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Socioeconomic Patterning of Household Ultra-Processed Food Consumption in China: Evidence from Family Dietary Decision- Making

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Abstract

Background

Ultra-processed food (UPF) consumption is rising rapidly in middle-income countries, yet evidence on its socioeconomic and behavioral determinants remains concentrated in high-income settings and relies largely on aggregate measures of intake. This study examines household UPF consumption in China from the perspective of the household members responsible for food purchasing and preparation, distinguishing consumption at main meals, outside main meals, and the overall dietary share.

Methods

We conducted a cross-sectional online survey of 1,946 Chinese adults responsible for household food purchasing and preparation (non-probability sample). We estimated ordered-logit models for UPF consumption frequency at main meals and outside them, and a beta regression for the respondent-estimated share of UPFs in the weekly household diet (Smithson–Verkuilen adjustment of boundary values). Guided by the nutrition transition framework and a Theory of Planned Behavior–informed selection of variables, the share model included mean-centered income × education and age × education interactions. All specifications were re-estimated excluding takeout frequency as a robustness check.

Results

Education was positively associated with consumption frequency at main meals and outside them (28% and 24% higher odds per standard deviation). Takeout frequency was the most consistent correlate across all three outcomes, with a one-point increase nearly tripling the odds of more frequent consumption. Online grocery purchasing and urban residence were associated with consumption outside main meals and with the dietary share. Willingness to cook was associated with lower consumption in all three outcomes (38% and 28% lower odds). The income association with the dietary share shifted from positive among the less educated (ratio 1.10) to negative among the more educated (ratio 0.93). Principal associations were unaffected or strengthened when takeout frequency was excluded.

Conclusions

Among Chinese household food decision-makers, UPF consumption shows education-led socioeconomic patterning, with takeout delivery as the most proximal channel of the modern food environment and household willingness to cook as a consistent protective correlate. The patterns are consistent with China remaining in the pre-reversal segment of the nutrition transition while revealing emerging socioeconomic heterogeneity across households and eating contexts.

Clinical trial number:

Not applicable.

1. Background

The global rise in ultra-processed food (UPF) consumption has drawn increasing attention from researchers and public health authorities due to its association with adverse health outcomes, including potential harms to individuals with chronic kidney disease, obesity, type 2 diabetes, and cardiovascular disease [1–3]. UPFs are industrial formulations that contain little to no whole food, often rich in added sugars, sodium, and saturated fats, and are designed for convenience, palatability, and extended shelf life. While high-income countries have long reported elevated UPF intake, middle-income countries such as China are now experiencing rapid dietary transitions driven by urbanization, rising incomes, and changes in food environments [4]. This shift carries important implications for public health policy, food security, and healthcare systems, particularly as the widespread availability and strategic placement of UPFs in retail environments are likely to drive their purchase and consumption [5].

Food processing enhances food safety and preservation, improves transportability and availability, and reduces losses and production costs [6–7]. The relevant distinction is therefore not between processed and unprocessed foods in general, but between forms and purposes of processing. The NOVA system classifies foods into four groups according to the extent and purpose of industrial processing: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods (UPFs) [8–10]. UPFs are industrial formulations made largely from refined substances and additives, with little or no intact whole food, and are typically designed for convenience, long shelf life, and high palatability [11].

UPFs account for a substantial share of diets in many high-income countries. Estimates indicate that they provide about 45% of daily energy intake among Canadian adults and 57.9% in the United States, while household availability across Europe ranges from approximately 10% in Portugal to 50% in the United Kingdom [1, 12–13]. Their consumption is also expanding in middle-income countries [14–15]. In China, data from the China Health and Nutrition Survey indicate that the mean daily intake of UPFs increased from 12.0 g in 1997 to 41.5 g in 2011, while their contribution to total energy rose from 1.0% to 3.6% [16]. More recent evidence from Guangdong reports that the share of dietary energy from UPFs increased from 0.88% in 2002 to 8.52% in 2022 [17]. Although these levels remain comparatively low, their rapid growth reflects China's changing food environment.

The socioeconomic distribution of UPF consumption varies by country. Income is positively associated with intake in Brazil and Mexico, where greater purchasing power may facilitate access to industrialized convenience foods [18–19]. In the United States, however, higher consumption is more concentrated among lower-income groups [20]. Education follows a similarly context-dependent pattern: it is positively associated with UPF intake in some middle-income settings but negatively associated in high-income

countries, where nutritional knowledge and health-oriented preferences may be more established [18–20]. These contrasting findings indicate that income and education do not have universal associations with UPF consumption and should be interpreted in relation to each country's stage of dietary and economic change.

Demographic and household characteristics also shape consumption. Younger adults generally report higher UPF intake [21–22], a pattern also observed among adolescents [23]. Evidence by sex is mixed, while the association with marital status varies across countries: several studies report greater consumption among unmarried adults, whereas recent evidence from Türkiye finds higher intake among married respondents [24, 25]. Urban residence and employment conditions may influence consumption through differences in food access, work routines, and time constraints [24, 26]. Household food practices are also relevant. Cooking and food-preparation skills can increase the capacity to select less processed alternatives, whereas limited willingness or time to cook may increase reliance on convenient products [25].

The relationship between UPF intake and household weight status offers another reason to examine these consumption patterns. Studies in high- and middle-income countries generally report a positive association between UPF consumption and adiposity [12, 16, 27–28]. Because most of this evidence is observational, however, weight status and UPF consumption should be treated as associated outcomes rather than interpreted as having a unidirectional causal relationship. Existing studies therefore document both the expansion of UPF consumption and substantial variation by socioeconomic position, demographic characteristics, food access, and household food practices [17, 24]. Nevertheless, most analyses use aggregate intake measures [16] or focus on health outcomes [29]. Limited evidence distinguishes the correlates of UPF consumption at main meals from those operating outside them—with Chang et al. [30] serving as a rare exception—and few studies examine these patterns from the perspective of household members responsible for food purchasing and preparation [25].

Empirically, multiple linear regression is commonly used when UPF intake is expressed as a continuous share of dietary energy [18], whereas logistic and mixed-effects logistic models are frequently applied when UPF intake is used to explain binary health outcomes, particularly overweight and obesity [12, 16, 29]. Beta regression has also been used to model the proportional contribution of NOVA food groups to dietary intake [31], consistent with its suitability for continuous outcomes bounded between zero and one [32]. A critical unresolved question is how individual attitudes, perceived behavioral control, and social norms jointly shape consumption decisions [33–34]. Yet existing studies rarely examine these behavioral processes in China, focusing either on health consequences, such as overweight and obesity [16, 29], or on aggregate consumption levels over time [17], with little insight into how intake varies across eating contexts [30].

This paper examines the socioeconomic and behavioral correlates of household ultra-processed food consumption in China. The analysis follows a theory-informed framework drawing on the Theory of Planned Behavior [33] and life-course food-choice research [35], adapted to household-level dietary

decision-making and differentiated across eating contexts. We examine UPF consumption from the perspective of household members responsible for food purchasing and preparation, while jointly considering socioeconomic characteristics, digital food-acquisition channels, household food-preparation behavior, and demographic factors. We further distinguish consumption at main meals, outside main meals, and the overall dietary share. By combining household food decision-making with eating context and socioeconomic heterogeneity, the study provides a multidimensional account of the correlates of UPF consumption in China.

This dual focus—linking a theory-informed framework to household-level dietary decisions and distinct eating contexts—structures the study's empirical contribution. The analysis is also grounded in the nutrition transition framework [36–37], which suggests that markers of socioeconomic modernization may be positively associated with UPF intake at China's current stage of development. Using original survey data from 1,946 adults responsible for household food choices, we estimate ordered logit models for consumption frequency at main meals and outside them, and beta regression for the respondent-estimated share of UPFs in the total weekly household diet. This design distinguishes UPF consumption at main meals, outside main meals, and in overall dietary composition, while examining whether socioeconomic patterning varies across the population.

2. Methods

2.1. Theoretical background

This analysis employs two complementary theoretical layers pitched at different levels of explanation. The distinction is conceptual, not statistical: it concerns where each layer locates its account of UPF consumption, not the level at which the data are observed—which is uniformly the household. At the macro level, the nutrition transition framework describes the systematic shift in national diets toward processed, energy-dense foods as economies urbanize and incomes increase [36–37]. A central finding in this literature concerns the social distribution of this shift: during the early and intermediate stages of the transition, consumption of industrialized foods is concentrated among higher-income, more educated, and more urbanized groups, for whom such foods are accessible, aspirational, and compatible with modern work and time constraints. In later stages, once these products become inexpensive and widely available, the pattern reverses, with consumption shifting toward lower socioeconomic strata, as extensively documented in the United States and the United Kingdom [20, 28].

China, which has undergone the largest and fastest dietary transformation in recent decades, is likely still in the pre-reversal segment of this trajectory [16]. The nutrition transition framework thus suggests a directional relationship that can be tested with the available data: markers of socioeconomic modernization, including income, education, urban residence, and integration into modern food-acquisition channels, may be positively associated with household UPF consumption [16, 37]. Accordingly, these markers of socioeconomic modernization are interpreted not only as individual or household attributes but as household-level signatures of a broader, system-wide transformation.

At the micro level, we draw on the Theory of Planned Behavior (TPB) [33], extended with life-course considerations from food-choice research [35], to organize which individual and household characteristics enter the analysis and the behavioral channels through which they may operate. In the TPB, intention proximally influences behavior and is shaped by three constructs: attitudes toward the behavior; subjective norms; and perceived behavioral control. Perceived behavioral control may also affect behavior directly when individuals face constraints on their ability to act. Schematically, intention and behavior can be represented as follows:

$$I_i \quad = f(A_i,\ SN_i,\ PBC_i),$$

$$B_i = g(I_i,\ PBC_i),$$

where, in the present model, I_i denotes the intention of individual or household i to consume UPFs; B_i denotes observed UPF consumption behavior; A_i represents attitudes toward UPF consumption, shaped by prior experience, information, and the perceived consequences of the behavior; SN_i denotes subjective norms, representing the perceived social expectations from relevant others, particularly household members; and PBC_i represents perceived behavioral control over consuming or avoiding UPFs, reflecting skills, resources, opportunities, and constraints. These expressions provide a conceptual representation of the behavioral process rather than a structural model estimated directly, since the survey does not contain validated measures of all TPB constructs.

2.2. Operationalization of the conceptual framework

The TPB constructs are latent psychological variables. The survey instrument was designed to capture household food behavior and socioeconomic profiles, not to elicit the multi-item psychological scales needed to estimate the TPB structurally. We therefore do not attempt to estimate the structural model. Instead, the framework serves two disciplined functions: it selects, ex ante, the blocks of observable variables that enter the empirical model and identifies the construct each block proxies, and it anchors each block's interpretation in the nutrition transition framework, which situates household food choices within a broader process of dietary modernization.

Table 1 organizes the constructs into three blocks based on their role in the empirical analysis. The first block comprises the main theoretical constructs—attitudes and life course, subjective norms and household context, perceived behavioral control, and the food environment—operationalized through the empirical variables AGE, EDU, MARRY, COOKING, WILLING, LINCOME, JOBFULL, STUDENT, CITY, ONLINE, TAKEOUT. These are the constructs whose associations with UPF consumption the framework predicts and that carry the directional priors into the analysis. The second block contains demographic and regional controls (GENDER, EC) and a household health correlate (OVER), included to absorb compositional and health-context differences without claiming a causal interpretation in either direction.

Table 1
Theoretical constructs and their empirical proxies

Group	Construct	Definition	Variable(s)	Proxy rationale	Proxy limitations
SES; D	Attitudes and life course	Evaluation of UPF consumption shaped by accumulated experience and information	EDU, AGE	Age indexes formative exposure to traditional versus modern diets; education indexes nutritional information and processing of health messages	Indirect proxies; no direct attitude measurement
D	Subjective norms and household context	Perceived social pressure and normative environment of the food decision	MARRY, EC	Marital status defines the audience of daily food decisions; region proxies' broader normative context	Structural correlates of norms, not measured normative beliefs
HC; SES	Perceived behavioral control and personal food system	Capacity and constraints to prepare food and to resist convenient alternatives	COOKING, WILLING, LINCOME, JOBFULL, STUDENT	Cooking practice and willingness capture effective preparation capacity; LINCOME (log of monthly household income) relaxes budget constraints; occupational status captures time constraints	Realized behaviors rather than perceptions; income and cooking are choices potentially co-determined with diet
FE	Food environment (structural food-choice influences)	Physical and digital accessibility of UPFs	CITY, ONLINE, TAKEOUT	Urban residence and acquisition channels measure exposure to the modern retail and delivery environment	Self-reported channel use; channel choice is itself behavioral
D	Demographic controls	Respondent sex	GENDER	Absorbs compositional differences by sex	No directional prior; included to avoid omitted-variable bias
D	Household health correlate	Household weight status	OVER	Included as a control for household health context	Plausibly simultaneous with diet; no causal reading is warranted in either direction

2.3. The reduced-form empirical model

For estimation, the variables in Table 1 are grouped into four functional categories. Let Y_i^* denote household i's latent propensity to consume UPFs. We specify the following reduced-form model:

$$Y_i^* = \beta'_{SES} SES_i + \beta'_{FE} FE_i + \beta'_{HC} HC_i + \beta'_{D} D_i + \epsilon_i$$

1

where SES collects the socioeconomic resource variables (LINCOME, EDU); FE the food-environment group (CITY, ONLINE, TAKEOUT); HC the household-capacity group (COOKING, WILLING, JOBFULL, STUDENT); and D the demographic and regional controls (AGE, GENDER, MARRY, EC), together with the household health control (OVER). We estimate the same specification for all three outcomes: an ordered logit for consumption frequency at main meals (MAIN) and outside main meals (NOMAIN), and a beta regression for the UPF share of the household diet (PROP).

Two interpretive commitments hold throughout the paper. First, the coefficients in Eq. (1) are theory-informed reduced-form associations: the framework selects and organizes the regressors and signs the predictions, but the estimates are not structural parameters of the TPB, and no mediation through the latent constructs is identified or claimed. Second, because the data are cross-sectional and self-reported, all results are read as conditional associations. Several regressors—most clearly cooking practice, takeout use, and household weight status—are plausibly co-determined with diet. We return to the resulting interpretive limits in the Discussion.

These theoretical considerations yield a small set of empirical expectations. Because China is likely still situated on the pre-reversal segment of the nutrition transition [16, 37], household income, education, and urban residence should be positively associated with UPF consumption. Greater integration into the modern food environment, particularly through takeout and online food purchasing, should also be associated with higher consumption. In contrast, household food-preparation capacity, reflected in cooking practices and willingness to cook, should be associated with lower consumption. We test whether the positive association between household income and UPF consumption weakens with educational attainment, consistent with an incipient education-led moderation of the nutrition transition. In addition, we distinguish UPF consumption across structured main meals and unstructured eating occasions to describe how intake is distributed across eating contexts.

2.4. Dataset

We collected the data for this study through a survey administered via the WeChat-based WenJuanXing Mini Program from July to September 2024. The survey targeted individuals aged 18 and above who were primarily responsible for purchasing, handling, and preparing food in their households. The study protocol was approved by the Ethics Review Committee of the West China Medical Center, Sichuan Medical University (IRB No. 2024 − 826), and all participants provided informed consent electronically. Of the 2,278 responses received, 332 (14.6%) were excluded because of incomplete or inconsistent entries,

leaving an analytical sample of 1,946 respondents. The survey collected information on age, sex, education level, marital status, occupation, working hours, willingness to cook, cooking skills, household disposable income, family composition, frequency of cooking and takeout, food purchasing methods, presence of overweight or obese family members, region, and residence type. Data cleaning involved recoding certain variables for clarity and consistency, such as converting categorical responses into dummy variables and adjusting erroneous entries.

The survey relies on non-probabilistic convenience sampling through a widely used Chinese digital platform. While this design does not support population-level generalization, it is appropriate for examining associations among household food decision-makers—the specific target group of this study—provided the analytical objective is to identify structural relationships rather than estimate national prevalence [38–39]. All inference is conducted with robust standard errors.

2.5. Variable definitions

The dependent variables MAIN and NOMAIN measure the frequency of UPF consumption during main meals and outside them, respectively, on a five-point Likert scale (1 = Never to 5 = Always). PROP is the respondent-estimated share of UPF in total weekly household food consumption, interpreted as a measure of perceived UPF intensity, normalized to the unit interval. The raw distribution contains 57 observations (2.9%) with a reported share of exactly zero and no observations at exactly one. To meet the beta regression requirement of values strictly within the open unit interval, we adjusted these boundary values using the Smithson–Verkuilen transformation, which maps observed proportions from [0, 1] to (0, 1) while preserving their relative distances [40].

The median estimated share in the full sample was 0.26 (IQR: 0.18–0.44). Because PROP is a respondent estimate rather than a dietary-recall measure, we assessed its internal consistency by cross-tabulating it with the self-reported frequency scales. Table A.4 shows that the median estimated share rises monotonically across the five MAIN categories—from 0.17 among households reporting "never" to 0.78 among those reporting "always"—indicating that the estimated share orders households consistently with self-reported consumption intensity. The same monotonic pattern holds for the NOMAIN scale (median rising from 0.18 to 0.66), as reported in Table A.4. At the same time, even households reporting 'never' consuming UPFs reported a median estimated share of 0.17—well above zero—indicating that respondents classify foods into UPF categories more broadly than the NOVA system does, inflating the level of the estimated share relative to energy-share estimates from recall-based surveys. We therefore interpret PROP as an ordinal measure of perceived UPF intensity and not as a direct estimate of the energy contribution of UPFs.

Table 2 defines the independent variables in the empirical models and groups them by the functional categories of Eq. (1): socioeconomic resources (SES), food environment (FE), household capacity (HC), and demographic controls (D). All definitions follow the survey instrument, and coding decisions are noted where applicable. Descriptive statistics are reported in Appendix A.

Table 2
Variable definitions

Groups	Variable	Definition
SES	EDU	Years of formal education.
	LINCOME	Natural logarithm of monthly household income (yuan).
FE	CITY	Urban residence (1 = City, 0 = Countryside).
	ONLINE	Primary food source is online grocery (1 = Online, 0 = Otherwise).
	TAKEOUT	Frequency of purchasing takeout food (Likert: 1 = Never to 5 = Always).
HC	COOKING	Frequency of cooking at home (Likert: 1 = Never to 5 = Always).
	WILLING	Willingness to cook (1 = Willing, 0 = Not willing).
	JOBFULL	Full-time employment (1 = Full-time, 0 = Otherwise).
	STUDENT	Student status (1 = Student, 0 = Otherwise).
D	AGE	Respondent age in years.
	GENDER	Respondent sex (1 = Female, 0 = Male).
	MARRY	Marital status (1 = Married, 0 = Unmarried).
	EC	Eastern China region (1 = Eastern China, 0 = Otherwise).
	OVER	At least one household member is overweight (1 = Yes, 0 = Otherwise).

2.6. Empirical strategy

The two frequency outcomes, MAIN and NOMAIN, are measured using a five-point Likert scale (1 = Never to 5 = Always). Because these responses are inherently ordered, we estimate ordered-logit models, which treat the observed outcome as arising from a latent continuous variable separated by estimated threshold parameters [41]. The proportional-odds (parallel-lines) assumption, which requires covariate effects to remain constant across cumulative response thresholds, was assessed using likelihood-ratio tests of nominal effects for each covariate. Where evidence of non-proportionality was detected, partial proportional-odds specifications were estimated as robustness checks, allowing the corresponding coefficients to vary across thresholds while retaining the proportional-odds restriction for the remaining covariates [42]. All coefficients are reported in log-odds form [41].

The share outcome, PROP, is continuous and bounded in the unit interval, so ordinary least squares is unsuitable because it may produce fitted values outside the admissible range and does not accommodate the distributional features of proportion data. We therefore estimate a beta regression with a logit link [32], which models the conditional mean of the UPF share on the logit scale while allowing its dispersion to be governed by a precision parameter. We use the same baseline specification

across all three outcomes, including household income, education, urban residence, food-acquisition and preparation variables, and the full set of controls.

The PROP model additionally includes two theoretically motivated interactions: income × education, which tests whether the association between household income and the UPF share weakens with educational attainment, consistent with an incipient, education-led moderation of the nutrition transition; and age × education, which captures whether the association with education varies across the life course. AGE, EDU, and LINCOME are mean-centered before estimation of the proportion model, so that zero on each centered variable corresponds to its sample mean. Consequently, their constituent coefficients are interpreted at substantively meaningful reference values: the association of income is evaluated at mean education, that of age at mean education, and that of education at mean age and income. The interaction terms are constructed from these centered variables, preserving the underlying interaction effects while facilitating interpretation of the constituent terms [43].

3. Results

Table 3 reports the regression coefficients and model-fit statistics for the three outcomes. We estimate the MAIN and NOMAIN equations by ordered logit with flexible thresholds (log-odds coefficients) and the PROP equation by beta regression with a logit link (logit-scale coefficients). Standard errors appear in parentheses.

Table 3
Estimated regression results

Group	Variable	MAIN (Ordered Logit)	NOMAIN (Ordered Logit)	PROP (Beta Regression)
SES	EDU	0.044**	0.038*	0.009
		(0.015)	*(0.015)*	*(0.007)*
	LINCOME	0.008	0.020	0.011
		(0.061)	(0.061)	*(0.028)*
FE	CITY	0.240.	0.523***	0.196**
		(0.146)	*(0.150)*	(0.069)
	ONLINE	0.130	0.235*	0.161***
		(0.102)	*(0.102)*	*(0.047)*
	TAKEOUT	1.008***	1.011***	0.392***
		(0.073)	*(0.073)*	*(0.032)*
HC	COOKING	-0.006	0.078*	-0.096***
		(0.038)	*(0.039)*	*(0.018)*
	WILLING	-0.481***	-0.325**	-0.144**
		(0.103)	*(0.103)*	*(0.048)*
	JOBFULL	0.177	-0.029	-0.081
		(0.145)	*(0.145)*	*(0.066)*
	STUDENT	0.523*	0.160	-0.074
		(0.221)	*(0.221)*	*(0.102)*
D	AGE	-0.024***	-0.039***	-0.019***
		(0.006)	(0.006)	(0.003)
	GENDER	0.064	-0.182.	0.023
		(0.098)	*(0.099)*	*(0.045)*

Note: *Significance levels are *** p < 0.001, ** p < 0.01, * p < 0.05,. p < 0.1; dashes indicate that the variable is excluded from that specification. Coefficients are reported as log-odds for the ordered-logit models and on the logit scale for the beta-regression model, with robust standard errors in parentheses. Odds ratios and exponentiated beta-regression coefficients (ratios) for the principal associations are reported in the text; full estimates with 95% confidence intervals for all covariates are reported in Appendix Table A.6.*

Group	Variable	MAIN (Ordered Logit)	NOMAIN (Ordered Logit)	PROP (Beta Regression)
	MARRY	0.326*	0.287.	0.271***
		(0.156)	*(0.159)*	*(0.073)*
	EC	-0.176.	-0.176.	-0.067
		(0.101)	*(0.101)*	*(0.047)*
	OVER	0.156	0.222*	0.112*
		(0.097)	*(0.098)*	*(0.045)*
Interactions	LINCOME × EDU	—	—	-0.015*
				(0.006)
	AGE × EDU	—	—	-0.002***
				(0.001)
	Observations	1,946	1,946	1,946
	Log-likelihood	−1,939.42	−1,892.50	563.59
	Pseudo R^2	—	—	0.16

Note: *Significance levels are *** p < 0.001, ** p < 0.01, * p < 0.05,. p < 0.1; dashes indicate that the variable is excluded from that specification. Coefficients are reported as log-odds for the ordered-logit models and on the logit scale for the beta-regression model, with robust standard errors in parentheses. Odds ratios and exponentiated beta-regression coefficients (ratios) for the principal associations are reported in the text; full estimates with 95% confidence intervals for all covariates are reported in Appendix Table A.6.*

Proportional-odds diagnostics showed no evidence of non-proportionality for any covariate in the MAIN model. For NOMAIN, non-proportionality was detected only for gender (p = 0.011) and the Eastern China indicator (p = 0.044). A partial proportional-odds specification allowing these coefficients to vary across thresholds significantly improved model fit relative to the standard ordered logit (LR $\chi^2(6) = 20.70$, p = 0.002), without materially changing the substantive results.

Overall, the results are broadly consistent with the theoretical framework while also revealing substantial heterogeneity across outcomes. The ordered-logit models for MAIN and NOMAIN describe UPF consumption frequency at structured main meals and unstructured eating occasions, respectively, and the beta-regression model for PROP captures the overall dietary share and shows that the associations of income, education, and age are not uniform across households, as reflected in the income × education and age × education interactions. Table A.6 reports the corresponding odds ratios (ORs) for the ordered-logit models—expressing the factor by which the odds of more frequent consumption change per unit of each predictor—and, for the beta regression, the corresponding ratios, which express the multiplicative

change in the odds of the expected share. The discussion below examines these findings in turn, focusing on socioeconomic patterning, food environments, household food capacity, and demographic and regional controls.

For socioeconomic resources, education is positively associated with UPF consumption at both main meals and outside main meals, indicating that higher educational attainment corresponds to more frequent UPF consumption in both eating contexts. One standard deviation of educational attainment (5.5 years) is associated with 28% higher odds of more frequent consumption at main meals (OR = 1.28) and 24% higher odds outside main meals (OR = 1.24). This pattern is consistent with the nutrition transition framework, which suggests that in middle-income settings socioeconomic modernization may initially be linked to greater exposure to convenience-oriented norms and modern food environments [16, 37]. In the PROP model, however, the constituent coefficients on education and household income are not statistically significant.

Regarding the food environment variables, takeout frequency is positively and statistically significantly associated with all three outcomes. A one-point increase in takeout frequency is associated with 174% higher odds of more frequent UPF consumption at main meals (OR = 2.74) and outside main meals (OR = 2.75). Urban residence and online grocery purchasing are positively associated with consumption outside main meals (69% and 26% higher odds, OR = 1.69 and 1.26, respectively) and with the overall dietary share. In contrast, their associations with structured main meals do not reach conventional statistical significance. The expansion of online food purchasing and the changing urban food environment in China are well documented in the literature [16, 37, 44–45]. Taken together, these patterns suggest that the associations between the modern food environment and UPF consumption vary across eating contexts and outcome measures.

Because takeout frequency is conceptually proximal to the outcome — in the Chinese context, delivered meals are disproportionately processed and energy-dense, so the channel overlaps with the content it delivers — we re-estimated all three specifications excluding it (Appendix Table A.5). The education gradient in the frequency models, the links of urban residence and online grocery purchasing across all three outcomes, the negative effect of willingness to cook, and both socioeconomic interactions remain statistically significant and, in most cases, increase in magnitude; no principal association changes sign. The coefficient on student status, by contrast, is not robust to this specification.

Household capacity variables present a more nuanced pattern of association with UPF consumption. Willingness to cook is negatively and statistically significantly associated with all three outcomes: it is associated with 38% lower odds of UPF consumption at main meals (OR = 0.62) and 28% lower odds outside them (OR = 0.72), with a correspondingly lower estimated dietary share. This pattern is consistent with the Theory of Planned Behavior [33], insofar as willingness to cook may capture attitudinal and motivational aspects of food preparation in household dietary decision-making. Its consistent relationship across eating contexts and with the overall dietary share suggests that willingness to cook may represent an important dimension of household food choice.

Cooking frequency, by contrast, shows a context-dependent pattern. It is not significantly related to UPF consumption at main meals; it is positively related to consumption outside main meals—though this link is not robust to excluding takeout frequency (Appendix Table A.5); and it is negatively related to the overall UPF dietary share. This contrast suggests that cooking often at home does not necessarily reduce UPF consumption outside structured meals, even though it accompanies a lower overall contribution of UPFs to the household diet. The result highlights the importance of distinguishing meal-specific consumption frequency from overall dietary composition when examining household food-preparation behavior.

Student status is positively associated with UPF consumption during main meals but is not significantly associated with the other two outcomes. This association is not robust to excluding takeout frequency (Appendix Table A.5)—a channel through which students disproportionately obtain food—and we therefore treat it as descriptive rather than as an independent finding. The pattern is nonetheless consistent with descriptive evidence from China suggesting relatively rapid growth in the dietary share of UPFs among students and their greater representation in the highest consumption quartile [17, 29]. Li et al. [17] relate higher UPF intake among younger adults to more frequent consumption of food prepared outside the home and less engagement in cooking. By contrast, full-time employment is not significantly associated with any of the three outcomes, suggesting that employment status alone may not adequately capture the differences in time constraints, workplace food environments, or household meal arrangements through which work could plausibly shape diet within the population represented by our sample.

Among demographic characteristics, age is negatively and statistically significantly associated with UPF consumption across all three outcomes, consistent with evidence suggesting that younger individuals tend to consume more ultra-processed foods [21–22]. Respondent sex is not significantly associated with UPF consumption at main meals or with the overall dietary share. For consumption outside main meals, the association is negative and only marginally significant, which may suggest women report lower consumption than men. This pattern aligns with evidence that sex does not uniformly predict UPF intake across settings [24], although some studies report higher consumption among men [21].

By contrast, marital status is positively associated with all three outcomes, reaching conventional statistical significance for main meals and the overall dietary share, and marginal significance outside main meals. This result accords with evidence from Türkiye, where married adults reported higher UPF consumption than their single counterparts [25]. However, international evidence more generally has linked marriage or cohabitation to lower UPF intake [24]. These divergent patterns suggest that the relationship between marital status and UPF consumption may depend on sociocultural and household contexts.

The Eastern China indicator is negatively associated with all three outcomes, reaching marginal statistical significance for consumption at main meals and outside main meals in the baseline specification, though not for the overall dietary share. These marginal associations are no longer

statistically significant when takeout frequency is excluded (Appendix Table A.5). This pattern may reflect the possibility that households in the more developed eastern region are further along in the nutrition transition and beginning to show greater health-oriented differentiation in dietary behavior [37]. This interpretation should remain cautious, however, given the limited statistical strength of the regional estimates, their sensitivity to specification, and the broad nature of the indicator.

Finally, the household weight environment, captured by the presence of at least one overweight household member, is positively associated with UPF consumption outside main meals and with the overall dietary share, but is not significantly associated with consumption at main meals. These findings align with the broader literature documenting a positive association between UPF intake and adiposity [27–28]. In the present sample, this pattern suggests that the relationship between household weight status and UPF consumption may be more apparent in overall dietary composition than within main meals themselves.

Beyond the frequency models, the beta regression expresses associations on the logit scale of the expected share; evaluated at the sample median (0.26), these correspond to a 32% higher estimated share per point of takeout frequency, a 12% higher share for online grocery purchasing, and a 10% lower share for willingness to cook. The proportion model also identifies two interactions showing that the associations of income, education, and age with the UPF share vary across households.

The negative income–education interaction is statistically significant, suggesting that the association between household income and the UPF share becomes more negative as educational attainment increases. Numerically, the income ratio—the multiplicative change in the odds of the UPF share per unit of log income—is approximately 1.10 at one standard deviation below mean education; that is, among the less educated, wealthier households tend to consume more UPF. At one standard deviation above mean education, the ratio is 0.93—among the more educated, wealthier households tend to consume less, although this estimate is less precise. Equivalently, the association between education and the UPF share becomes more negative as household income increases. This conditional pattern is compatible with evidence that the socioeconomic patterning of UPF consumption varies across dimensions of socioeconomic status and stages of the nutrition transition [18, 24].

The negative age–education interaction is likewise significant, suggesting that the association between age and the UPF share becomes more negative as educational attainment increases; equivalently, the association between education and the UPF share becomes more negative as age increases. This pattern may reflect life-course heterogeneity in the way education is related to dietary modernization and is compatible with evidence of age-related differences in UPF consumption and the importance of cooking and food-preparation practices [17, 25]. Taken together, these interactions suggest that the socioeconomic and life-course patterning of the overall UPF dietary share varies across households.

4. Discussion

This paper examined the socioeconomic and behavioral correlates of household ultra-processed food consumption in China, integrating the nutrition transition framework with a Theory of Planned Behavior–informed approach to household-level dietary decisions across eating contexts. Drawing on original survey data from Chinese household food decision-makers, we estimated ordered logit models for UPF consumption frequency at main meals and outside them and beta regression for the overall dietary share. The findings reveal substantial heterogeneity across socioeconomic characteristics, food environments, household food-preparation behavior, and eating contexts.

The socioeconomic results point to a heterogeneous pattern of dietary transition. In the proportion model, the associations of income and age with the overall UPF dietary share vary with educational attainment, becoming increasingly negative as education rises — a pattern captured by the income–education and age–education interactions. These patterns are compatible with a transitional setting in which the socioeconomic patterning of UPF consumption is becoming increasingly differentiated across population groups [20, 24]. Contemporary food-acquisition channels are associated with UPF consumption in ways that complement conventional socioeconomic characteristics. Takeout frequency emerges as the most consistent food-environment correlate across all three outcomes, while online purchasing and urban residence show context-dependent patterns of statistical significance. This reinforces the value of distinguishing among different dimensions of UPF intake rather than relying solely on aggregate measures. This prominence of delivery channels is consistent with evidence on the rapid expansion of online-to-offline food delivery and online grocery shopping in China's urban food environments [44–45].

Household food-preparation behavior also emerges as relevant. Willingness to cook is consistently associated with lower UPF consumption across all three outcomes, whereas cooking frequency shows a more context-dependent relationship. This distinction cautions against treating the motivational and behavioral aspects of household food preparation as interchangeable. From a policy perspective, both food-acquisition channels and household food-preparation practices merit consideration alongside socioeconomic characteristics when developing nutrition strategies in rapidly changing food environments. The protective role of cooking disposition is consistent with recent evidence linking cooking skills and food literacy to lower UPF consumption [25].

Read through the Theory of Planned Behavior, the findings are consistent with the constructs the framework highlights. The life-course and attitudinal block (AGE, EDU) captures how formative exposure and nutritional information shape consumption, consistent with the positive education patterning observed in both frequency models. The perceived-behavioral-control block is where the household-capacity results sit: willingness to cook—a motivational, attitudinal proxy—shows the strongest and most consistent negative association across outcomes, while realized cooking behavior is context-dependent, suggesting that control over food preparation operates more through disposition than through practice alone. The food-environment block maps to perceived control's structural counterpart: takeout, online purchasing, and urban residence represent the opportunity constraints within which households execute

intentions. We emphasize that these readings are interpretive: with single-item proxies, the TPB here organizes associations rather than testing the structural model [33–34].

The study should be interpreted in light of some limitations. Its cross-sectional, self-reported design limits causal interpretation, while the non-probabilistic sampling strategy limits how well the findings generalize to the broader Chinese population. [38–39] In addition, the survey did not measure latent TPB constructs using validated multi-item scales; accordingly, the theory serves as an organizing basis for the reduced-form analysis rather than as a structural behavioral model. These limitations warrant caution when interpreting the estimated associations as mechanisms or population-wide patterns.

These limitations qualify the strength of the evidence, but they do not diminish its orienting value for policy. The present findings are consistent with China being in the pre-reversal stage of the nutrition transition [36–37], in which UPF consumption is concentrated among more advantaged households; at such a stage, dietary behavior may still be responsive to policy intervention. The results therefore offer timely orientation for channel-focused regulation, for nutrition education aimed at household food dispositions, and for establishing monitoring baselines before the gradient reverses and consumption shifts toward less advantaged groups, as documented in high-income settings [20, 28].

5. Conclusions

This study provides a multidimensional account of the socioeconomic and behavioral correlates of household ultra-processed food consumption in China, distinguishing structured main meals, unstructured eating occasions, and the overall dietary share. Three findings stand out. First, UPF consumption is patterned by education rather than income, and the education gradient is positive: more educated household food decision-makers report more frequent consumption both at main meals and outside them.

Second, the modern food environment shows the strongest and most consistent associations: takeout frequency is the largest correlate in the model and is significant across all three outcomes, while online grocery purchasing and urban residence are associated specifically with unstructured eating occasions and the overall dietary share. Third, willingness to cook is the one consistently protective household characteristic across all three outcomes, operating through disposition rather than through cooking frequency alone.

The patterns are consistent with China being in the pre-reversal segment of the nutrition transition, while the income × education and age × education interactions suggest that the transition is already becoming socially differentiated. These findings contribute to understanding how dietary modernization unfolds within households during the nutrition transition by linking socioeconomic heterogeneity, household food-choice behavior, and eating context within a common empirical framework. They also carry an orienting implication for policy: strategies developed for settings where UPF consumption concentrates among lower socioeconomic groups may not transfer directly to China at its current stage of the

transition, and the delivery and online grocery channels and the household disposition to cook emerge as candidate targets for intervention and monitoring.

Future research using longitudinal and more representative data could examine how these relationships evolve as China's nutrition transition progresses, while surveys specifically designed to measure TPB constructs could assess the underlying behavioral mechanisms more directly. Comparative analyses across Chinese regions and countries at different stages of dietary transition could further determine whether the heterogeneity observed here represents a transitional phenomenon or a more persistent feature of changing food systems.

Abbreviations

AGE: Age of respondent (years)

CI: Confidence interval

CITY: Urban residence indicator

EC: Eastern China region indicator

EDU: Years of formal education

FE: Food-environment variable group

GENDER: Respondent sex indicator (1 = female)

HC: Household-capacity variable group

IQR: Interquartile range

IRB: Institutional Review Board

JOBFULL: Full-time employment indicator

LINCOME: Natural logarithm of monthly household income

MAIN: UPF consumption frequency at main meals

MARRY: Marital status indicator

NOMAIN: UPF consumption frequency outside main meals

OLGROC: Online grocery purchasing indicator

OR: Odds ratio

OVER: Overweight household member indicator

PROP: Respondent-estimated share of UPF in the weekly household diet

SES: Socioeconomic resource variable group

STUDENT: Student status indicator

TAKEOUT: Takeout food purchase frequency

TPB: Theory of Planned Behavior

UPF: Ultra-processed food

Declarations

Human Ethics and Consent to Participate

The study protocol was approved by the Ethics Review Committee of the West China Medical Center, Sichuan Medical University (IRB No. 2024-826; approval granted on 24 July 2024). All methods were carried out in accordance with relevant guidelines and regulations and the principles of the Declaration of Helsinki. All participants provided informed consent electronically before completing the survey.

Consent for publication

Not applicable.

Availability of data and materials

The dataset supporting the findings of this study is publicly available at https://raw.githubusercontent.com/chaveslima/data/main/upchina.csv. The R code used for data preparation and estimation is publicly available at https://raw.githubusercontent.com/chaveslima/data/main/UPF-China-model.R.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AY conceived and supervised the study. ZZ designed the survey, collected the data, and performed the statistical analysis. RCL contributed to the statistical analysis and interpretation of results. GOG and

PSGMN contributed to data processing and analysis support. HL contributed to the interpretation of results and manuscript preparation. All authors read and approved the final manuscript.

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