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Does food insecurity compromise maternal dietary Zinc or energy intake in favor of her child, in rural poor Mexican households?

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Abstract

Objective. To analyze quantitative indicators of food insecurity (FI), and estimate if FI modifies the association between maternal and child Zinc and energy intake as evidence for maternal dietary compromise in favor of her child. **Material and Methods.** Cross-sectional study (n=2 563), data derived from baseline impact evaluation of the Mexican *Programa de Apoyo Alimentario*. Quantitative indicators of FI were: Household food storage, maize and/or bean production, food expenditure, and spatial access to food markets. We evaluated percentage adequacy of energy (PAE) and Zinc (PAZn) intake. Multiple linear regression model was fitted to estimate the association between maternal and child PAE and PAZn. **Results.** Child PAE and PAZn were positively associated with those of their mothers. None of the FI indicators modified the association between maternal and child PAE and PAZn. **Conclusions.** No evidence of maternal dietary compromise in favor of her child was observed using four quantitative indicators of FI in central-southern rural Mexican households.

Key words: food security; maternal diet; preschool child diet; rural Mexico

Moreno-Tamayo K, González de Cossío T, Flores-Aldana M, Rodríguez-Ramírez S, Ortiz-Hernández L. ¿En hogares rurales pobres de México, la inseguridad alimentaria compromete el consumo de zinc y energía de las madres en favor de sus hijos? *Salud Publica Mex* 2011;53:299-311.

Resumen

Objetivo. Analizar indicadores cuantitativos de inseguridad alimentaria (IA) y estimar si IA modifica la asociación del consumo de energía y zinc en madres e hijos como evidencia del compromiso de la dieta materna a favor de su hijo. **Material y métodos.** Estudio transversal, información basal de la evaluación de impacto del Programa de Apoyo Alimentario. Indicadores de IA: reserva de alimentos en hogar, autoproducción maíz y/o frijol, porcentaje del gasto en alimentos y acceso físico a mercados de alimentos. Se calculó el porcentaje de adecuación del consumo energético (PAE) y Zinc (PAZn) (n=2 563 pares). Se estimó un modelo de regresión lineal ajustado por covariables. **Resultados.** El PAE y PAZn de madres e hijos se asoció positivamente. Ningún indicador de IA modificó la asociación entre PAE y PAZn materno con respecto a sus hijos. **Conclusiones.** Los indicadores de IA estudiados no modifican la relación entre la dieta de madres-hijos en hogares rurales de México.

Palabras claves: seguridad alimentaria; dieta de la madre; dieta del niño preescolar; México rural

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In the World Food Summit of 1996 it was agreed upon that food security exists when *all people, at all times, have physical and economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for a healthy and active life.*¹ Some adverse effects on health have been documented in individuals from food insecure households, such as changes in cognitive development, poor reproductive outcomes in women, physical deterioration and psychological distress.²

Frequently accepted dimensions of food security include food access, availability and utilization. Food insecurity affects the quantity and quality of food consumption and, through these, nutritional status and physical well-being.^{3,4} Because of the multi-dimensional nature of food insecurity, it may be measured in many forms and attention needs to be paid as to not oversimplify or misunderstand its core meaning.⁵ Initially, household food availability was used to assess the existence of food insecurity.⁴ Subsequently, important scales focusing on subjective experiences of hunger were developed. A common practice is to validate scales of subjective experiences, having the food inventories as standard.^{6,7} However, it has been agreed upon that there may not be a unique measurement of food security that would capture all its dimensions.⁸ Thus, food insecurity can and has been measured through different angles, some focusing in the actual physical problems of access of food within and around households, others on purchasing power and still others on the perceived effect of such limited access.

The Radimer / Cornell hunger scale was originally developed in the nineties to qualitatively estimate the prevalence of perceived hunger in a sample of poor New York State households. This scale identifies those experiencing hunger through a household member reported experience of food insecurity.³ Based on this questionnaire, on the "Community Childhood Hunger Identification Project" (CCHIP), and on other US sources of information on this topic,⁹ a Food Security Scale (FSS) was developed to estimate food insecurity prevalence in that country. This is a widely used questionnaire that focuses on the effect of limited resources on food acquisition and the consequent experiences of hunger at the household level.¹⁰

The 1996 World Food Summit Food Security description suggests that measurement of the different dimensions of food security in a given setting would document its state relative to the defined construct. As an example of this association between measures of perceived food insecurity and other direct measures of some of its quantitative dimensions, a Mexican study conducted in a rural isolated community in Sierra de Manantlán revealed that more than 90% of households

experienced some level of food insecurity as measured by the FSS, and that this was negatively correlated with household food inventory and individual maternal diet variety.⁶ Other Latin American countries have employed different indicators such as household food inventory,⁷ or the Basic Food Basket or the evaluation of internal adjustment strategies that poor households implement to cope with economic crisis in Venezuela.¹¹ Again, as expected, these studies show that food diversity is compromised in food insecure household.^{6,11}

Access to food has been estimated only recently in Mexico through a study representative of its rural areas.¹² This study documented that constant access to food markets, especially those distributing fresh foods, is limited in rural areas and that this situation is especially critical for indigenous populations. This information suggest that measuring actual food access with indicators of presence, type and distance to food distribution points, considering transportation, may be critical in the estimation of food insecurity. Different dimensions of food security need to be assessed to obtain a more equilibrated image of particular populations, as had been suggested by Pinstrup-Andersen.¹³

In high income countries, a negative association has been reported between food insecurity and dietary quality in adult men and women.^{14,15} In the United States and Canada, vitamin, mineral and energy intake has been found to be lower in women living in households with food insecurity than in food-secure households⁽¹⁶⁻²⁰⁾ though this association was not observed for preschool children.^{16,18}

It has been shown that each household member experiences food insecurity differently. Adults, especially women, suffer its negative impact before children do, a phenomenon that could be interpreted as a form of protection of the child food intake.^{3,17,21} Few studies have attempted to answer the question of whether mothers compromise their consumption to protect their children as the level of food insecurity rises. Compromised dietary consumption by mothers in favor of the children was documented in a study of single Canadian mothers, in which food insecurity occurred in 78% of households.²² The study found that women reduced their intake of seven vitamins and two minerals, whereas only reductions in folate and Zinc intake were observed in their children.

One can study this maternal dietary compromise in terms of dietary quantity, and energy would be the selected indicator; or in terms of dietary quality. The latter would need an element that singles out meaningful dietary quality. In Mexico, the 1999 National Nutrition Survey showed that Zn is highly deficient in the diet of rural children and women.²³ Its prevalence in rural areas

was 24.7% in children < 2 years, 55.8% in children 3-4 years, and 33.9% in women.²³ Due to these findings, Zn has in fact been used, along with other key micronutrients, as a fortification element in national nutrition programs based on its potential to promote healthy growth.^{24,25} Programs currently using Zn as a fortifier include *Oportunidades*, which distributes a complementary micronutrient fortified food for young children, or *Liconsa* which distributes fortified milk to poor households with children <12y. Together these programs reach more than 30 million households every day.²⁶

The aim of this study was to evaluate a potential maternal dietary compromise (in quantity or quality as estimated by energy and Zn adequacy of intakes respectively) in favor of her preschool child, using ad-hoc developed quantitative indicators of food insecurity, in rural households in central-southern Mexico.

Material and Methods

Study design and sample

A cross-sectional study was carried-out using baseline information from the impact evaluation of the Mexican *Programa de Apoyo Alimentario* (PAL, "Food Assistance Program").²⁷ The PAL is directed toward the poorest population in rural Mexico living in communities without schools and/or health centers. Due to these conditions, such communities are not eligible for the largest governmental Human Development Program *Oportunidades*. To evaluate the PAL, 208 communities with the same degree of poverty and development characteristics were randomly selected from eight states in central-southern Mexico (Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatán). Thirty-three households were selected through a systematic random method within each community. Fieldwork was conducted from October 2003 to April 2004. A sample of 2 133 mothers aged 12-49 years (who may have had more than one preschool child) and 2 563 non breastfeeding children aged 6-59 months was studied. In total, the sample analysis was composed by 2 133 mothers 20% of whom had two children in the study, so that there were 2 563 children, all with complete dietary information. The study was approved by the Biosecurity, Ethics and Research Commissions at the National Institute of Public Health (INSP for its Spanish name) and written informed consent was obtained from mothers.

Data were collected by trained personnel who conducted one 24-hour dietary recall. When possible, food similar to that reported as consumed, was weighed at home. When not possible, weights were estimated using

standard household measurements (e.g., glass, cup or spoon). Nutrient dietary content and adequacy of intake were calculated based on the dietary information^{28,29} using the nutrient composition database compiled by the INSP which is based on various sources.³⁰ Information on whether or not the child was breastfed was available. Though we had information on frequency of breastfeeding, no milk consumption data was obtained. We considered we could not derive valid estimates of breast milk consumption so dietary energy could not be quantified for breastfed children. Thus breastfed children were excluded from the analysis.

Household-level food insecurity indicators

Our data set does not contain measures of perceived food security as estimated by the FSS. It does, however, contain quantitative measures of different components of food security as shown in Figure 1.

A household food availability indicator was developed based on a) food inventory and b) household food production. A food access indicator was developed considering both a) economic and b) spatial access to local food markets.

Food availability indicator through a food inventory. a) We calculated the amount of food stored at home (in grams and by food groups) adjusted per adult equivalent (AE) using information on a household food inventory performed the day of the interview. Foods were classified into seven groups: 1) fruits and vegetables (e.g., onion, tomato, chard, avocado, zucchini, chayote, chili, lime, apple, banana, watermelon, carrot); 2) cereals and tubers (tortilla, oatmeal, amaranth, rice, maize flour, wheat flour, cookies, crackers, bread, pasta, potato, or yucca); 3) legumes (beans, lentils, chickpeas, or soy); 4) animal food sources (milk and dairy products, eggs, cheese, beef, chicken, pork, pork rinds, sardine, or tuna); 5) industrialized foods (pastries, sodas, chips, mayonnaise, instant soups, oil, sugar, powdered soft drinks, coffee, powdered or hard chocolate, jello, catsup, hot chili salsa), 6) nuts (sesame seeds, almonds, peanuts, walnuts, or pumpkin seeds) and 7) seasoning (garlic, basil, cumin, cinnamon, cloves, thyme, hibiscus flower, bay leaves, chamomile, oregano, pepper, or mint). Adult equivalent (AE) was estimated according to the dietary energy requirement for age, sex and physiological status of each household member. Energy for an adult was considered to be the equivalent of 597.5 kJ/d (2500 kcal/d recommended for an adult).²⁹ Correlation between amounts of food group was estimated. To identify patterns across data and reduce it to one variable, principal component analysis was performed on data with 2 093 households

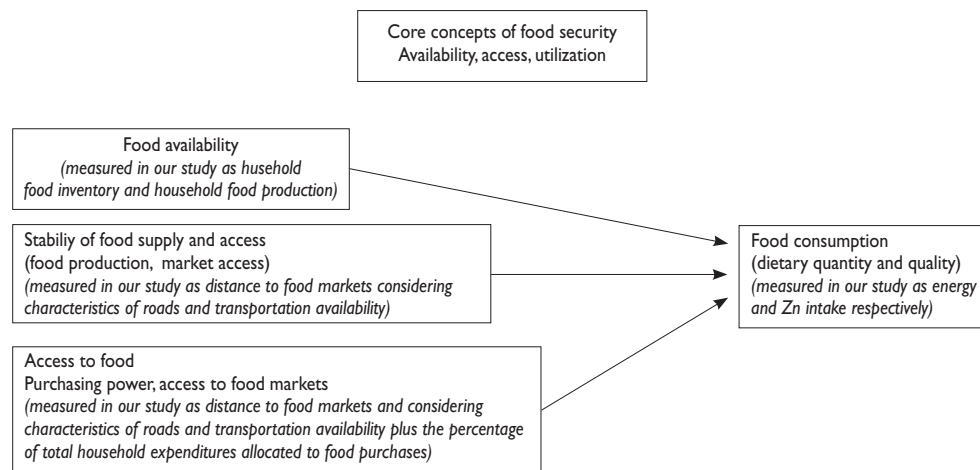


FIGURE I CORE CONCEPTS OF FOOD INSECURITY AS MEASURED QUANTITATIVELY IN THIS STUDY, MEXICO

with complete information. After *varimax* rotation, three factors with eigenvalues >1.0 were identified. Each factor was studied according to the percent of variance explained, its profile and interpretability (other solutions are available upon request). We chose to use items with factor loadings ≥ 0.3 ³¹⁻³³ based on the distribution of loadings within a factor across factors, and retained the first factor which explained 25% of variance and was the most relevant (see Table II).

Food availability indicator through household food production
b) Household food production was defined as a dichotomous variable based on whether or not the household consumed *any* amount of maize and / or beans produced by the household within the seven days prior to the interview. These two food items are the country's main staples, so that the consumption of either one may be considered at the root of the peasants' survival strategies and cultural preferences.³⁴

Food access indicator: a) Economic access. This was measured using the percentage of total monthly household expenditure spent on food. Total estimated household expenditure included expenditure in the following items: food, transportation, cleaning products, health care, education, fuel, electricity, rent, clothes, and expenditure in special ceremonies. Information on these expenses were obtained on different time frames; i.e., weekly, monthly, annually; and calculated as monthly total expenditure

Food access indicator: b) Spatial access index developed based on: distance to food markets and time from home to market, using information of place of food purchases (local store, weekly local market, weekly produce mar-

ket, regular or irregular produce vending trucks, street stallholder, local domestic production, supermarket or small grocery store) and traveling time (min) to the place of food purchases. The latter was estimated considering topographic conditions through travel time isochrones using the geographic information system ArcInfo Version 8.3 according to classifications for local land communication routes available at the time of the study.* Each food market spot calculated to be within 30 min from the household was assigned a score of 0.5; otherwise, a score of zero. The total points from spatial access food index were obtained and higher values were considered to reflect greater spatial access to food. The index was categorized on zero, one, and two or more close local food markets.

Diet quality and maternal compromise

We estimated maternal adequacy of energy and Zinc intake^{28,29} as a function of the adequacy of the child's intake adequacy. Using this approach, it is possible to evaluate whether mothers compromised their dietary consumption in favor of her children. The study hypothesis is that as the severity of food insecurity increases, the consumption of the mother decreases relative to that of her child. The association between the mother's consumption and that of her child's would be negative, indicating the

* González D, Santos R, Gutiérrez JP, González-Cossío T. Índice de Disponibilidad de Alimentos en la Localidad. In press 2004.

existence of a compromise on the part of the mother in the presence of food insecurity. We chose to analyze Zinc as an indicator of dietary quality because is one of the most important nutrient to achieve adequate health and development of human capital in a population.²⁵

Covariates

Children's and mothers' variables were included as covariates. The child sex, age and nutritional status were included. Three indicators of nutritional status were used: underweight, wasting and stunting, classified by the z-score values (< -2) of the weight-for-age (WAZ), weight-for-height (WHZ) and height-for-age (HAZ) indexes, respectively. The 2006 World Health Organization (WHO) international standards were used to construct the indices.³⁵ Maternal age and marital, physiological and nutritional status were also covariables. In mothers aged <18 y, body mass index (BMI) was adjusted by cut-off points suggested by Cole.³⁶ In adult mothers cut-off points suggested by the WHO³⁷ were used. The following household covariables were included: head of household sex; indigenous condition (if at least one person in the household over 17 years spoke a native language); and percentage of household members ≤5 y (number of children ≤5 / total household members). Using information from type of floor, wall and ceiling construction material, number of rooms (not including kitchen or bathrooms), sanitation service, electricity, and possession of refrigerator, gas stove, television, radio, VCR, telephone and computer a socioeconomic index was determined. The index was generated by principal component analysis, which explained 43.6% of the variance in the first factor. The index was divided into tertiles: low, medium and high. Since it was detected that some households were registered in social programs (even if residing in communities where the programs did not formally operate), participation in social programs was considered by adding up the number of programs in which the members of the household were registered. This variable was dichotomized as none, and one or more. Some social programs had a specific nutritional components (nutritional supplement for children from *Oportunidades*, *Free Tortilla*, *Milk Supply Program*, *Food Baskets* and *School Lunch*) while others had different contents (cash transfer and scholarships from *Oportunidades*, transportation scholarships, *Popular Health Insurance*, *Productive Options* and *Temporary Employment*).

Statistical Analysis

Medians, inter-quartile ranges and frequencies of each variable were calculated. According to the scale of vari-

ables, the association among dependent, independent and covariables was evaluated using the Pearson, Spearman, point bi-serial or *phi* correlation coefficients.

The association between food insecurity and maternal adequacy of intake was estimated using a linear regression model for energy and another for Zinc, adjusting for covariates and for clustering effect to indicate that observations may be correlated. We did this because mothers in our sample may have had more than one child in the study, resulting in a lack of independence between siblings' data. We calculated our estimates with and without siblings in the sample, and did not find evidence that including siblings had an effect on our estimates. Therefore we adjusted for the clustering effect.

Maternal adequacy of intake was the outcome variable. We included interaction terms between each food insecurity indicator and child adequacy of intake to evaluate the potential different association between maternal and child intake depending on different levels of food the insecurity indicators. The resulting model is presented in Equation (1):

$$y = \beta_0 + \sum_{i=1}^{n-4} \beta_i X_i + \beta_5 \sum_{i=1}^{n-4} \beta_i X_i * Z + \beta_j X_j + \epsilon \quad (1)$$

Where y is maternal adequacy of intake, β represents the regression coefficient term, X_i represents each food insecurity indicator, Z is the child adequacy of intake, is the interaction term, and $\sum_{i=1}^{n-4} \beta_i X_i * Z$ refers to the series of relevant covariables. Equation (1) illustrates the effect on maternal adequacy of intake per one-unit change in child adequacy of intake taking into account indicators of food insecurity. Interaction terms were not statistically significant so that Equation (1) became:

$$y = \beta_0 + \sum_{i=1}^{n-4} \beta_i X_i + \beta_5 Z + \beta_j X_j + \epsilon \quad (2)$$

Statistical differences were considered when $p < 0.05$. Data was processed using STATA/IC version 10.1.*

Results

Descriptive analysis

Table I presents child, maternal and household-level characteristics in the studied sample. Child and maternal median adequacies of energy intake were less than

* StataCorp. 2007. Stata Statistical Software: Release 10. College Station, TX: StataCorp LP.

Table I
SOCIAL AND DEMOGRAPHIC CHARACTERISTICS
OF CHILDREN, MOTHERS AND HOUSEHOLDS PARTICIPATING
IN THE STUDY, CENTRAL-SOUTHERN MEXICO 2004

Characteristics	Median or %
Child characteristics (n=2 563)	
Age, in months, median	34.3
Male (%)	47.0
Has sibling less than 5 years old (%)	38.5
Nutritional status* (%)	
Underweight (<-2Z WAZ)	8.30
Wasting (<-2Z WHZ)	0.9
Stunting (<-2Z HAZ)	19.9
Adequacy of energy intake, median	70.1
Adequacy of zinc intake, median	120.4
Maternal characteristics (n=2 133)	
Age in years, median	27.0
Physiological status (%)	
Not pregnant, not breastfeeding	71.3
Pregnant or pregnant and breastfeeding	8.3
Non-pregnant breastfeeding	20.4
Marital status (%)	
Single, divorced or widowed	10.4
Nutritional status [‡] (%)	
Underweight	2.30
Overweight	36.1
Obese	20.3
Adequacy of energy intake, median	83.1
Adequacy of zinc intake, median	77.2
Household characteristics (n=2 133)	
Male head of household (%)	91.3
Indigenous (Yes=1) (%)	21.7
Socioeconomic level (%)	
Low	39.1
Medium	33.7
High	27.2
% of household members under 5 y, median	31.0
Participation in social programs (%)	43.3

* Anthropometric Z-scores were calculated using WHO 2006 growth references

[‡] Body mass index (kg/m²) cut-off points suggested by WHO in adult mothers and criteria suggested by Cole in mothers <18y

100% (70.1% and 83.1% respectively). Median child adequacy of Zinc intake was 120.4%, whereas maternal was 77.2%. The prevalence of child wasting in these very poor communities was very low but stunting was high (0.9 and 19.9% respectively). Prevalence of maternal underweight was low. However, their prevalence of excess

weight was quite high; more than half of the mothers were overweight or obese (56.4%). Twenty percent of the households were considered indigenous and approximately 40% participated in some social program.

Descriptive analysis of the food insecurity indicators developed in this study is shown in Table II. The industrialized food group was the most frequent in the households (366g/AE), followed by cereals and tubers (232.1g/AE), and finally legumes (198.1g/AE). Through the principal component analysis, legumes, cereals and tubers showed the greater and most positive correlation factor loadings. On the other hand, animal food products had negative correlation. Approximately 40% of this population produced their own maize and/or beans which they consumed the week prior to the interview. Median household maize and beans production was 2695g/AE. More than half (54.9%) of the total household expenditure was on food. Around three quarters (74.5%) of households had access to food markets from at least one source located less than 30 minutes away.

Bivariate associations

Table III shows a correlation matrix among selected dietary, food security and demographics variables. Household food production of maize and/or beans had a positive correlation with household storage but a negative one with food expenditure (as % of total monthly monetary expenditure) and with spatial access to local food markets. For mothers, household food storage and production of maize and/or beans showed a positive correlation with their own adequacy of energy and Zinc intake. Indigenous household condition showed positive correlation with maternal adequacy of energy and Zinc intake, household production of maize and/or beans, household food storage and with participation in social programs. It was negatively correlated with spatial access to local food markets, food expenditure (as % of total monthly monetary expenditure), and child adequacy of energy and Zinc intake.

Maternal and child adequacy of intake

The association between maternal and child adequacy of energy and Zinc intake is showed in Table IV. Five models were estimated. Model I presents the association adjusted by child, maternal and household characteristics without food insecurity indicators. Subsequent models examine the relationship when food insecurity indicators were added, as described next. Model II included food household storage, model III was model II plus household production of maize and/or beans, model IV was model III with the addition of spatial ac-

Table II
HOUSEHOLD FOOD INSECURITY INDICATORS, CENTRAL-SOUTHERN MEXICO 2004

Variables	Median or %	Interquartile range	Factorial load [‡]
Dimensions of food insecurity			
I. Food availability			
Food household storage (g/AE [*])(from food inventory)			
Legumes	198.1	261.7	0.84
Cereals and tubers	232.1	415.6	0.79
Industrialized foods	366.0	523.0	0.38
Fruits and vegetables	140.1	314.2	0.16
Seasonings (salt, pepper, thyme, etc.)	13.0	31.4	0.05
Nuts and other oilseeds	54.8	58.3	0.03
Animal food products	124.9	240.9	-0.10
Household food production			
Maize and/or beans (%) (Yes=1)	37.6		
II. Food access			
Food expenditure (as a percentage of total household monthly monetary expenditure)			
	54.9	29.4	
Spatial access to local food markets [§] (%)			
None	24.5		
One	4.8		
Two or more	69.7		

* See text for description of AE (Adult Equivalent)
[‡] Factorial loads obtained by the principal component factor analysis. The first factor was retained, which explained 25% of total variance
[§] Distance to food markets and considering characteristics of roads and transportation availability (see text for detailed description)

cess to local food markets and model V was model IV plus the variable that indicated food expenditure (as % of total monthly monetary expenditure). Both energy and Zinc child adequacies were positively associated with maternal adequacy in all models ($p < 0.001$). Model II shows that food household storage was associated positively with maternal adequacy of energy ($p < 0.05$) but not with adequacy of Zinc intake ($p > 0.05$). The association was not significant after adjustment for the other food insecurity indicators. Household production of maize and/or beans was positively associated with maternal adequacy of energy and Zinc intake ($p < 0.001$) and the magnitude increased by adding all the food insecurity indicators.

Food expenditure (as a percentage of total household monthly monetary expenditure) was positively associated with maternal adequacy of energy intake ($p < 0.05$) but not with adequacy of Zinc intake ($p > 0.05$). Lastly, spatial access to local food markets was not associated with maternal adequacies of intake ($p > 0.05$).

Table V shows regression models fitted to determine the presence of maternal diet compromise in favor of her child. Other variables statistically associated with maternal adequacy of energy intake were an indigenous

condition ($p < 0.001$) and whether the mothers were breastfeeding ($p < 0.05$). On the other hand, there was a negative association between maternal adequacy and social programs ($p < 0.001$); with mothers being single, divorced or widowed ($p < 0.001$), and their BMI ($p < 0.05$).

The adequacy of Zinc intake was examined using an independent final multivariate regression model (Table V). Maternal adequacy of Zinc intake was positively associated with household production of maize and/or beans and with the indigenous condition of the household. Child age had a positive association with maternal Zinc intake. Breastfeeding was negatively associated with the adequacy of Zinc intake; being single, divorced or widowed mothers was negatively associated with both adequacies of intakes.

Discussion

Our study sought to evaluate whether mothers compromised their dietary consumption in favor of their child's consumption in the presence of food insecurity. We measured food insecurity with quantitative indicators of food production, access, household availability and purchasing power and found no evidence that maternal

Table III
CORRELATION MATRIX AMONG SELECTED DIETARY, FOOD INSECURITY AND DEMOGRAPHIC VARIABLES,
CENTRAL-SOUTHERN MEXICO 2004*

	2	3	4	5	6	7	8	9	10	11	12
1. Maternal adequacy of energy intake	0.42 [‡] (2563)	0.81 [‡] (2133)	0.30 [‡] (2563)	0.07 [§] (2072)	0.12 [‡] (1896)	0.02 (1966)	0.02 (2165)	0.14 [‡] (2133)	-0.01 (2133)	0.05 [§] (2133)	-0.08 [‡] (1928)
2. Child adequacy of energy intake	---	0.39 [‡] (2563)	0.82 [‡] (2563)	-0.04 (2450)	-0.15 [‡] (1896)	0.07 [§] (1966)	0.07 [‡] (2561)	-0.11 [‡] (2133)	-0.03 (2563)	-0.03 (2164)	0.04 [§] (2279)
3. Maternal adequacy of Zinc intake	---	---	0.42 [‡] (2563)	0.05 [§] (2072)	0.06 [§] (1898)	0.01 (1966)	0.01 (2165)	0.06 [§] (2133)	-0.10 (2133)	0.03 (2133)	-0.02 (1928)
4. Child adequacy of Zinc intake	---	---	---	-0.04 [§] (2450)	-0.15 [§] (1898)	0.04 (1966)	0.01 (2561)	-0.10 [‡] (2133)	-0.03 (2563)	-0.03 [§] (2133)	0.04 (2279)
5. Household food storage	---	---	---	---	0.21 [‡] (1811)	-0.04 [§] (1887)	-0.14 [‡] (2072)	0.09 [‡] (2072)	0.02 (2072)	0.02 (2072)	-0.06 [§] (1848)
6. Household production of maize and/or beans	---	---	---	---	---	-0.13 [‡] (1723)	-0.40 [‡] (1896)	0.46 [‡] (1898)	-0.03 (1896)	0.28 [‡] (1898)	-0.16 [§] (1686)
7. Spatial access to local food markets	---	---	---	---	---	---	0.04 (1965)	-0.10 [‡] (2863)	0.04 (1966)	-0.12 [‡] (1966)	0.05 [§] (1759)
8. Food expenditure (as % of total monthly monetary expenditure)	---	---	---	---	---	---	---	-0.25 [‡] (2165)	0.02 (2165)	-0.04 (2165)	0.06 (1927)
9. Indigenous condition	---	---	---	---	---	---	---	---	0.01 (2164)	0.23 [‡] (2133)	-0.15 [‡] (1928)
10. % of household members under 5 y	---	---	---	---	---	---	---	---	---	-0.11 [‡] (2164)	-0.11 [‡] (1928)
11. Social programs	---	---	---	---	---	---	---	---	---	---	-0.06 (1926)
12. Maternal BMI	---	---	---	---	---	---	---	---	---	---	---

* Correlation coefficient (n) which could be Pearson or Spearman for the continuous variables, point bi-serial for continuous and dichotomous variables, and phi for dichotomous variables

‡ p<0.001

§ p<0.05

dietary adequacy of intake was compromised in favor of her child, in neither quantity nor quality as measured by dietary energy and Zinc intake, as indicators of food insecurity varied.

The conceptual framework of food insecurity suggests that adults, and especially mothers, tend to compromise their consumption in favor of that of their young children.^{3,17,38} With data from poor rural areas in the Mexican central-southern region, our analysis did not support this hypothesis. Through our developed indicators of the availability of and access to food (both physical and economic access), we studied two quantitative dimensions of food insecurity and their association with Zn adequacy intake as an indicator of dietary quality of rural Mexican mothers and that of their preschool children. For both energy and Zinc, larger values of adequacy of dietary intake in children were positively associated with a greater adequacy of maternal dietary intake; and, this association was not modified by the dimensions of food insecurity. Since our

hypothesis was that maternal adequacy of intake would be compromised, we would expect that variations in the dimensions of food insecurity could affect or modify the associations between mother-child dietary intakes. This did not occur.

Some evidence from North America report different results from ours when using indicators of perceived food insecurity. In a rural community in New York state, women experiencing food insecurity reported low consumption of potassium, fiber and vitamin C, while the rest of the family maintained optimal consumption.³ More evidence from North America pointed that, more generally women reporting perceived food insecurity, reduced their consumption of energy, magnesium, and vitamins A, E, C and B₆; this association, however, was not found in preschool children.^{16,18} McIntyre followed a group of low-income Canadian women on a weekly basis for one month.²² This period was considered to cover times when a household's economic resources to purchase food would range from high to low. It was

Table IV
ASSOCIATION AMONG MATERNAL AND CHILD ADEQUACY OF ENERGY AND ZINC INTAKE, CENTRAL-SOUTHERN MEXICO 2004*

Variables	Model I		Model II		Model III		Model IV		Model V	
	Coef	95% CI	Coef	95% CI	Coef	95% CI	Coef	95% CI	Coef	95% CI
Maternal adequacy of energy Intake										
Child adequacy of energy intake	0.353 [‡]	(0.317 - 0.390)	0.353 [‡]	(0.316 - 0.390)	0.360 [‡]	(0.320 - 0.400)	0.347 [‡]	(0.304 - 0.389)	0.345 [‡]	(0.302 - 0.388)
Household food storage			0.04 [§]	(0.008 - 0.072)	0.027	(-0.006 - 0.061)	0.026	(-0.010 - 0.062)	0.029	(-0.007 - 0.065)
Household maize and/or beans production (Yes=1)					0.074 [‡]	(0.025 - 0.123)	0.086 [‡]	(0.034 - 0.138)	0.104 [‡]	(0.049 - 0.159)
Spatial access to local food markets							0.025	(-0.030 - 0.080)	0.025	(-0.029 - 0.080)
Food expenditure (as % of total monthly monetary expenditure)									0.001 [§]	(0.000 - 0.002)
Maternal adequacy of zinc Intake										
Child adequacy of Zinc intake	0.319 [§]	(0.287- 0.352)	0.317 [‡]	(0.283 - 0.350)	0.323 [‡]	(0.289 - 0.358)	0.322 [‡]	(0.286 - 0.358)	0.322 [‡]	(0.286 - 0.358)
Household food storage			0.032	(-0.004 - 0.068)	0.019	(-0.018 - 0.056)	0.018	(-0.023 - 0.059)	0.019	(-0.021 - 0.060)
Household maize and/or beans production (Yes=1)					0.091 [‡]	(0.038 - 0.145)	0.107 [‡]	(0.051 - 0.164)	0.116 [‡]	(0.056 - 0.175)
Spatial access to local food markets							0.047	(-0.010 - 0.105)	0.047	(-0.010 - 0.105)
Food expenditure (as % of total monthly monetary expenditure)									0.001	(-0.001 - 0.002)

* All models were multiple linear regression models adjusted by child, maternal and household characteristics

[‡] p-value <0.001

[§] p-value <0.05

Table V
REGRESSION MODELS OF ASSOCIATION AMONG MATERNAL AND CHILD ADEQUACY OF ENERGY AND ZINC INTAKE ADJUSTED FOR HOUSEHOLD FOOD INSECURITY INDICATORS, CENTRAL-SOUTHERN MEXICO 2004*

	Maternal adequacy of energy intake		Maternal adequacy of zinc intake	
	Coefficient	95% CI	Coefficient	95% CI
Child adequacy of energy intake	0.345 [‡]	(0.302 - 0.388)	-	-
Child adequacy of Zinc intake	-	-	0.322 [‡]	(0.286 - 0.358)
Food household storage	0.029	(-0.007 - 0.065)	0.019	(-0.021 - 0.060)
Household of maize and/or beans production (Yes=1)	0.104 [‡]	(0.049 - 0.159)	0.116 [‡]	(0.056 - 0.175)
Spatial access to local food markets	0.025	(-0.029 - 0.080)	0.047	(-0.010 - 0.105)
Food expenditure (as % of total monthly monetary expenditure)	0.001 [§]	(0.0001 - 0.002)	0.001	(-0.001 - 0.002)
Indigenous (Yes=1)	0.149 [‡]	(0.089 - 0.209)	0.165 [‡]	(0.105 - 0.224)
Social programs (Yes=1)	-0.049 [‡]	(-0.093 - -0.005)	-0.019	(-0.067 - 0.028)
Child age (months)	0.001	(-0.0002 - 0.002)	0.002 [‡]	(0.001 - 0.004)
Maternal BMI (kg/m ²)	-0.006 [§]	(-0.010 - -0.001)	-0.004	(-0.009 - 0.001)
Breastfeeding (Yes =1)	0.087 [§]	(0.029 - 0.145)	-0.291 [‡]	(-0.352 - -0.231)
Single, divorced or widowed (Yes =1)	-0.125 [‡]	(0.050 - 0.200)	-0.116 [§]	(0.042 - 0.190)
R-squared	24.5%		27.8%	
Observations	1757		1754	

* Multiple linear regression models adjusted by child sex and nutritional status, maternal age and % of household members under 5 y

[‡] p-value <0.001

[§] p-value <0.05

found that over the one-month period studied, mothers compromised their consumption in favor of their children, as indicated by the mean adequacy of dietary intake for the mothers being lower than that of their children, particularly energy, vitamin A, folate, Zinc, calcium and iron. In general, adequacy of dietary intake in the mothers was low and was shown to decrease over time. However, this study did not differentiate according to household food insecurity status, although roughly 80% reported experienced it.

The foods that were key indicators of food insecurity were maize and beans, both commonly foods present in household storage and production. This is because both foods constitute the basic diet of the population in rural Mexico. Maize and beans are likely to be produced primarily as a form of subsistence, with the priority of meeting the nutritional needs of the household. Excess production is used to generate income in order to meet other needs.³⁹ We found that the dimensions of food insecurity related to adequacy of energy and Zinc intake in the mother were household production of maize and beans and the percentage of food expenditure, although it only had a slight association with adequacy of energy intake. The fact that energy adequacy is positively associated with this indicator of food security, by no means intends to imply that the more energy mothers –or any family member– consumes, the better. The aim in nutrition policies must be to improve dietary quality while recommending a prudent energy intake; especially in a country as Mexico where two thirds of the adult population is overweight or obese.⁴⁰

Since consumption is strongly associated with income level and the family's physical access to different products, the availability of foods does not guarantee food security for the household. The Mexican National Committee for the Evaluation of Social Development Policy revealed that in rural areas in Mexico, 31.8% of individuals did not have enough income to meet their nutritional needs.⁴¹ It is known that poor households spend a large portion of their income on food. This study observed that households in this study typically spent more than half of their expenses on the acquisition of food; higher than the 41% reported for rural Mexico in 2004.⁴²

The strategies used and decisions made within households when facing a scarcity of food, are not known with certainty. However there were households with available foods which were not a source of bioavailable micronutrients (i.e., industrialized low-priced food items) which provided poor variety to the diet. On the other hand, our results suggest that when availability of and access to food is scarce, this population

turns to household food production: 40% of households consumed household production of maize and/or beans. A study in Sierra de Manantlán,⁶ a rural Mexican community with little socioeconomic variability, found that 90% of households experienced some degree of food insecurity, this negatively correlated with the availability in the household of fruits, vegetables and foods from animal origin, including dairy products. It was found that when faced with scarcity or limitations, households depended on foods which they produced themselves.

In contrast to what we expected, the spatial access to local food markets was not associated with the outcome, although the coefficients were always positive. This indicator provides information about location stores (<30 minutes); however it may be not the best to describe the potential access to a variety of food items and their characteristics (number, type, size, price).

The evidence indicates that households experiencing food insecurity typically receive assistance in order to reduce their vulnerability.^{7,18,22,43-47} Our study finds that participation in social programs is negatively associated with adequacy of energy intake in mothers and, although not statistically significant, the coefficient for adequacy of Zinc intake was also negative. This suggests that participation in social programs is an indicator of poverty, and that therefore these households have a greater probability of experiencing food insecurity.

The findings of our study are important because particularly they respond to the need to study the gender aspects of food insecurity in rural and marginalized areas in Mexico. Traditionally, the study of the association between food insecurity and diet has been conducted in high-income countries using nationally representative surveys,^{16,18} in urban zones with scarce resources^{19,20,22} and in rural communities.³ In Latin America, the understanding of this phenomenon is just beginning;^{6,7,11,43,48} and this work contributes to that understanding.

A potential limitation of this study may be that dietary information was collected only from mothers and their preschool children, which made it impossible to study the intra-household distribution in-depth. It is known that the nature of a compromised diet varies between populations because it depends on availability, access, and the way in which food is distributed within the family.^{17,38} Another potential limitation in our study is that dietary information obtained was provided by the mother who may have responded thinking it was a way to evaluate her ability as the caretaker or the one responsible for her family's nutrition; this could result in over-reporting the consumption of the child

and underreporting that of the mother. If this were the case, this would indeed obscure the very compromise we are evaluating. However, we have no basis to assume mothers in the more food insecure households of our sample, would underreport their child's diet while over reporting theirs. Regarding external validity of our study, communities' random selection and large sample sizes allow for generalization of the findings to rural communities in southern Mexico, but only to those non-breastfeeding mother-child pairs.

The mother being single, divorced or widowed was negatively associated with the adequacy of her energy and Zinc intake. It may be that not having a partner results in having more limited resources or less financial security with which to face situations within the household, and that this is directly reflected in decreased adequacy of dietary intake. Single and divorced mothers are found to have a more vulnerable health status, and with respect to diet, it has been documented that they consume less fruits and vegetables.^{49,50}

The physiological demand for nutrients in lactating women⁵¹ was evident in this study, as lactation was found to be negatively associated with adequacy of Zinc intake. In our study we found that BMI was negatively associated with energy adequacy of intake. We evaluated our estimates including BMI as a covariate. We also stratified by maternal obesity but did not find significant changes in the estimate, its magnitude, direction or p value. The potential error due to underestimation of maternal dietary intake may be debilitating our estimated association, possibly bringing it towards the null value.⁵²

The mothers in indigenous households, independently of other factors, may have better practices with regard to choosing the quantity and quality of food they consume (reflected by the positive and statistically significant association with the coefficients for energy and Zinc, respectively). However, they are only meeting three quarters of the nutritional requirement (>70%). This data are of concern because women in rural areas have a predominant dietary pattern consisting of maize and its derivatives, wheat and its derivatives, and beans and legumes,⁵³ all of which have low bioavailability for micronutrients. Regardless, the finding that women in indigenous households have higher adequacy of dietary intake suggests that something is occurring for those women. This could be studied in the future so as to clarify the processes that occur within these households.

We analyzed the relationship of a quantitative indicator of food insecurity with the diet of mothers and children in poor southern rural communities in

Mexico. We found that in the present of food insecurity, maternal diet is not compromised in favor of that of their children, in terms of either quantity (adequacy of energy intake) or quality (adequacy of Zinc intake). With the assumption that maternal dietary consumption is related to that of the other household members, particularly children, we observed that child adequacy of dietary intake, household production of maize and/or beans, and indigenous household condition, were all associated with a higher maternal adequacy of energy and Zinc intake. The design of this analysis was cross-sectional. In the future, it may be meaningful to explore the relationship between food insecurity and a maternal compromised diet mother in favor her children through time, and not only on a cross sectional study. This could aid in answering the question of whether such a strategy is used by adults in households with food insecurity, and especially by mothers, compromising their own consumption to protect their children.

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