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Understanding food westernisation and other contemporary drivers of adult, adolescent and child nutrition quality in urban Vietnam

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Abstract

Objective: To examine the association between consumption of western foods purchased and consumed away from home and measures of nutrition quality: average daily caloric intake and macronutrient (carbohydrates, fat and protein) shares, for urban consumers in Vietnam, a country undergoing economic transition.
Design: Cross-sectional observational data were collected using household surveys and 24-h food diaries. Outcome variables were individual average daily caloric intake and shares of calories from macronutrients: carbohydrates, fat and protein. The key explanatory variable was individual daily share of calories from western food purchased and consumed away from home. Ordinary least squares and multivariate regression analyses were used to examine the association between the outcome variables: caloric intake and macronutrient shares and the share of calories from western food consumed away from home.
Setting: Hanoi and Ho Chi Minh City in Vietnam.
Participants: In total, 1685 households and 4997 individuals, including adults (aged $\geq$ 18 years), adolescents (aged 10–17 years) and children (aged 0–9 years).
Results: The share of calories from western food away from home was significantly associated with higher caloric intake among male and female adults ($P < 0{\cdot}01$), adolescents ($P < 0{\cdot}01$) and male children ($P < 0{\cdot}10$) and was associated with higher shares of fat for male and female adults ($P < 0{\cdot}01$), adolescents ($P < 0{\cdot}01$) and male children ($P < 0{\cdot}01$).
Conclusions: Policymakers must be conscious of the numerous factors associated with poor nutrition quality, especially in younger Vietnamese individuals. Relevant interventions targeting at risk groups are required if nutrition improvement is a long-term goal.

Keywords
Western food away from home
Nutrition quality
Daily caloric intake
Macronutrient shares
Vietnam

In Vietnam, lifestyles are changing as a result of industrialisation, globalisation, increasing disposable incomes and urbanisation[1–8]. Combined, these factors are leading to changes in consumer demand for food products[8–15]. Correspondingly, food retailing is transforming to meet the changing needs of consumers[10–20]. For example, in urban Vietnam, traditional food markets and vendors (e.g. formal wet markets, informal street markets, street stalls and hawkers) now exist alongside modern food retailers (e.g. formal hypermarkets, supermarkets and convenience stores)[5,9–11,21] and 'western-style' food service establishments.

A variety of western-style food service establishments, including fast food chains (e.g. McDonalds, KFC), family-style restaurants (e.g. Pizza Hut) and coffee shops/cafés (e.g. Starbucks)[5,21], can now be found in most urban areas in Vietnam. For consumers, these western food establishments may be substitutes for traditional 'street food' vendors that have long been part of the local food culture in Vietnam, offering time-pressed urban consumers affordable, convenient, relatively nutritious food (e.g. pho, a popular street food, traditionally contains lean sources of protein and vegetables). However, consumers may be attracted to modern western food service establishments

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through advertising which promotes consumer benefits such as appealing food (tasty, more palatable), improved food safety, more sanitary facilities and even status[10–12].

There are concerns that changes in the food environment in urban Vietnam are contributing to an undesirable diet and nutrition transition, characterised by increasing consumption of energy-dense and highly processed western foods at the expense of nutrient-dense, lower energy traditional foods[1–3,18]. Energy-dense diets have been shown to be associated with higher rates of diet-related non-communicable diseases, including obesity, type 2 diabetes and cardiovascular disease (CVD)[22–33]. A number of studies in emerging Asian countries, including China[20], Indonesia[17,18], Malaysia[34] and Thailand[19], have examined the relationship between food market modernisation, diet quality, diet transition and non-communicable diseases, and the findings have been mixed.

Two relevant recent studies have examined the relationship between retail transformation and measures of diet quality in Vietnam. A study of 400 women of reproductive age in Hanoi used mixed methods, including household surveys and 24-h dietary recall, and found no significant association between food retail transformations and dietary quality[10]. Another study found that food expenditure at modern markets was not directly associated with urban Vietnamese households' dietary diversity[15].

Other studies have used various data and methods to explore measures of diet quality and other various factors affecting diet quality[7,8,35–39]. For example, a study of women in Northern Vietnam used a Food Frequency Questionaire (FFQ) and found that macronutrient intake was more likely to be inadequate when women were poor, less educated and food insecure[39]. Out-of-home food intake was positively associated with a high energy intake for Vietnamese adolescents[35].

This cross-sectional study of urban Vietnamese consumers attempts to shed light on how consumption of western food away from home is related to caloric intake and three main macronutrients in the diet[40]: carbohydrates, fat and protein. This relationship is yet to be explored empirically. We control for other contemporary factors related to individuals' lifestyle and socioeconomics, and we disaggregate by gender and different age cohorts: adults (aged 18 years and/or above), adolescents (aged from 10 to 17 years) and children (aged from 0 to 9 years).

Understanding the relationship between western food away from home and measures of nutrition quality is important considering the growth of western-style food service establishments in urban Vietnam and in light of the rising trend in overnutrition-induced overweight and obesity in Vietnam[41,42]. The relationship for younger individuals (adolescents and children) is especially important to understand because increasing consumption of energy-dense foods and drinks may affect an individual's long-term ability to make healthy food choices[43]. Furthermore, in high-income countries, higher shares of calories from western foodservice establishments have been found to be associated with high caloric intake, poor diet quality and diet-related non-communicable diseases[23–33].

Methods

Data

Data from 1685 urban households located in Hanoi and in Ho Chi Minh City (HCMC) in Vietnam were analysed to address the objectives of this study. Ethics approval was obtained (University of Adelaide Human Research Ethics Review Committee, H-2015-159), and data were collected from December 2016 to April 2017 (with a 4-week break to avoid any atypical food consumption fluctuations around the Vietnamese Lunar New Year). Households were selected using a proportional random sampling strategy. Specifically, ward-level population and household income distribution were considered. Ward-level income distribution was considered because household income generally reflects household purchasing power and has been shown to be related to households' food purchasing and consumption decisions[44].

Two instruments were used for data collection: (1) a household survey, designed to collect data on socioeconomics, lifestyle, food purchasing behaviour, food expenditures and individual attitudes; and (2) a 24-h food diary, where households kept detailed records (diaries) of the food items consumed by each member of the household over a 24-h period.

Household surveys were conducted by trained and experienced enumerators, through face-to-face interviews with the household member determined to be the most knowledgeable about the household's food purchasing behaviour.

The 24-h food diary (see Online Appendix A) was designed to collect detailed food and beverage intake data for each individual living in the household. Information was collected on both food consumed at home and food consumed away from home. The food intake data were collected on three different days (two consecutive weekdays and one non-consecutive weekend day, chosen randomly within a week) and then averaged to reduce measurement error from day-to-day fluctuations in food intake.

Outcome variables

Caloric intake

$Calories_{ijk}$, is a continuous variable representing average daily (3-d average) caloric intake in kilocalorie (kcal) from all food items consumed over a 24-h period by individual i, living in household j, in city k (see equation (1)).

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$$Calories_{ijk} = \sum_f C^f_{ijk} \cdot M^f \cdot E^f \quad (1)$$

In equation (1), C^f_{ijk} denotes the consumption of food item f by individual i, in household j, located in city k. M^f denotes the food energy conversion factor of food item f, which converts the consumed quantities of each food C^f_{ijk} into gram equivalents and allows it to be comparable with other food items[45]. The gram equivalents are converted into kcal using the energy contribution factor of each food, E^f. Values for E^f are from the 2007 Vietnamese Food Composition Table (VFCT)[46], the online version of the 2017 Vietnamese Food Composition Table[47] approved by the National Institute of Nutrition and other reputable online standard nutrition conversion calculators. The total caloric intake, $Calories_{ijk}$, is finally computed by summing the energy contributions of all food items. The nutrient contents of mixed dishes not included in the Vietnamese Food Composition Table database are calculated by identifying the average component ingredients from Vietnamese recipes[48]. The full list of food items and their macronutrient content are provided in the Online Appendix B.

Macronutrient shares

Macronutrient shares are calculated from individuals' 3-d average consumption of carbohydrates, fat and protein as a share of $Calories_{ijk}$ using equations (2) to (4):

$$Carbohydrates_{ijk} = \frac{(\sum_f C^f_{ijk} \cdot M^f_{carbohydrates})*4}{Calories_{ijk}} \times 100 \quad (2)$$

$$Fat_{ijk} = \frac{(\sum_f C^f_{ijk} \cdot M^f_{fat})*9}{Calories_{ijk}} \times 100 \quad (3)$$

$$Protein_{ijk} = \frac{(\sum_f C^f_{ijk} \cdot M^f_{protein})*4}{Calories_{ijk}} \times 100 \quad (4)$$

$Carbohydrates_{ijk}$, Fat_{ijk} and $Protein_{ijk}$ represent, for individual i, the average daily share of calories from consumption of carbohydrates, fat and protein, respectively. Similar to equation (1), $M^f_{carbohydrates}$, M^f_{fat} and $M^f_{protein}$ represent the food energy conversion factor of carbohydrates, fat and protein, respectively. The Atwater coefficients (kcal/g) associated with the macronutrients, 16·7 kilojoules (kJ) (4 kcal)/g for carbohydrates and protein, and 37·6 kJ (9 kcal)/g for fat, are used to convert the gram equivalent of each macronutrient to calories[49].

Main explanatory variable: WesternFAFH

$WesternFAFH_{ijk}$, defined in equation (5), represents the share of individual *i*'s average daily caloric intake ($Calories_{ijk}$) that is obtained from western-style foods purchased and consumed away from home.

$$WesternFAFH_{ijk} = \frac{\sum_W C^W_{ijk} \cdot M^W \cdot E^W}{Calories_{ijk}} \times 100 \quad (5)$$

In equation (5), the superscript W stands for western food items consumed away from home. C^W_{ijk} denotes the consumption of western food item W by individual i, M^W denotes the food energy conversion factor of western food item W and E^W is the energy contribution factor of food item W.

Empirical estimation of outcome variables

The baseline regression equation to estimate $Calorie_{ijk}$ is specified in equation (6) below:

$$Calories_{ijk} = \alpha + \beta WesternFAFH_{ijk} + \gamma \boldsymbol{X}_{ijk} + \delta \boldsymbol{H}_{jk} + c_k + u_{ijk}. \quad (6)$$

The system of equations shown in equations (7) to (9) is estimated to explore the main factors associated with the share of calories from the macronutrients, carbohydrates, fat and protein

$$Carbohydrates_{ijk} = \alpha + \beta WesternFAFH_{ijk} + \gamma X_{ijk} + \delta H_{jk} + c_k + u_{ijk} \quad (7)$$

$$Fat_{ijk} = \alpha + \beta WesternFAFH_{ijk} + \gamma X_{ijk} + \delta H_{jk} + c_k + u_{ijk} \quad (8)$$

$$Protein_{ijk} = \alpha + \beta WesternFAFH_{ijk} + \gamma X_{ijk} + \delta H_{jk} + c_k + u_{ijk} \quad (9)$$

$WesternFAFH_{ijk}$ represents our main explanatory variable of interest, X_{ijk} is a vector of individual-level covariates, H_{jk} is a vector of household-level covariates, c_k is a city indicator variable and α represents the constant term. Finally, u_{ijk} is the vector of error terms assumed to be independent and identically distributed in the model.

Tables 1 and 2 provide definitions and summary statistics for each outcome variable, the main variable of interest, *WesternFAFH,* and each individual-level and household-level covariates.

The vector of individual-level covariates, (X_{ijk}), includes *Age*, *Age*^{2}, *ConsFreq* and *WatchTV*. *Age* is the age of individual i and is included to explore the possibility that individuals change their consumption patterns as they get older[15,17,18]. *Age*^{2} is included to understand if there is a non-linear relationship between the age of an individual and total daily average caloric intake and macronutrient shares. The variable *ConsFreq* represents the average

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Table 1. Descriptive statistics for outcome variables and the main explanatory variable, *WesternFAFH,* for male and female adults, adolescents and children

Variables	Description		Male Mean	Male SD	Female Mean	Female SD	Male *v.* Female |*t*|-statistic	df
Dependent variables								
Calories	Individual's daily average caloric intake	Adults	2221	448	2273	443	3·47***	3532
		Adolescents	2385	472	2396	608	0·24	549
		Children	2205	573	2166	616	0·97	910
Carbohydrates	Individual's daily average share of total calories from carbohydrates	Adults	62·01	7·10	62·83	7·00	5·79***	3532
		Adolescents	61·85	6·69	61·10	7·36	1·02	549
		Children	59·86	8·40	59·70	8·82	1·13	910
Fat	Individual's daily average share of total calories from fat	Adults	20·89	4·23	20·08	4·40	2·24**	3532
		Adolescents	21·03	2·60	21·50	4·30	1·27	549
		Children	22·05	6·36	22·20	3·93	0·05	910
Protein	Individual's daily average share of total calories from protein	Adults	17·10	2·97	16·90	2·87	4·42***	3532
		Adolescents	17·12	4·30	17·40	3·07	0·75	549
		Children	18·09	3·27	18·10	6·27	1·81*	910
Explanatory variable								
WesternFAFH	Individual's daily average share of total calories from western food purchased and consumed away from home	Adults	6·62	9·52	6·60	8·81	0·07	3532
		Adolescents	13·26	11·07	12·39	10·74	0·94	549
		Children	12·96	10·02	12·88	9·16	0·12	910
Number of individuals		Adults (≥ 18 years)	1750		1784			
		Adolescents (10–17 years)	284		267			
		Children (0–9 years)	448		464			
Number of households			1685					

Asterisks ***, ** and * indicate statistical significance at the 1, 5 and 10 % levels, respectively.
Source: Authors' estimation from Vietnam Urban Food Consumption and Expenditure Study.

number of times individual *i* consumes food each day. An increase in the number of eating occasions per day (e.g. more snacking throughout the day) is likely to increase individuals' caloric intake[50]; however, the relationship with specific macronutrient shares is unclear as the types of food consumed will influence the macronutrient shares. The variable *WatchTV* is included as previous research found increased exposure to food advertisements via television (TV) can influence individuals' preferences for foods advertised regularly (e.g. packaged chips or western-style fast food)[51,52].

Several household-level covariates, (H_{jk}), are considered. *HouseholdSize* is the number of individuals living in individual *i*'s household (*k*). A larger household size has been shown to be a risk factor for malnutrition in developing countries[53]. *EduMale* and *EduFemale* represent the years of education completed by the male and female heads of household, respectively. A recent study in Vietnam found that the share of calories from carbohydrates relative to protein and fat tended to decrease, and the share of fat relative to protein tended to increase, as the education of the adult head of household increased[38]. However, we disaggregate our education variable by gender to understand if the education of male *v.* female household heads matters.

FemaleWork (average hours of paid weekly work by the female household head) is considered because previous studies found a positive association between female participation in the workforce and household expenditures on prepared food and food away from home[54] and maternal employment and total caloric intake of household members[55]. Therefore, we hypothesise that this covariate may also be associated with higher total individual consumption of calories as well as relatively higher shares of carbohydrates and fat in the diet.

Two binary household covariates are used to indicate the main religion of the household, *Buddhist* or *Christian*, respectively. In Vietnam, Buddhists are often vegetarian, and as a result, their diets may be lower in protein and fat than individuals from other households[17,56].

Four binary income variables representing gross monthly household income categories (in thousands of Vietnamese Dong) are included: *LowInc*, *LowerMiddleInc*, *UpperMiddleInc* and *HighInc*. Previous studies found that caloric intake often increases with household income[57,58], the share of calories from starches and plant-sourced proteins generally declines, and the share of calories from animal fats and proteins and from sweeteners increases[59].

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Table 2. Descriptive statistics for all individual-level and household-level covariates for male and female adults, adolescents and children

		Adults (≥ 18 years)				Adolescents (10–17 years)				Children (0–9 years)			
		Male		Female		Male		Female		Male		Female	
Covariates	Description	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Individual-level													
Age	Individual's age (years)	41·20	13·60	39·10	13·30	13·50	2·30	13·50	2·30	4·60	2·60	4·70	2·60
Age^2	Individual's age (years), squared	1882·00	1233·00	1711·00	1195·00	188·00	63·00	188·30	63·00	28·10	25·30	29·90	26·40
ConsFreq	Number of eating occasions per day (3-d average)	4·87	1·12	5·03	1·08	5·10	1·03	5·10	1·02	5·43	0·97	5·45	0·93
WatchTV	Number of hours per day the individual watches TV	1·97	1·56	2·11	1·61	2·57	1·10	2·52	1·06	1·99	1·46	1·97	1·47
Household-level													
HouseholdSize	Number of children and adults living in the household	4·00	1·10	4·00	1·15	4·20	0·80	4·30	0·80	4·20	0·90	4·20	0·90
EduMale	Highest years of education completed by male head of household	10·90	3·30	11·00	3·30	10·90	3·10	10·70	3·00	12·10	3·00	11·90	3·30
EduFemale	Highest years of education completed by female head of household	10·60	3·20	10·60	3·20	10·70	2·80	10·40	2·90	11·80	3·00	11·60	3·20
FemaleWork	Average hours per week the female household head undertakes paid work outside of the home	25·40	26·10	26·08	26·10	29·10	26·50	27·45	26·40	28·97	26·10	30·90	25·40
Buddhist	(= 1 if the household head is Buddhist, 0 otherwise)	0·30	0·49	0·37	0·48	0·40	0·49	0·41	0·49	0·30	0·46	0·34	0·47
Christian	(= 1 if the household head is Christian, 0 otherwise)	0·07	0·26	0·08	0·26	0·06	0·24	0·06	0·23	0·06	0·23	0·05	0·23
Income	Monthly household income levels												
LowInc	Less than 4·49 million VND/month	0·06	0·17	0·05	0·16	0·02	0·14	0·03	0·17	0·03	0·17	0·03	0·18
LowerMiddleInc	4·5 to 7·49 million VND/month	0·27	0·45	0·27	0·44	0·27	0·45	0·27	0·44	0·27	0·44	0·27	0·45
UpperMiddleInc	7·5 to 14·9 million VND/month	0·43	0·50	0·43	0·50	0·47	0·50	0·50	0·50	0·43	0·50	0·43	0·50
HighInc	15 million or more VND/month	0·24	0·43	0·25	0·43	0·24	0·43	0·20	0·40	0·27	0·44	0·26	0·44
HCMC	(=1 if Ho Chi Minh City, otherwise 0)	0·56	0·50	0·55	0·50	0·56	0·50	0·55	0·50	0·46	0·50	0·50	0·50
Number of individuals (n)		1750		1784		284		267		448		464	
Number of households						1685							

VND/month represents Vietnamese dong per month. 1 USD = 22 318 VND on 30 December 2016.
Source: Authors' estimation from Vietnam Urban Food Consumption and Expenditure Study.

Finally, a binary variable *HCMC* is included to control for unobservable city-level effects (c_k, e.g. social norms, cultural traditions, dietary patterns and levels of economic development) that may differ between cities and affect nutritional outcomes[17].

The STATA 15 statistical package was used for all estimations. The variable *WesternFAFH* is potentially endogenous because food consumption decisions are made by individuals; therefore, endogeneity tests are run. However, there is no foolproof statistical test to determine endogeneity; thus, the results in the following section must be interpreted as associations between explanatory and outcome variables, not causal relationships. The mean variance inflation factor (mean VIF) was used to check the multicollinearity of all the covariates before including them in the estimation of equations (6) to (9).

Results

Descriptive statistics

Data were analysed from 1685 households, including 3534 adults (aged 18 years and above), 551 adolescents (aged from 10 to 17 years) and 912 children (aged from 0 to 9 years). Table 1 provides summary statistics for the outcome variables, *Calories*, *Carbohydrates*, *Fat* and *Protein* and the main explanatory variable of interest, *WesternFAFH*. Summary statistics for each individual and household level variable used in the empirical estimations are provided in Table 2.

On average, adult females consume significantly more ($P < 0·01$) calories/d (9510·23 kJ or 2273 kcal) than adult males (9292·66 kJ or 2221 kcal) (Table 1), higher shares of carbohydrates (62·83 % *v.* 62·01 %, $P < 0·01$) and lower shares of fat (20·08 % *v.* 20·89 %, $P < 0·05$) and protein (16·90 % *v.* 17·10 %, $P < 0·01$). No significant differences in caloric intake or macronutrient shares were found between male and female adolescents or children (Table 1).

Food consumed away from home (FAFH, Table A1 in Online Appendix C) makes up a relatively large share of the dietary energy (calories) consumed by Vietnamese adults (37–39 %), adolescents (38–39 %) and children (45–46 %). However, the share from western food (*WesternFAFH*) is relatively low, between 6·6 and 13·3 %; but, interestingly, the share of adolescents' and children's calories from western food away from home is double that of adults.

The household income distribution of our sample is comparable with other large household studies[60] conducted in HCMC and Hanoi (see online Supplemental Figs. A1 and A2 in Online Appendix D), suggesting our sample is representative with regard to the income distribution of the populations in these two cities. To further check the robustness of our data, the median caloric intake and macronutrient shares were compared with those found in other Vietnamese studies[36,61]. The median daily caloric intake for individuals in our sample was estimated to be 9301.03 kJ (2223 kcal), which is similar to other relevant Vietnamese studies. Further, the macronutrient shares are similar to the 2014 Vietnam Household Living Standard Surveys data for urban Vietnamese households[38]. However, because our results are disaggregated by gender and life stage, they are not directly comparable with the Vietnam Household Living Standard Surveys data.

Endogeneity tests, conducted as part of each of the regression analyses discussed below (see the Online Appendix C, Table A5), suggest that *WesternFAFH* can be treated as exogenous and doing so is unlikely to result in significant estimation bias or inconsistency in results. However, as we discussed above, all significant relationships between this variable and the outcome variables should be considered as associations, not causal relationships.

Ordinary least squares regression results: individual daily caloric intake

Ordinary least squares regression results for estimations of adult, adolescent and child caloric intake are reported in Table 3.

Associations between WesternFAFH *and Calories for adults, adolescents and children*

A positive and significant association is found between *WesternFAFH* and *Calories*, for adults ($P < 0·01$) and adolescents ($P < 0·01$) and for male children ($P < 0·10$). As individuals consume a higher share of their calories from western food away from home, their average daily caloric intake is likely to increase. However, the effects (magnitude of the coefficients) are relatively small (Table 3).

Associations between other covariates and Calories for adults, adolescents and children

Age is positively associated with *Calories,* and a non-linear relationship is found between age and average daily caloric intake (increasing at a decreasing rate as age increases) for adult females ($P < 0·05$) and children ($P < 0·01$, Table 3). The magnitude of the *Age* coefficients in the children models is much larger than in the adult female model. *ConsFreq* is significantly associated with high caloric intake for all individuals ($P < 0·01$ in all models, Table 3).

For adult males, we find a negative association between the education of the male head of household (*EduMale*) and caloric intake ($P < 0·05$). A positive association is found between the number of hours the female head of household works outside of the home (*FemaleWork*) and the caloric intake of male adolescents ($P < 0·10$) and male children ($P < 0·05$).

Compared with households that practice another religion or no religion, a negative association ($P < 0·01$) is

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Table 3. Ordinary least squares (OLS) regression results for estimation of caloric intake for adults, adolescents and children

	Adults		Adolescents		Children	
	Male	Female	Male	Female	Male	Female
WesternFAFH	0·018***	0·014***	0·018***	0·014***	0·005*	0·001
Age	–0·003	0·009**	0·091	0·067	0·361***	0·404***
Age²	0·001	–0·001**	–0·003	–0·002	–0·030***	–0·030***
ConsFreq	0·029***	0·027***	0·072***	0·084***	0·082***	0·083***
WatchTV	0·004	–0·011	0·009	0·035	0·012	0·008
HouseholdSize	–0·015	–0·008	–0·018	–0·039	0·084**	0·028
EduMale	–0·012**	–0·006	0·010	0·008	–0·004	–0·007
EduFemale	0·002	0·001	–0·014	0·002	0·018	0·000
FemaleWork	–0·001	0·001	0·002*	–0·001	0·003**	0·001
Buddhist	–0·220***	–0·246***	–0·131	–0·203**	–0·165**	–0·347***
Christian	–0·211***	–0·177***	–0·013	0·109	0·055	–0·310***
Income(Ref: LowInc)						
LowerMiddleInc	–0·008	–0·033	–0·121	–0·355**	–0·107	0·265*
UpperMiddleInc	0·020	0·006	–0·145	–0·259	–0·175	0·301**
HighInc	0·070	0·067	–0·078	–0·301*	–0·175	0·349**
HCMC	0·215***	0·248***	0·219*	0·300**	0·192**	0·288***
Constant	2·140***	1·880***	1·317	1·414	0·364	0·383
Mean VIF	2·480	2·520	3·740	3·150	3·070	2·930
R^2	0·193	0·139	0·273	0·158	0·296	0·358
Observations	1750	1784	284	267	448	464
Number of households			1685			

HCMC, Hanoi and in Ho Chi Minh City; VIF, Variance inflation factor.
Asterisks ***, ** and * indicate statistical significance at the 1, 5 and 10 % levels, respectively. Caloric intake is the average kcal consumed by each individual per day. *Ref* is reference level of income. 1 USD = 22 318 on 30 December 2016. Full results with robust SE are reported in online Appendix C, Table A3.

found with caloric intake for adults from Buddhist and Christian households. The results are mixed for adolescents and children, *Buddhist* is negative for female adolescents ($P < 0·05$) and male ($P < 0·05$) and female ($P < 0·01$) children, and *Christian* is negative for female children ($P < 0·01$) (see Table 3).

Female adolescents from lower-middle income ($P < 0·05$) and high-income ($P < 0·10$) households are more likely to have lower caloric intake than those from low-income households. However, female children from lower-middle ($P < 0·10$), upper-middle ($P < 0·05$) and high-income ($P < 0·05$) households are more likely to have higher caloric intake. For female children, the magnitude of the positive association with caloric intake increases as household income increases.

Finally, individuals from HCMC (in all models) are more likely to have higher caloric intake than those in Hanoi (Table 3). The size of the coefficients on the *HCMC* variable is relatively large compared with those on other covariates, with the exception of the coefficients representing household income.

Multivariate regression results: individual macronutrient shares

The three-stage multivariate results provide insight on the relationships between *WesternFAFH* and macronutrient shares. They are reported in Table 4·1 (for adults) and Table 4·2 (for adolescents and children).

Adult macronutrient estimates and WesternFAFH

In Table 4·1, the variable *WesternFAFH* is shown to be negatively and significantly associated with *Carbohydrates* and *Protein* for both adult males ($P < 0·01$ for carbohydrates and $P < 0·05$ for protein) and females ($P < 0·01$), but it is positively and significantly associated with *Fat* in both adult models ($P < 0·01$). Therefore, for adults, higher energy shares from western food away from home are associated with a shift away from carbohydrates and protein, towards relatively more fat in the diet.

Adult macronutrient estimates and other covariates

WatchTV is positively associated with carbohydrate shares for adults ($P < 0·01$ for males and $P < 0·05$ for females). However, a negative association is found between *WatchTV* and fat shares for males ($P < 0·10$) and protein shares for both males and females ($P < 0·05$). As adults watch more hours of TV, it appears they substitute protein and possibly fat (weak to no association) with more carbohydrates (Table 4·1).

The variable *EduMale* is negatively ($P < 0·10$) associated with *Fat* for adult males, but the same variable has no significant association in the female model. Another variable related to economic development and women empowerment, *EduFemale*, is negatively associated with *Carbohydrates* for adult males ($P < 0·01$), but positively associated with *Fat* ($P < 0·05$) and *Protein* ($P < 0·01$) in male models (Table 4·1).

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Table 4·1. Three-stage multivariate regression results for the estimation of macronutrient shares (carbohydrates, fat and protein) for male and female adults

	Male (n 1750)			Female (n 1784)		
Adults	Carbohydrates	Fat	Protein	Carbohydrates	Fat	Protein
WesternFAFH	–0·107***	0·139***	–0·019**	–0·073***	0·129***	–0·027***
Age	–0·031	–0·031	0·018	0·001	–0·013	0·011
Age^2	–0·001	0·001	–0·001	–0·001	0·001	0·001
ConsFreq	–0·121	0·136	–0·039	0·206	0·053	–0·090
WatchTV	0·355***	–0·131*	–0·122**	0·251**	–0·069	–0·107**
HouseholdSize	0·074	–0·051	–0·118	0·288	–0·149	–0·106
EduMale	0·120	–0·078*	–0·016	0·029	–0·066	0·039
EduFemale	–0·291***	0·113**	0·090***	–0·120	0·055	0·018
FemaleWork	–0·007	0·004	0·001	–0·008	0·004	0·002
Buddhist	–0·803	0·069	0·107	0·562	–0·461	–0·224
Christian	–0·119	–0·540	0·241	0·083	–0·473	0·049
Income (ref: LowInc)						
LowerMiddleInc	0·652	0·097	–0·138	0·063	–0·098	0·098
UpperMiddleInc	0·741	0·054	–0·347	–0·944	0·605	0·193
HighInc	–0·316	0·644	0·078	–1·364	0·874*	0·365
HCMC	0·530	–1·390***	0·201	1·128*	–1·485***	0·297
Constant	66·990***	22·540***	17·560***	64·320***	23·370***	17·590***
Breusch-Pagan χ^2		1953·600***			1956·900***	
R-squared	0·042	0·130	0·022	0·036	0·117	0·020

Asterisks ***, ** and * indicate statistical significance at the 1, 5 and 10 % levels, respectively. 1 USD = 22 318 VND on 30 December 2016. *Ref* is reference level of income. Total number of individuals is represented by n. Full results with standard errors are reported in online Appendix C, Table A4.1. The Breusch–Pagan χ^2 in the multivariate regression analyses is sufficiently large to reject the null hypothesis of homoscedasticity of the error terms in equations (7) to (9), thus confirming that the estimated variance of the residuals in all models is dependent on the values of the independent variables.

We find a positive association between high income and the fat share for adult females ($P < 0·10$). Finally, the city effect reported in Table 4·1 shows that the share of fat in the diets of adults in HCMC is relatively lower ($P < 0·01$ both for males and females) than adults living in Hanoi. The carbohydrate share is higher ($P < 0·10$) among females in HCMC compared with those in Hanoi.

Adolescent and child macronutrient estimates and WesternFAFH

As shown in Table 4·2, similar to the adult models, the association between *WesternFAFH* and *Carbohydrates* is negative for male ($P < 0·01$ in Panel A) and female adolescents ($P < 0·05$ in Panel A), and male children ($P < 0·05$ in Panel B). Again, similar to the adult models, the variable *WesternFAFH* is positively associated with *Fat* intake for male and female adolescents ($P < 0·01$, Panel A) and male children ($P < 0·01$, Panel B). In the female adolescent *Protein* models, *WesternFAFH* is significant ($P < 0·05$ in Panel A) and negative (similar to the adult results). These results suggest that similar to adults, adolescents' and children's diets shift towards relatively more fat and less carbohydrates as a higher share of their calories comes from western food away from home. Female adolescents may be replacing both carbohydrates and protein with more fat. In all cases, the magnitude of the *WesternFAFH* coefficients is relatively small.

Adolescent and child macronutrient estimates and other covariates

As adolescent females get older, the share of carbohydrates in their diet appears to increase ($P < 0·01$) but at a decreasing rate (see variable *Age*^{2} in Panel A, $P < 0·01$). This increase in carbohydrates appears to be at the expense of protein, with the share of protein in the diet decreasing at an increasing rate ($P < 0·01$).

For children, similar to adolescents (but for both male and female children), as age increases, the share of carbohydrates in the diet increases ($P < 0·01$, Panel B, Table 4·2), but at a decreasing rate. The results of the *Fat* and *Protein* models for children are different than the adolescent models and suggest that as children get older the share of fat in their diet declines at an increasing rate ($P < 0·01$). No significant association is found between age and protein shares for children. For children, as they grow older, it appears that fats are substituted for carbohydrates, but this substitution effect lessens as the children reach adolescent age.

The number of times per day that an individual eats (*ConsFreq*) is positive and weakly significant ($P < 0·10$) in the female adolescent (Panel A, Table 4·2) and male child (Panel B, Table 4·2) models for *Carbohydrates,* and the female child *Fat* model; and it is negative and weakly significant ($P < 0·10$) in adolescent female *Fat* model (Panel A, Table 4·2).

Similar to the results found in the adult macronutrient analyses, the variable *WatchTV* in the children models is associated with a relatively higher share of calories from carbohydrates ($P < 0·10$ for males and $P < 0·01$ for females, Panel B of Table 4·2); but a lower share from fat ($P < 0·10$ for males and $P < 0·05$ for females) and from protein for female children only ($P < 0·05$). Interestingly, for adolescent males, the associations between *WatchTV*

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Table 4·2. Three-stage multivariate regression results for the estimation of adolescent and child macronutrient shares (carbohydrates, fat and protein)

	Male (*n* 284)			Female (*n* 267)		
	Carbohydrates	Fat	Protein	Carbohydrates	Fat	Protein
Panel A: Adolescents						
WesternFAFH	−0·102***	0·142***	−0·024	−0·088**	0·146***	−0·041**
Age	1·816	−1·181	0·094	7·420***	−1·570	−3·100***
Age²	−0·051	0·033	−0·007	−0·252***	0·058	0·099***
ConsFreq	0·201	−0·063	−0·069	0·735*	−0·409*	−0·026
WatchTV	−0·846**	0·421*	0·193	0·074	−0·150	0·006
HouseholdSize	−0·018	0·187	−0·054	0·343	0·168	−0·472*
EduMale	0·065	0·017	−0·071	−0·040	0·128	−0·057
EduFemale	−0·005	0·028	−0·050	0·317	−0·232*	−0·082
FemaleWork	0·004	−0·007	0·002	−0·016	0·009	0·008
Buddhist	0·854	0·157	−0·623	−2·170	0·968	0·511
Christian	3·130	0·162	−2·100***	−1·673	−0·329	1·091
Income (Ref: LowInc)						
LowerMiddleInc	0·558	0·270	−0·295	−1·831	1·627	−0·670
UpperMiddleInc	−0·262	0·532	−0·077	−4·155	3·140**	−0·530
HighInc	0·965	−0·096	−0·323	−4·327	3·217**	−0·115
HCMC	0·145	−1·714*	0·922	5·688***	−3·240***	−1·262*
Constant	51·320***	30·360***	19·370***	6·862	33·190***	45·620***
Breusch-Pagan χ^2		347·200***			286·500***	
R-squared	0·080	0·170	0·070	0·160	0·230	0·160
Panel B: Children		**Male (*n* 448)**			**Female (*n* 464)**	
WesternFAFH	−0·077**	0·116***	−0·015	0·035	0·008	−0·012
Age	3·416***	−3·370***	−0·182	1·963***	−2·830***	0·089
Age²	−0·278***	0·275***	0·003	−0·136**	0·220***	−0·019
ConsFreq	0·660*	0·042	−0·159	0·125	0·538*	0·098
WatchTV	0·619*	−0·417*	−0·126	0·955***	−0·465**	−0·304**
Household_size	−0·015	0·291	−0·509**	−0·343	0·069	0·260
EduMale	−0·169	−0·006	0·097	0·058	−0·028	0·006
EduFemale	−0·026	0·014	−0·044	−0·277	0·098	0·061
FemaleWork	0·005	−0·008	−0·002	0·001	−0·012	0·008
Buddhist	0·233	−0·920	0·202	0·716	−0·417	−0·542
Christian	0·431	−1·789	0·761	0·795	−0·913	−0·331
Income (Ref: LowIncome)						
LowerMiddle	0·843	−0·113	−0·828	1·854	0·257	−2·060*
UpperMiddle	0·128	0·594	−0·740	2·594	0·525	−2·740***
HighIncome	−0·073	0·831	−0·415	1·845	1·344	−3·010***
HCMC	2·838**	−2·450***	0·016	1·978	−2·850***	0·963
Constant	48·910***	34·690***	21·700***	52·310***	31·650***	19·540***
Breusch–Pagan χ^2		430·100***			485·200***	
R-squared	0·217	0·381	0·056	0·132	0·261	0·050

Asterisks ***, ** and * indicate statistical significance at the 1, 5 and 10 % levels, respectively. 1 USD = 22 318 VND in 30 December 2016. *Ref* is reference level of income. Total number of individuals is represented by *n*. Full results with standard errors are reported in online Appendix C, Table A4.2 for adolescents and Table A4.3 for children. The Breusch–Pagan χ^2 in the multivariate regression analyses is sufficiently large to reject the null hypothesis of homoscedasticity of the error terms in equations (7) to (9), thus confirming that the estimated variance of the residuals in all models is dependent on the values of the independent variables.

and *Carbohydrates* and *Fat* in adolescent males are the opposite of those found in the children models (Panel A of Table 4·2); however, *WatchTV* is NS in the female adolescent models.

Household size (*HouseholdSize*) is negatively associated ($P < 0·10$) with protein shares for adolescent females (Panel A, Table 4·2) and male children ($P < 0·05$, Panel B, Table 4·2). The education level completed by the female head of household (*EduFemale*) is negative and significant ($P < 0·10$) in the adolescent female *Fat* model. For male adolescents, a negative association ($P < 0·01$) was found between *Protein* and the variable indicating the individual is from a Christian household.

Next, for adolescent females, there is a significant association ($P < 0·05$) between variables which indicate the household is from an upper middle-income and high-income household (as compared with a low- or lower-middle-income household) and increased share of calories from fat. The magnitude of the coefficients for these variables is relatively large. The household income coefficients in the female children model show a significant negative association ($P < 0·01$) between upper-middle and high-household income levels and protein shares. Further, as shown in Table 4·2 (Panel B), for the *Protein* model for female children, the magnitude of the income coefficients increases from lower-middle income (coefficient –2·06, $P < 0·10$) to upper-middle income (–2·74, $P < 0·01$) and to high income (–3·01, $P < 0·01$).

Finally, we find that female adolescents from HCMC *v.* Hanoi are more likely to consume a higher share of calories

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Table 5. Subsample analyses for adults, adolescents and children who watch low *v.* high TV hours (three-stage multivariate regression results for macronutrient shares)

	Carbohydrates	Fat	Protein	*n*
Watched TV (less than 2 h/d)				
WesternFAFH (adults)				
Males	−0·107***	0·144***	−0·015	605
Females	−0·074**	0·144***	−0·036***	591
WesternFAFH (adolescents)				
Males	0·039	0·062	−0·120*	44
Females	0·049	0·110	0·011	39
WesternFAFH (children)				
Males	−0·145**	0·101***	0·006	159
Females	−0·093	0·042	0·026	179
Watched TV (two or more hours per day)				
WesternFAFH (adults)				
Males	−0·110***	0·139***	−0·023**	1145
Females	−0·075***	0·118***	−0·020**	1193
WesternFAFH (adolescents)				
Males	−0·117***	0·152***	−0·019	240
Females	−0·107**	0·153***	−0·040**	228
WesternFAFH (children)				
Males	−0·012	0·110***	−0·030	289
Females	0·125**	0·001	−0·048**	285

Asterisks ***, ** and * indicate statistical significance at the 1, 5 and 10 % levels, respectively. Total number of individuals is represented by *n* for each subsample.

from carbohydrates and a relatively lower share of calories from fat and protein. In fact, the coefficient on the HCMC variable in the female adolescent *Carbohydrates* model is the largest of any coefficient ($P < 0·01$). A positive association ($P < 0·05$) is also found between *HCMC* and carbohydrate shares for male children, and a negative association ($P < 0·01$) is found between *HCMC* and fat shares for male and female children.

WesternFAFH *and low* v. *high hours of TV watching*

To better understand the association between *WesternFAFH*, macronutrient shares and the number of hours per day individuals watch TV (*WatchTV*), subsample analyses for male and female adults, adolescents and children were conducted for the subsamples watching less than two hours *v.* two or more hours of TV per day. The results from the subsample analyses are reported in Table 5.

For adults, the results show little difference in the association of *WesternFAFH* and macronutrient shares for those who watch fewer hours and those who watch more hours of TV. However, the significance of *WesternFAFH* variable across the low and high TV watching subsamples is different for both adolescents and children. For example, for the high TV watching subsample, *WesternFAFH* is significant for all adolescent models, except for the male adolescent *Protein* model. For the high TV watching subsample *v.* low TV watching subsample, the magnitude of the *WesternFAFH* coefficients for the *Carbohydrates* and *Fat* models is larger. Adolescents who watch relatively more hours of TV appear to be more likely to consume relatively less carbohydrates and relatively more fat.

Discussion

Our results are consistent with the literature on diet transition and complement other Vietnamese studies which suggest that changes in the food system, economic development and changes in food consumption behaviour are leading to a diet transition in Vietnam[10-15,35,36,38]. Specifically, we find evidence that in Vietnam, increasing consumption of western-style food away from home and other socioeconomic factors (e.g. increasing household income and more time watching TV) are likely to contribute to a longer-term negative shift in the diet and nutrition quality of urban Vietnamese consumers. In Vietnam, diet transition combined with other changing socioeconomic factors may lead to increasing rates of diet-related non-communicable diseases, including overweight, obesity, CVD and type 2 diabetes over time[41].

Although the average share of calories from western food away from home (*WesternFAFH*) is relatively small for individuals in the sample, the difference in *WesternFAFH* for adolescents and children compared with adults is substantial – nearly double. This finding and the significant and positive associations between *WesternFAFH*, higher caloric intake and a higher share of macronutrients from fat are worrying. Collectively, taking into account the finding that a higher share of younger individuals' calories come from western food away from home and considering the high share of their total calories from food away from home in general (38–46 % of total caloric intake), it is likely that western-style foods are likely to account for a larger share of Vietnamese consumers' daily energy in the future.

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Further, variables associated with economic development (income and hours of TV watched) also impact diet composition in a concerning manner, particularly for adolescents and children. For example, as income increases, individuals (particularly female adolescents and children) appear to be shifting away carbohydrates and proteins, to calories that are relatively higher in fat. Additionally, in most cases, individuals who watch a high amount of TV consume a significantly higher share of calories from fat, and they appear to be doing so at the expense of carbohydrates and protein.

Considering these results, the Vietnamese government may want to be proactive and develop initiatives to tackle the impacts of increasing consumption of westernised food on diet transition and longer-run diet-related health outcomes, plausibly to ensure the health of future generations and to reduce economic ramifications related to increasing non-communicable diet-related diseases. Early initiatives could include public health programs targeting school-aged children and their parents, which focus on communicating and raising awareness of the nutritive value (or lack thereof) of various types of western foods compared with traditional foods and improving knowledge and understanding of the individuals' and households' food related behaviour, lifestyles and long-term health outcomes. A recent study has indicated that placing reminders of healthy eating in supermarkets or other modern shopping environments where processed and ultra-processed food sales are heavily promoted may promote healthy choices[62].

Policymakers may also consider working with the food industry to reformulate food products and menu offerings at western foodservice establishments, and encouraging the food industry, for example, food processors, retailers and food service businesses, to provide information regarding the energy and macronutrient content of food options on menus in order to raise consumer awareness – an intervention that has already been introduced in many high-income countries[63-65].

Our research contributes to the growing body of literature on contemporary drivers of changes in caloric intake and dietary composition (macronutrient shares) in urban Vietnam. However, there are several limitations which future research might address. First, the cross-sectional nature of our data allows us to only examine associations between our covariates and outcome variables; we cannot make strong causal inferences. Second, the variable *WesternFAFH* used in this study may be correlated with individual daily caloric intake and the shares of macronutrients[38,66,67]. A potentially better variable to use might be the expenditure shares from western-style food away from home. However, we were not able to calculate expenditure shares on western-style food because the price data were not available. Third, the calculation of our outcome variables related to nutrition quality may vary due to the natural variability of the nutritional content of foods and cooking methods, which is a common limitation of similar studies[68]. Fourth, in our study, we did not account for western-style 'fast' foods that were purchased from the supermarket and eaten at home, either ready-to-eat or prepared at home (e.g. using a meal kit). Finally, our data, which are from the two largest Vietnamese cities, Hanoi and HCMC, may not be fully representative of all Vietnamese urban households.

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Supplementary material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1368980020001354

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