Effects of education on calorie and nutrient intake in Mexican families

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Abstract

This article analyzes calorie and micronutrient intake in relation to wealth distribution and education levels in Mexican households. Using data from the National Survey on Income and Household Expenditure, 2018 (ENIGH 2018), semiparametric regressions of intake of calories and five micronutrients are estimated across the distribution of expenditure and the head of household's education level. Higher economic status households consumed more calories and micronutrients; when controlled according to level of education, however, households with lower human capital demonstrated an increased caloric intake while simultaneously demonstrating a reduced nutrient intake. Findings also showed that as education level increases, households consume closer to recommended caloric intakes and show a preference for more micronutrient-dense foods.

Keywords: calorie intake; nutrition; education; households; economic status; semiparametric regressions.

1. INTRODUCTION

In recent decades, malnutrition has become an increasingly complex and global problem (OMS, 2018). Although malnutrition used to be a widespread phenomenon in Latin America, today we observe what the Commission for Latin America and the Caribbean (ECLAC) calls the double burden of malnutrition: the coexistence of malnutrition due to both the deficit and excess of calories and nutrients (Fernández *et al*., 2017). Although there are several explanations that account for changes in Mexicans' nutritional profile (Torres, 2017), the issue is not of minor importance; since 2000 the overweight and obesity rates have increased dramatically (Rivera *et al.,* 2017), while malnutrition still affects almost 24% of the population (CONEVAL, 2015).

A large portion of studies that estimate calorie and nutrient intake suggest that family financial capacity is one of the main determinants of food consumption (Drewnowski and Darmon, 2005; Drewnowski and Specter, 2004; Hernández *et al*., 2017). Although these studies have obtained relevant results about the importance of income in analyzing disparities in calorie intake, there is little clarity regarding the effects of socioeconomic level on micronutrient intake. These analyses also do not include other sociodemographic controls that could affect nutrition. For example, education level is a variable that not only provides information about human capital accumulation, but is an indicator of many of a household's capacities.

The goal of this study is to characterize Mexican households' calorie and micronutrient intake profile across their socioeconomic distribution, and to estimate the effects of education on said intake. To do this, data on the amount of food consumed inside and outside the home from the National Survey of Household Income and Expenditure [Spanish acronym ENIGH] of 2018 are used. Unlike other studies which focus on calorie intake, the present work includes additional information on iron, zinc, calcium, vitamin A and vitamin C. The study starts with the transformation of food quantities into calorie and micronutrient intake, to then estimate nonparametric and semiparametric regressions of said intake based on the distribution of expenditure and the head of household's education level, controlling for a set of sociodemographic household characteristics.

The results demonstrate that the higher a household's socioeconomic and expenditure levels are, the higher its intake of calories and micronutrients will be. However, when controlling for education level it is observed that in households with a head who has little or no education, there is a tendency towards high calorie intake which goes above the recommended standard—sacrificing the intake of micronutrients. As education level increases, households consume quantities of calories that are close to those recommended by various health organizations, and show a greater preference for foods rich in micronutrients. These findings coincide with other studies of the Mexican case, such as Hernández *et al*. (2017), Pérez and Minor (2011) and Martínez and Villezca (2005).

This article is divided into five sections, including this introduction; the second section provides a review of the literature on nutrition, economic level and education. In the third section, an identification strategy is developed, a description of families' adult-equivalent nutritional profile is undertaken using ENIGH-2018 data, and the models used to analyze the effects of education on calorie and micronutrient intake are presented. The fourth section provides the results of estimations of the determinants of calorie and micronutrient intake. To conclude, the fifth section discusses the implications of educational and nutritional inequalities in Mexican households.

2. STUDIES OF NUTRITION, ECONOMIC LEVEL AND EDUCATION

Nutrition is one of the factors with the biggest impact on a person's life outcome, and nutritional status affects their learning and productivity. The analysis of its behavior is thus of great interest for economic growth and development. In the economics literature, calorie and nutrient consumption is considered an investment in human capital (Schultz, 1961 and 1962); however, more recent approaches—such as a focus on capabilities—treat nutritional factors as one strategic aspect of how people are able to achieve states of being and perform valuable activities (Nussbaum, 2011).

The relationship between income and calorie intake is generally presented in a bidirectional manner: on the one hand, wages define the quantity and quality of a household's calorie and nutrient intake, while on the other, quantity and quality of food can influence productivity and income. Most studies of nutrition and economics do not address issues of endogeneity brought up by the omission of factors that affect both variables; rather, they focus on correlations between variables such as income and calorie intake. This literature suggests that calorie and nutrient intake is related to a family's financial capacity (Drewnowski and Darmon, 2005; Hernández *et al*., 2017), yet there is less clarity about the nature of this intake along the distribution of expenditure in particular.

Regarding the relationship between income, calorie intake and chronic degenerative disease, Drewnowski and Darmon (2005) assert that the high rates of obesity in the United States are not the result of a biological failure, but are a sociodemographic and economic phenomenon. This is because people on low-incomes tend to determine their food intake based on cost and taste—leaving aside other aspects, such as variety and health impact. It should be noted that these results are focused on socioeconomic level in terms of income, and put aside other variables that may affect calorie intake.

In the case of Mexico, Hernández *et al*. (2017) find that the cost of calories has been decreasing and that food consumption patterns vary over time. Furthermore, the poorest households prefer foods with low price variability and obtain most of the calories they consume from foods with high calorie density, and are therefore more likely to suffer from malnutrition. Furthermore, Martínez and Villezca (2005) show that these households are unable to cover their total calorie and nutritional requirements—despite the fact that they use more than half of their income flow—while richer households satisfy their protein requirements and even exceed in calories with just a fifth of their income.

Pérez and Minor (2011) demonstrate that, in light of rising food costs during the 2006 and 2008 crises, rural Mexican households substituted expensive foods for cheaper ones with higher calorie content and lower nutritional benefits. Their study analyzes the composition of food expenditure in a baseline population sector, identifying which foods are considered basic and analyzing changes following from the international food crisis. This work stands out in that it includes information about some minerals and vitamins in its analysis, unlike previous studies.

In Mexico there are few studies which incorporate education as a differentiating factor in the calorie and nutrient intake, while experiences in other countries suggest that more years of education may deter obesity. Monteiro *et al.* (2001) indicate that in Brazil a higher level of education can lower the risk of obesity, as individuals are able to make better decisions about their diet. For their part, Harding *et al*. (2018) analyze the relationship between maternal education level and the status of children's micronutrient intake in various countries. The authors find that maternal education is associated with fewer deficiencies in children's nutritional status; however, they point out that results vary according to each country's income level.

This review demonstrates the ways financial capacity is related to calorie and micronutrient intake, but also points to the existence of unobservable heterogeneity in the relationship between a family's nutritional status and socioeconomic position. The present work is based on the idea that financial wealth alone does not adequately represent a household's socioeconomic status. Accordingly, the household head's education level is included as information that not only concerns socioeconomic level, but also speaks to a family's advantages, disadvantages and capacities.[1]

3. IDENTIFYING NUTRITION IN THE ENIGH AND STATISTICAL MODELS

This article examines Mexican households' calorie and micronutrient intake levels according to their expenditure level and the head of household's education level, based on data from the ENIGH-2018. Calories represent the amount of energy that food consumption contributes towards keeping the body functional and carrying out various tasks; micronutrients are elements that form part of one's diet and which, in small amounts, are essential for the body's proper functioning. There is evidence that the excessive or insufficient intake of calories and micronutrients can have negative consequences which are associated with lower physical and cognitive development, or even with the development of chronic degenerative diseases.

Tables 1 and 2 show the calorie and micronutrient intake recommended by specialists according to the population's age group and gender. The values correspond to the average recommended intake in relation to sedentary and moderate physical activity, considering the low level of physical activity seen in the Mexican population. These reference amounts are important because in cases where the suggested micronutrient intake is not met, people may suffer from malnutrition—regardless of whether the calorie quotas are satisfied.[2]

Table 1. Calorie requirements by age group

Age	Category	Woman	Man
1 to 11 years old	Minors	1 510	1 619
12 to 17 years old	Adolescents	2 250	2 810
18 to 64 years old	Adults	2 219	2 681
65 years old and above	Seniors	1 950	2 213

Notes: kilocalories relative to the average between sedentary and moderate physical activity.
Source: prepared by the authors based on Bonvecchio et al. (2015).

Table 2. Micronutrient requirements for adults and seniors

Micronutrient	Adult		Senior	
	Woman	Man	Woman	Man
Vitamin A	600 µg	600 µg	800 µg	1,000 µg
Vitamin C	100-200 mg	100-200 mg	100-200 mg	100-200 mg
Iron	21 mg	9.1 mg	21 mg	9.1 mg
Calcium	1,000 - 1,200 mg	1,000 - 1,200 mg	1,000 - 1,200 mg	1,000 - 1,200 mg
Zinc	10 mg	10 mg	10 mg	10 mg

Source: prepared by the authors based on Martínez-Puga and Lendoiro (2005).

The analytical strategy used for this study focuses on nonparametric and semiparametric polynomial regressions that are controlled for households' socioeconomic and demographic characteristics, including both calorie intake and intake of five selected micronutrients. Nonparametric models of calorie intake are estimated based on expenditure distribution and the head of household's years of education as indicator variables of families' wealth and human capital. Subsequently, semiparametric regressions are performed in two stages: first, calorie and micronutrient intake are estimated, controlling for demographic and economic characteristics; second, nonparametric estimates are made, like those in the first model, after having controlled for variables from the first stage.

Nutrition in Mexican households according to the ENIGH-2018

One of the central objectives of the ENIGH is to be a source of detailed information about Mexican households' consumption. To calculate calorie and micronutrient intake for the present study, food amounts from the survey's expenditure module were taken and multiplied by the caloric and nutritional contribution of each food, as proposed in the nutrition composition tables of Muñoz de Chávez *et al*. (2010).[3] Intake among and within a household depends on the number and age of its members; accordingly, the OECD-Oxford[4] parametric equivalence scale proposed by Mancero (2001) is incorporated to obtain each household's equivalent apparent daily calorie and micronutrient intake.[5]

The food and beverage expenditure module of the ENIGH-2018 includes 39 categories, which are divided into 236 subgroups. The survey organizes this information into eight food groups: *i)* bread, tortillas and grains; *ii)* meats; *iii)* fish and seafood; *iv)* milk, milk derivatives and eggs; *v)* vegetable oils and fats; *vi)* fruits and vegetables; *vii)* sugar, coffee and packaged soft drinks; and *viii)* other foods. In this article, instead of classifying the population by income, it was divided into three groups according to level of education; *i)* low education level: households with heads who have a basic primary education or less; *ii)* intermediate education level: households with heads who have completed more than primary school, up to high school or less; and *iii)* high education level: families with heads of household who have university or postgraduate studies.

Table 3 shows food expenditure amounts, their share in total consumption, and the sociodemographic characteristics of Mexican households by education level. It is observed that 42% of households have heads with a low level of education; 45% have a secondary or high school level education, and only 13% have a higher education. Most of the households with a low level of education are in rural areas. Meanwhile, household heads are mostly male regardless of education level—although in households with a low level of education there is a greater involvement of female heads of household. Additionally, the average age of household heads is higher in families with a low education level.

Table 3. Food expenditures and demographics by head of household's education level

Household characteristics	*Low education level*	*Intermediate education level*	*High education level*	*Average*
Average monthly food expenditure	$ 2 871	$ 3 769	$ 5 652	$ 3 750
Food expenditure as proportion of total expenditure	46%	41%	33%	42%
Male head of household	67%	74%	74%	71%
Head of household's age	58.1	44.1	46.0	49.8
Rural area	37%	18%	5%	23%
Proportion of households by head of household's education level	42%	45%	13%	100%
Observations	31 236	33 312	10 099	74 647

Source: prepared by the authors based on the ENIGH-2018.

Regarding monthly food expenditure, a clear correlation is identified between households headed by someone with a high education level and higher monthly food expenditure—despite the fact that the share of said expenditure as a proportion of the total is decreasing. Expenditure on food in households with a high education level is about twice that of households with heads who have a primary education or less. One first piece of evidence regarding structural differences in intake by level of education is the empirical verification attributed to Engel in his studies on intake (Engel and Kneip, 1996; García, 2013), in which food expenditure becomes a smaller proportion of total expenditure as income increases.

Table 4 presents the proportion of food expenditure and calorie intake by the head of household's education level, grouped by calorie density; foods were classified into groups of high, medium and low calorie content.[6] The table shows that the proportion of high calorie food intake and the number of calories consumed decrease significantly with the increase of the head of household's education level. The inverse behavior is also observed in the food group with low calorie content; the intake proportion of this group increases by up to 20 percentage points between households with heads who have a low education level and those headed by people with a higher education.

Table 4. Proportion of expenditure and daily calorie intake by food calorie density and head of household's education level

Calorie density	*Low education level*		*Intermediate education level*		*High education level*		*Average*	
	Proportion of expenditure	*Calorie intake*	*Proportion of expenditure*	*Calorie intake*	*Proportion of expenditure*	*Calorie intake*	*Proportion of expenditure*	*Calorie intake*
High	21%	1 462	18%	1 055	13%	940	18%	1 190
Medium	34%	1 175	31%	1 239	22%	1 107	30%	1 192
Low	45%	417	51%	458	65%	578	52%	463
Total	100%	3 054	100%	2 752	100%	2 625	100%	2 845

Source: calculated by the authors based on the ENIGH-2018.

It is notable that most of the calories consumed by families with heads of household who have a low education level come from high calorie density foods, a fact which is generally associated with the increased probability of consuming foods with low nutritional impact. Families with intermediate and high education levels meet their caloric needs with foods which have a medium calorie density. It is worth mentioning that these findings coincide with the results of Hernández *et al*. (2017) for the years 1992, 2000 and 2010, which makes it possible to assume that there have been no important changes in the fulfillment patterns of Mexico's calorie requirements in the almost 30 years covered by these studies.

Meanwhile, table 5 presents the proportion of the equivalent daily expenditure by food group, and their respective calorie intake. Similarities can be observed in the distribution of expenditure, where households allocate most spending to the consumption of meat, grains (bread, tortillas, cereals), vegetables and dairy products. However, a decrease in the consumption of grains is also observed as the head of household's education level increases, which is in line with a decrease in foods with high calorie density. In terms of calorie intake, it is observed that the higher the education level, the lower the consumption of calories from grains and sugar. This suggests that in households with greater human capital, the consumption of foods richer in nutrients—such as fish, fruits and vegetables—is favored over calorie intake from the former group of foods. Meanwhile, households with a head who have a low education level sacrifice nutrients in favor of foods with a high calorie content relative to their price.

Table 5. Proportion of expenditure and daily calorie intake by food group and head of household's education level

Food group	Low education level		Intermediate education level		High education level		Average	
	Proportion of expenditure	Calorie intake	Proportion of expenditure	Calorie intake	Proportion of expenditure	Calorie intake	Proportion of expenditure	Calorie intake
Bread, tortillasand cereals	21%	1 186	18%	831	13%	638	18%	933
Meat	22%	227	24%	266	23%	266	23%	251
Fish and seafood	2%	18	2%	17	4%	33	2%	20
Milk and derivatives	13%	264	14%	307	14%	354	14%	299
Oils and fats	2%	216	1%	163	1%	116	1%	175
Fruits and vegetables	19%	345	17%	286	18%	309	18%	312
Sugar, coffee and soft drinks	12%	586	12%	624	11%	573	12%	601
Other foods	9%	212	12%	258	16%	336	12%	254
Total	100%	3 054	100%	2 752	100%	2 625	100%	2 845

Source: prepared by the authors based on the ENIGH-2018.

This same table suggests that specific educational strata are linked to variations in individuals' daily diets. While the proportion of meat consumption appears to be constant across the head of household's education level, for the less educated group, most calorie intake comes from three additional sources: grains; sugar, coffee and soft drinks; and fruit and vegetables.[7] For the group with an intermediate education level, the calorie sources are the same as in the previous case, but additional weight is given to the consumption of dairy and other foods. Lastly, in the high education level group, the number of calories is distributed more evenly among the food groups.

The tables presented in this section speak to the relationships between the amount, proportion of expenditure and calorie content accordingly to education level. Generally speaking, it is evident that the relationship between the head of household's education level and the equivalent calorie intake is inverse, since people who belong to families with a low education level intake an average of 3,054 calories daily, while in the cases of intermediate and high education levels, intake is 2,752 and 2,625 calories, respectively. It is also seen that this decrease in calorie intake occurs as the head of household's education level increases, and is accompanied by an increase in food expenditure and a lower share of said expenditure in total intake (see table 3). Additionally, households with a high education level spend about MXN$188 per day on 2,625 calories, while households with heads who are less educated spend only MXN$96 to intake 3,054 calories a day on average.

Households with less human capital accumulation allocate a greater proportion of expenditure on and consume more calories from foods with a high calorie content and low nutritional impact; these products which are less desirable in the nutritional process make the members of these households more likely to be overweight or obese, as suggested by Hernández *et al*. (2017). In contrast, households with intermediate and high levels of education prefer to reduce their intake of calories derived from grains and sugars, giving more weight to other foods such as fish, dairy products and vegetables; these are richer in micronutrients and thus reduce the propensity to develop diseases associated with malnutrition. These descriptions include clear indications that educational inequalities in Mexico are actively involved in the explication of nutritional inequalities.

Nonparametric and semiparametric models

To estimate the effects of education level on household calorie and nutrient intake, the behavior of calorie, iron, calcium, zinc and vitamin A and C intake is observed based on head of household's education level and the distribution of expenditure, without assigning a preconceived functional form. Nonparametric models, such as those used by Delgado and Miles (1997) and García (2012), are estimated using polynomial estimators derived from a kernel function:

$$nutr_i = m(edujh_i/gast_i) + \varepsilon_i \qquad (1)$$

Variable $nutr_i$ in equation (1) refers to household *i*'s intake of calories, iron, calcium, zinc, and vitamins A or C. The residual ε_i is random and independent from the explanatory variable. Function $m(edujh_i/gast_i)$ is a nonparametric function of the head of household's years of education $(edujh_i)$ or of the logarithm for expenditure $(gast_i)$ of household *i*, and is estimated using local polynomials. If the variable is defined as $X_j = edujh_j$ or $X_j = gast_j$, then for a level of education or expenditure x_o in equation $nutr_j = m(X_j) + \epsilon_j$, an estimate $m(x_o)$ results:

$$\text{argmin } m(x_o) = \sum_{j=1}^{N} F_j^{\,2} K(X_j - x_o) \qquad (2)$$

where *K* is a kernel function that gives greater weight to households whose heads have an age (or family expenditure) with values close to x_o. Based on what is proposed by Gutierrez *et al*. (2003), for each point x_o of the years of education or expenditure logarithm, equation (2) estimates an approximation $m(x_o)$, such that the function $m(edujh_i/gast_i)$ is very flexible for capturing variations in calorie and micronutrient intake according to households' education and economic levels.[8]

As an alternative strategy to elucidate the effects of head of household's education level on the behavior of calorie and micronutrient intake across household socioeconomic level, semiparametric regressions are estimated using a partial linear model in two stages, such as that proposed by Speckman (1988). This method combines parametric estimators obtained from ordinary least squares (OLS) and nonparametric estimators derived from a kernel function, such as those shown in equation (1) of the first part of this identification exercise. The general semiparametric regression to be estimated is:

$$nutr_i = \pi X_i + m(edujh_i/gast_i) + \varepsilon_{it} \quad (3)$$

As in equation (1), variable $nutr_i$ refers to the intake of calories, iron, calcium, zinc, and vitamins A or C by household *i*; and $m(edujh_i/gast_i)$ is a nonparametric function of the head of household's years of education or household expenditure logarithm, which are estimated using local polynomials —as described for equation (2) of the nonparametric model. X_i is a vector of characteristics including the head of household's gender, age and age squared; the number of members and employed people in the household; whether the home is in an urban or rural location; and, the share of food in total household expenditure. It also includes a control for expenditure decile (a regression based on education) or the head of household's years of education a (a regression based on the expenditure logarithm). Finally, the residual ε_i is random and independent of the explanatory variables.

An important difference between the nonparametric regression in equation (1) and the semiparametric regression in equation (3) is that the latter is estimated in two stages. In the first, the effects of the head of household's education level on calorie and micronutrient intake are calculated parametrically, controlling for all of the characteristics of vector X_i. In the second stage, the non-linear effects of education level and economic level on calorie and micronutrient intake are estimated nonparametrically, after controlling for the characteristics of the household—that is, using the values predicted in the first stage.

The regressions proposed in equations (1) and (3) have the advantage of being efficient in capturing the non-linear effects of education and economic level on calorie and micronutrient intake, without imposing restrictions and prior assumptions on the data's behavior. The loss of efficiency in the two-stage estimation of the semiparametric model, as compared to a single stage, is justified given the advantages of the partial linear methodology for capturing the non-linear effects of socioeconomic level on calorie and micronutrient intake.

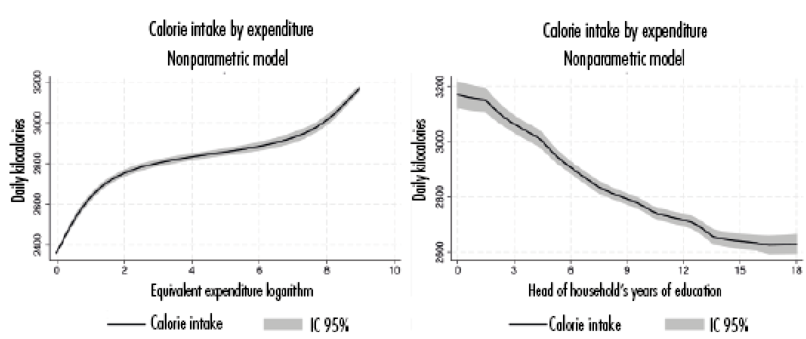
4. CALORIE AND MICRONUTRIENT INTAKE PROFILES

This section presents the graphic results of the nonparametric and semiparametric estimations proposed in the identification scheme. The section is divided into two subsections: first, calorie intake profiles are presented based on head of household's years of education and the household expenditure logarithm; second, mineral and vitamin intake profiles are examined based on household socioeconomic level, as represented by the head of household's education level and the expenditure level.

Head of household's education level and level of household expenditure by equivalent daily calorie intake

Figure 1, with its two panels, shows nonparametric estimates of the profiles for apparent intake of kilocalories per day (kcd), according to socioeconomic level in Mexican families. On the left side, the equivalent kcd intake is observed across the expenditure logarithm, as a representation of family economic level; on the right side, it is seen that said kcd intake changes with the head of household's years of education, which serves as a representation of a household's human capital. In both cases, calorie intake is modeled without imposing any additional restrictions on its behavior, as proposed in equation (1).

Figure 1. Calorie intake by expenditure and education level
Nonparametric models



Source: prepared by the authors based on data from the ENIGH-2018.

The nonparametric estimates indicate that calorie intake increases from 2,400 to 3,200 kcd with the rise in economic level throughout the household expenditure logarithm. It is seen that families with a low economic level do not reach the recommended thresholds of calorie intake, while those thresholds are exceeded at the opposite extreme—pointing to the effects of the double burden of malnutrition. On the right-hand side, with the increase in head of household's years of education, the equivalent daily calorie intake decreases from 3,200 kcd per person in households with less-educated heads, to around 2,600 kcd, at which point the head of household's education level is closer to higher education.

These opposing behaviors of calorie intake across education and expenditure levels represent the direct effects, without additional controls, of households' economic level and accumulation of human capital. Thus, while calorie intake per person rises with an increase in economic level, it decreases with the head of household's years of education, even approaching the thresholds recommended by international organizations.

As has been mentioned, there are many variables that contribute to the identification of household calorie intake. One immediate question is whether these calorie intake behaviors—across the level of expenditure and head of household's education level in the nonparametric model—are maintained after controlling for other sociodemographic factors, as proposed in the semiparametric strategy.

Table 6 presents OLS estimates for the first stage of the calorie intake models according to (1) the head of household's education level, and (2) the level of household expenditure. These were controlled for geographical location, indicating that people in rural areas consume on average between 436 and 506 kcd more than those who live in urban areas. An additional household member reduces calorie intake by around 170 kcd per person, while an additional employed member of a household increases said consumption by around 100 kcd. Smaller positive effects are seen with a male head of household and with an increase in the head of household's age.

Table 6. Calorie intake by expenditure and education levels
Semiparametric models – First stage

Sociodemographic controls	*(1)* *Calorie intake by education level* *(kcd)*	*(2)* *Calorie intake by expenditure* *(kcd)*
Rural area	506.15***	436.35***
	(16.93)	(17.47)
Number of household members	-168.12***	-171.56***
	(5.33)	(5.59)
Number of employed household members	106.42***	87.10***
	(8.00)	(8.48)
Male head of household	12.14	98.55***
	(16.67)	(17.53)
Age of head of household	33.69***	30.97***
	(3.08)	(3.21)
Age squared	-0.25***	-0.30***
	(0.03)	(0.03)
Proportion of food in total expenditure	57.92***	40.22***
	(0.69)	(0.61)
Household per capita income logarithm	-319.38***	345.66***
	(15.33)	(15.16)
Household monetary expenditure logarithm	831.43***	2nd stage
	(12.67)	
Head of household's years of education	2nd stage	-16.24***
		(2.12)
Constant	-1,652.02***	-781.05***
		(105.82)
Observations	74,573	74,573
R-squared	0.2083	0.1287

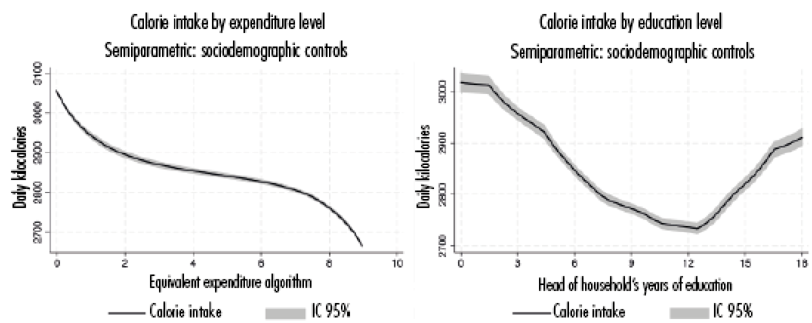
Notes: *** p<0.01; ** p<0.05; * p<0.1. Robust standard errors in parentheses.

Source: prepared by the authors based on data from the ENIGH-2018.

When controlling calorie intake by per capita household income in the first stage of the semiparametric models, differentiated effects appear given the high correlation of income with family expenditure. In the semiparametric model for education level, a 1% increase in income decreases the equivalent calorie intake by 3.19 kcd; meanwhile, this calorie intake increases by 3.45 kcd when expenditure is not included in the equation for the semiparametric model of economic level. Expenditure and head of household's education level confirm positive and negative effects, respectively, as indicated by the nonparametric models. In general, the effects of the first stage in both cases show quite intuitive behaviors, and include the expected evidence regarding the effects of sociodemographic factors on calorie intake.

After controlling during the first stage for a set of sociodemographic factors (see table 6), figure 2 presents the graphic results of the semiparametric model in the second stage. On the left side, it shows that

Figure 2. Calorie intake by expenditure and education levels



Source: prepared by the authors with data from the ENIGH-2018.

Mexican households' calorie intake along the expenditure logarithm has a decreasing behavior, from 3,100 to around 2,600 kcd; that is, once sociodemographic controls have been incorporated into the analysis of calorie intake by expenditure level, it is observed that at higher economic levels the kcd intake per person approaches the recommended threshold for good nutrition. In the case of calorie intake across the head of household's education level, after incorporating the controls from the first stage, the semiparametric model shows that the behavior of equivalent calorie intake nominally maintains a negative slope. That is, the higher the education level, the lower the calorie intake—as in the nonparametric case. However, once the head of household completes high school-level studies, this behavior changes, creating a "U" shape for calorie intake across education level.

Head of household's education level by micronutrient intake

Below are Mexican households' vitamin and mineral intake profiles according to the head of household's education level, presented in a semiparametric form—i.e., after controlling for sociodemographic variables in the first stage, as was done for calorie intake.

Table 7 presents OLS estimates for daily intake in milligrams (mg) and micrograms (μg) of iron, calcium, zinc, vitamin A and vitamin C, each explained by the household sociodemographic characteristics. As with calorie intake, it is observed that the equivalent intake of the five micronutrients is greater in rural areas than in urban ones, while as the size of the household increases, said intake decreases. An increase in the number of employed people in a household increases micronutrient intake, with the exception of calcium and vitamin C which decrease by 22.60 and 2.87 mg, respectively.

Table 7. Micronutrient intake by head of household's education level
Semiparametric models – First stage

Sociodemographic controls	*(1) Iron intake (mg)*	*(2) Calcium intake (mg)*	*(3) Zinc intake (mg)*	*(4) Vitamin A intake (μg)*	*(5) Vitamin C intake (mg)*
Rural area	2.56***	92.28***	1.37***	33.44***	5.30***
	(0.21)	(6.84)	(0.17)	(8.89)	(1.42)
Number of household members	-2.11***	-25.25***	-1.29***	-35.92***	-0.56
	(0.08)	(2.16)	(0.06)	(2.63)	(0.38)
Number of employed household members	1.55***	-22.60***	1.10***	31.04***	-2.87***
	(0.11)	(3.31)	(0.09)	(4.19)	(0.62)
Male head of household	-0.97***	-48.93***	-0.17	-51.80***	-10.86***
	(0.20)	(6.83)	(0.16)	(9.00)	(1.22)
Head of household's age	0.33***	11.72***	-0.18***	14.43***	2.38***
	(0.03)	(1.08)	(0.02)	(1.43)	(0.21)
Age squared	-0.00***	-0.07***	-0.00***	-0.10***	-0.02***
	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Proportion of food in total expenditure	0.48***	16.85***	0.31***	14.36***	2.03***
	(0.01)	(0.24)	(0.01)	(0.30)	(0.05)
Household per capita income logarithm	-4.38***	-85.95***	-2.40***	-70.18***	7.81***
	(0.24)	(5.70)	(0.21)	(7.18)	(1.09)
Household monetary expenditure logarithm	7.11***	256.90***	4.82***	220.67***	37.47***
		(4.38)	(0.15)	(5.93)	(0.91)
Constant	-3.10**	-477.29***	-3.84***	-682.08***	-223.83**
		(38.21)	(4.24)	(52.63)	(8.78)
Observations	74,573	74,573	74,573	74,573	74,573
R-squared	0.1065	0.1166	0.0750	0.0546	0.0728

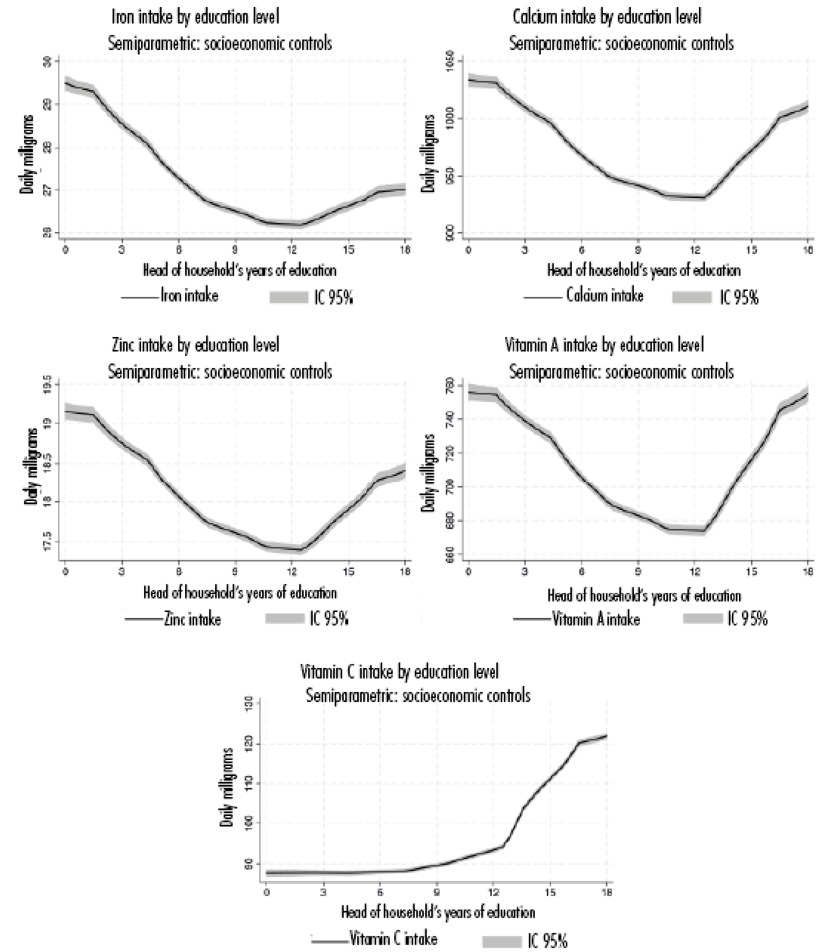
Notes: *** p<0.01; ** p<0.05; * p<0.1. Robust standard errors in parentheses.

Source: prepared by the authors based on data from the ENIGH-2018.

It is important to note in this first stage of the model that for micronutrient intake across expenditure and head of household's education, although a male head of household increases the family's calorie intake, this clearly decreases the intake of the three minerals and two vitamins in question. The rest of the sociodemographic factors exhibit effects in the same direction as calorie intake. In other words, with the increase in head of household's age, as well as the proportion of expenditure on food and total household expenditure, micronutrient intake increases; meanwhile, with the increase in per capita income said intake decreases, except for that of vitamin C.

Finally, figure 3 presents the equivalent intake profiles for iron, calcium, zinc, vitamin A and vitamin C according to head of household's education level. Similar to the behavior of calorie intake by education level, the intake of minerals (iron, calcium, zinc) and vitamin A has a "U" shape. In principle, with the increase in the head of household's years of education, mineral and vitamin A intake has a decreasing behavior until education exceeds the level of high school education (i.e. 12 years), at which point iron, calcium and zinc intake begin to rise with the raised education level.

Figure 3. Micronutrient intake by education level
Semiparametric models – Second stage



Source: prepared by the authors with data from the ENIGH-2018.

In the particular case of equivalent vitamin C intake, the shape simply increases with the increase in head of household's years of education, with a marked acceleration in the intake of this vitamin after the head of household exceeds 12 average years of education and begins university and postgraduate studies.

5. CONCLUSION

This study provides statistical evidence of the factors that determine calorie and micronutrient intake in Mexican households. In order to study the relationship between socioeconomic status and nutrition, semiparametric models of calorie and micronutrient intake are estimated according to a set of variables representing families' wealth and human capital. To go beyond the monetary dimension and what is typical in the literature, this analysis emphasizes the identification of the effects head of household's education level has on the behavior of calorie and micronutrient intake. The results indicate that education level acts as a modifier of household nutrition across the distribution of household expenditures. Specifically, as the head of household's educational achievements beyond high school increase, families control excessive calorie intake while increasing their intake of micronutrients such as iron, calcium, zinc and vitamins A and C.

The article also provides statistical evidence for the importance of financial capacity as explanatory of the configuration of Mexican families' food and nutritional intake. In general, calorie and micronutrient intake increases along with households' monetary wealth, when no additional controls are introduced (nonparametric model). However, once household sociodemographic variables are taken into account (semiparametric model), low-income families—located in the lower part of the monetary expenditure distribution—have diets that, due to excess calories and micronutrient deficiencies, are far from the recommended levels. Meanwhile, high-income households have varied diets which approach the levels recommended by experts and health agencies.

The results indicate that levels of family wealth can affect calorie and micronutrient intake according to the head of household's academic achievements. When no restrictions are imposed, the nonparametric model shows that calorie intake always decreases as the head of household's years of education increase. Yet even after controlling for sociodemographic variables—including wealth in the semiparametric model—it is confirmed that with the increase in the head of household's level of education, calorie intake decreases. This happens at least until the level of high school education, given that after 12 years of formal education there is a slight rebound in calorie intake, creating a "U"-shaped distribution. Furthermore, the "U" shape on years of education is a behavior that is replicated in the semiparametric model for micronutrient intake, with the exception of vitamin C intake, which increases throughout the entire distribution.

Based on this set of results, at least three implications stand out. These are, first, the limited capacity of wealth (as represented by monetary expenditure) to solely determine households' calorie and micronutrient intake; second, the fundamental role of human capital, especially education level, as a determinant of Mexican families' food and nutritional results; and finally, the existence of accumulated advantages and disadvantages based on correlations between the educational dimension and families' nutritional status. In this regard, evidence is presented that increasing household income and expenditures—in the absence of human capital—does not necessarily lead to adequate nutritional levels.

Finally, it is important to highlight that the head of household's level of education generates differential effects on the household's calorie and micronutrient intake. In particular, high school and higher studies create improved nutritional results, such that a strengthening of education has a favorable impact on people's health, by way of better eating habits. On the other hand, the academic levels associated with lower levels of education have a negative impact on the configuration of diets, generating negative results that could trigger the same tendency in other dimensions of life. Based on the foregoing reflection, and in the face of alarming levels of overweight, obesity and malnutrition that are observed in Mexico, it is urgent to assess and encourage the design of public policies aimed at education levels in vulnerable households—and in turn the intake of balanced and varied diets, in order to disrupt and avoid the emergence of disadvantages in those households.

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[1] The head of the household’s education variable was used under the assumption that it relates the rest of the household members in their accumulation of human capital and that the head of household plays an active role in decisions about household consumption. Compared to options such as the average education level in the home, this variable has the advantage of the completed school education cycle and generates less data dispersion.

[2] The micronutrients included in this study jointly influence the capacity of memory, attention and motor stimulation, especially during childhood; see Martínez-Puga and Lendoiro (2005), Rosado *et al*. (1999), FAO (2003).

[3] This methodology was developed based on Hernández *et al*. (2017). The weekly food quantities are divided by seven and multiplied by the calorie or nutrient amounts in the nutrition tables found in Muñoz de Chávez *et al.* (2010).

[4] This scale determines each member of the household’s portion of the total consumption; it assigns a value of 1 to the first adult, 0.7 for each additional adult, and 0.5 of the first adult for each child under 12 years old.

[5] Apparent consumption, since it is usually assumed that the quantities reported in the survey are consumed entirely by household members, though not in a homogeneous way (Martínez and Villezca, 2005).

[6] Based on Hernández *et al*. (2017), they were grouped by the number of calories they contain in portions of 100 grams or milliliters, as follows: low calorie density of 4 to 145 calories per 100g or ml; medium calorie density of 145 to 300 calories per 100g or ml; and high calorie density of 300 to 900 calories per 100g or ml.

[7] The limited variation in meat consumption across education level can be explained by the relevance of this food group in the Mexican diet. However, similar proportions of expenditure (or even calorie intake) do not imply that different households consume identical products—rather, within this food group there may be significant variations in the type and quality of meat products.

[8] Gutierrez *et al*. (2003) propose: $\operatorname{argmin} m(x_o) = \sum_{i=1}^{N} \{\text{Yi} - \sum_{j=0}^{p} \beta_j (X_i - x_o)^j\}^2 K(X_i - x_o)$. Equation (2) fixes the grade of polynomial *p* at 0, and uses a Kernel Epanechnikov function—a common configuration in the application of such models.