magnitude of the estimated associations. Overall, the similar direction, significance, and statistical conclusions across the Probit and Logit models provide evidence that the principal associations are robust to the choice of binary-response model specification. Nevertheless, given the cross-sectional and convenience-sampled nature of the data, these results should be interpreted as associations rather than causal relationships.

Table 3: Logit Regression Results

Variable	Coefficient (β)	z-value	p-value	95% CI
Junk food frequency (binary)	+1.487	2.85	0.004	0.464 to 2.510
Media exposure score	+0.395	2.00	0.045	0.008 to 0.782
Parental awareness score	-0.682	-2.18	0.029	-1.295 to -0.069
How often consumed	+0.292	1.85	0.065	-0.017 to 0.601
Gender (male = 1)	+0.235	0.61	0.540	-0.520 to 0.990
Age	-0.156	-1.76	0.078	-0.330 to 0.018
Urban residence	+0.487	1.29	0.196	-0.253 to 1.227
Constant	-3.618	-3.05	0.002	-5.943 to -1.293

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The Likelihood Ratio test confirms that the overall Logit model is statistically significant (LR chi²(7) = 28.21, p = 0.0003), meaning the included predictors jointly improve prediction of the health outcome relative to a null model. The Pseudo R^2 of 0.224 suggests the model accounts for a moderate share of the variation in reported health outcomes. This McFadden-type Pseudo R^2 is not numerically or conceptually equivalent to the R^2 of an OLS regression and should not be interpreted as "22.4% of variance explained" in the OLS sense; it is best read only as a relative indicator of model fit, and values in this range are common and considered acceptable in health and behavioral research, where individual outcomes are influenced by many unobserved factors.

Table 4: Likelihood Ratio Test and Pseudo R^2

Statistic	Value	p-value
LR chi²(7)	28.21	0.0003
Pseudo R^2	0.224	—

The marginal effects (from the Logit model, evaluated at sample means) quantify the change in the predicted probability of a reported health issue associated with a one-unit change in each predictor, expressed in percentage points:

- Junk food consumption frequency is associated with a 27.6 percentage-point higher probability of a reported health issue (p = 0.004).
- Media exposure is associated with a 7.4 percentage-point higher probability per additional daily advertisement (p = 0.046).
- Parental awareness is associated with a 13.1 percentage-point lower probability (p = 0.030).
- Frequency of consumption shows a marginally significant 5.6 percentage-point association (p = 0.067).
- Gender, age, and urban residence show no statistically significant marginal effect in this sample; the urban coefficient (+8.9 percentage points, p = 0.195) is directionally consistent with higher urban consumption reported in Section 2 but should not be read as a confirmed effect given its non-significance.

Table 5: Marginal Effects

Variable	Marginal effect (dy/dx)	p-value	95% CI
Junk food frequency (binary)	+0.276	0.004	0.088 to 0.464
Media exposure score	+0.074	0.046	0.001 to 0.147
Parental awareness score	-0.131	0.030	-0.249 to -0.013
How often consumed	+0.056	0.067	-0.004 to 0.116
Gender (male = 1)	+0.045	0.541	-0.099 to 0.189
Age	-0.031	0.075	-0.065 to 0.003
Urban residence (n.s.)	+0.089	0.195	-0.046 to 0.224

Deepening the Discussion: Behavioral, Socioeconomic, and Policy Mechanisms

Beyond statistical significance, several plausible mechanisms help explain these associations. Behaviorally, frequent junk food consumption may reflect both habituation and preference formation driven by repeated advertising exposure, particularly given the high volume of child-directed food marketing reported in the Pakistani media environment (PEMRA, 2020); this is consistent with the positive, independent association of media exposure found here even after controlling for consumption frequency. Socioeconomically, time-constrained caregivers, particularly in urban households, may substitute convenience foods for home-prepared meals, while lower-income households may face genuine affordability constraints that make energy-dense processed foods cheaper per calorie than fresh alternatives (Section 2); this affordability dynamic is a food-systems and agricultural-value-chain issue as much as a household behavioral one, which is why Section 5 extends the discussion to agricultural policy. From a policy-mechanism perspective, the protective association of parental awareness is consistent with the Social Ecological Model's household-level pathway (Section 1): caregivers with greater nutritional knowledge may be better positioned to regulate children's diets even within a food environment that makes unhealthy choices convenient, though weak school-level regulation (Section 2) limits how much any single household can mitigate exposure on its own.

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The Hosmer-Lemeshow test compares observed and model-predicted probabilities across risk deciles. With $\chi^2(8) = 6.12$ and $p = 0.632$ ($p > 0.05$), we fail to reject the null hypothesis of no difference between observed and predicted outcomes, indicating the Logit model fits the data adequately.

Table 6: Hosmer-Lemeshow Test Results

Statistic	Value	p-value
Hosmer-Lemeshow $\chi^2(8)$	6.12	0.632

All VIF values fall well below the conventional threshold of 5 (mean VIF = 1.22), indicating no material multicollinearity among predictors.

Table 7: Variance Inflation Factor (VIF) Results

Variable	VIF
Junk food frequency	1.21
Media exposure score	1.17
Awareness score	1.28
How often consumed	1.36
Gender	1.12
Age	1.29
Urban residence	1.10
Mean VIF	1.22

The linktest evaluates model specification: in a correctly specified model, the predicted value (_hat) should be significant and its square (_hatsq) should not. Here, _hat is significant ($p = 0.001$) and _hatsq is not ($p = 0.386$), consistent with correct specification and no evidence of a major omitted nonlinear term.

Table 8: Linktest Results

Variable	z-value	p-value
_hat	3.19	0.001
_hatsq	0.87	0.386

The ROC curve generated from the fitted Logit model, shown in Figure 1, yields an Area Under the Curve of 0.855. An AUC of 0.855 indicates excellent discriminative power by conventional benchmarks (0.7-0.8 = acceptable, >0.8 = excellent), meaning the Logit model discriminates well between children with higher and lower predicted probabilities of a reported health issue based on the included predictors.

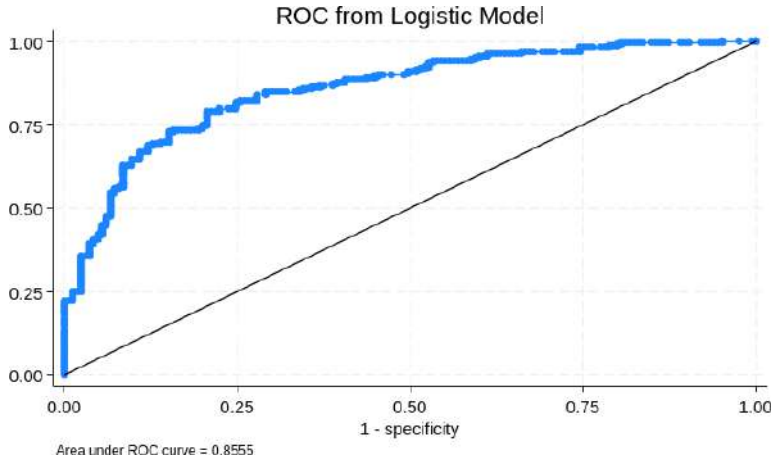

Figure 1: ROC and AUC Results

Summary of Findings and Study Limitations

Taken together, the Logit model is statistically significant overall (LR chi²(7) = 28.21, p = 0.0003), fits the data adequately (Hosmer-Lemeshow p = 0.632), shows no material multicollinearity (mean VIF = 1.22), is correctly specified (linktest), and discriminates well between higher- and lower-risk children (AUC = 0.855). Junk food consumption frequency, media exposure, and parental awareness are the three variables consistently and significantly associated with the reported child health outcome across both the Probit and Logit specifications and the marginal-effects analysis; gender, age, and urban residence are not statistically significant predictors in this sample.

These results should nonetheless be interpreted in light of several limitations. First, the sample was recruited through convenience sampling at a single homeopathic clinic in Swabi District; caregivers attending this clinic may differ systematically from the wider population of Pakistani (or even Khyber Pakhtunkhwa) caregivers in health beliefs and health-seeking behavior, so findings should not be extended to "Pakistani children" in general and are best read as evidence from this specific clinic-attending population. Second, the cross-sectional design cannot establish causality: it cannot be concluded that junk food consumption or media exposure causes adverse health outcomes, or that parental awareness causally reduces them; omitted-variable bias, reverse causality (e.g., caregivers of already-unwell children may alter reporting or recall), and common-source bias (the same caregiver reports both exposure and outcome) are all plausible. Third, the modest sample size (n = 100) limits statistical power, particularly for variables with smaller effects (age, gender, urban residence), and precludes meaningful subgroup or interaction analysis. Fourth, the health-outcome and exposure measures are caregiver-reported rather than independently verified, introducing potential recall and social-desirability bias. These limitations motivate the cautious, associational language used throughout this manuscript and the future-research directions outlined in Section 5.

6. CONCLUSIONS AND POLICY IMPLICATIONS

Conclusion

Rising junk food consumption among children is a significant concern in Pakistan, where urbanization, changing lifestyles, and aggressive marketing have reshaped dietary habits. This study investigated how junk food consumption, media exposure, parental awareness, and related factors are associated with the health outcomes of children aged 3-14 years in Swabi District, Khyber Pakhtunkhwa, using primary data from 100 caregivers and a Probit/Logit econometric framework.

The findings, drawn from the marginal-effects analysis in Section 4, indicate that children whose caregivers reported junk food consumption more than three times per week had a 27.6 percentage-point higher predicted probability of a reported health issue than less frequent consumers, holding other factors constant. Each additional daily junk food advertisement viewed was associated with a 7.4 percentage-point higher probability, while higher parental nutritional awareness was associated with a 13.1 percentage-point lower probability, demonstrating a protective association for informed caregiver behavior. Urban residence showed a higher point estimate (8.9 percentage points) consistent with the descriptively higher urban consumption reported in Section 2, but this association was not statistically significant (p = 0.195) and should not be presented as a confirmed urban-rural difference in health risk without further, adequately powered research.

In plain terms, the results suggest that more frequent consumption of fast food, packaged snacks, and sugary drinks is associated with a meaningfully higher likelihood of reported health concerns such as fatigue, dental problems, weight gain, and difficulty concentrating, and that frequent advertising exposure is associated with a further increase in this likelihood. Caregivers with greater nutritional awareness report fewer such issues in their children, consistent with, though not proof of, a protective role for informed parental monitoring. Because the design is observational and the sample is a single-clinic convenience sample, these should be read as associations that warrant further, more representative research rather than as established causal effects.

Agricultural and Food Policy Implications

Beyond household-level behavior, the findings of this study sit within a wider process of dietary transition in Pakistan that is fundamentally a food-systems phenomenon, not solely a public-health or parenting issue. As discussed in Section 2, Pakistan's food supply currently under-provides the fruits, vegetables, and legumes needed to support healthy diets relative to national guidelines, even where overall caloric availability is adequate (UNSDG, 2024), a gap rooted in agricultural production incentives, value chains, and market access rather than parental awareness alone.

Four food-systems and agricultural-policy priorities follow from this study:

- Nutrition-sensitive agricultural diversification: provincial agricultural extension and input-subsidy programs could incorporate nutrition-sensitive criteria for example, incentivizing diversification toward fruit, vegetable, and pulse production in peri-urban districts supplying Swabi and comparable markets following

the logic of nutrition-sensitive agriculture interventions evaluated elsewhere in South Asia (Ch et al., 2024; Grant et al., 2025).

- Healthy food value chains and retail environments: municipal and district authorities could support short, local value chains for fresh produce (farmers' markets, licensed fruit/vegetable vending near schools) to improve the relative price and convenience of healthy options against ultra-processed alternatives, directly addressing the affordability mechanism discussed in Section 4.
- School food systems: building on Punjab's partial canteen regulations (Section 2), a nationally coordinated school food policy, combining canteen standards with locally procured, nutrition-sensitive school meal or snack programs, could align education, agriculture, and nutrition objectives, consistent with emerging school-meal models in Pakistan (UN Network for SUN, 2025).
- Multisectoral food and nutrition security governance: consistent with political-economy evidence that fragmented governance undermines nutrition outcomes in Pakistan (Ahmed et al., 2024), agricultural, health, and education authorities at federal and provincial levels would benefit from coordinated food and nutrition security planning rather than siloed sectoral action.

Policy Recommendations

In light of the findings above, a 27.6 percentage-point association between frequent junk food consumption and reported health issues, and a 7.4 percentage-point association for advertising exposure, three near-term interventions are recommended alongside the agricultural-policy priorities in Section 5.

First, school canteen regulations should be strengthened and extended beyond Punjab. Provincial Food Authorities should issue clear guidelines restricting the sale of carbonated drinks, packaged chips, and other processed snacks in school canteens, backed by routine inspection and enforceable penalties, since voluntary compliance has proven insufficient (Section 2).

Second, given the significant association between media exposure and reported health issues, restrictions on child-directed junk food advertising should be strengthened across television and digital platforms (YouTube, Facebook, TikTok) through coordinated PEMRA-PTA regulation, including limits on advertising during children's programming.

Third, because urban residence was not a statistically significant predictor in this sample, urban-focused interventions should be framed as responding to the descriptively higher urban consumption documented in the literature (Section 2) rather than to a confirmed urban health-risk differential from this study. With that caveat, expanding access to affordable fresh food, through licensed vendors and farmers' markets near schools, as outlined in Section 5, remains a reasonable complementary measure grounded in the food-environment literature.

Fourth, community-based nutrition education for caregivers should be expanded and adapted to address the participation barriers identified in Section 2 (scheduling conflicts, geographic and linguistic barriers), given the protective association of parental awareness found in this study.

Limitations and Future Research

The principal limitations of this study, convenience sampling from a single clinic, cross-sectional design, modest sample size, and caregiver-reported outcome measures, are detailed in Section 4 and should be read alongside these conclusions and recommendations. Future research would benefit from probability-based, multi-site sampling across rural, peri-urban, and urban Khyber Pakhtunkhwa; longitudinal designs capable of assessing temporal ordering; independently verified (clinician-assessed) health outcomes; and explicit measurement of food-environment characteristics such as distance to healthy food retail and local agricultural diversification, to more directly test the food-systems mechanisms discussed in Section 5.

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