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Shahid Sadoughi University of Medical Sciences
School of Public Health
Department of Nutrition
Shahid Sadoughi University of Medical Sciences School of Public Health

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Food Availability, Accessibility, and Affordability through the Scope of Food Security Level and Food Environment Perception in Mexico City's Marginated Area

Vianey Camacho-Vallejo; MSc[1] & Alfonso Totosaus; PhD [*1]

[1] *Food Science Lab and Pilot Plant, TecNM/TES Ecatepec. Av. Tecnológico eq. Av. Central s/n, Ecatepec de Morelos 55210, Estado de Mexico, Mexico.*

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Corresponding author:
atototosaus@tese.edu.mx
Food science lab and pilot plant, TecNM/TES Ecatepec. Av. Tecnológico eq. Av. Central s/n, Ecatepec de Morelos 55210, Estado de Mexico, Mexico.

Postal code: 55210
Tel: +52 55 5000 2300

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ABSTRACT

Background: Food availability, accessibility, utilization, and stability, the four pillars of food security, have sound impact on food environment activities, regarding households' food availability, accessibility, and affordability. Food availability implies the adequate supply of healthy food and food accessibility complements and builds on food availability by ensuring that households are able to obtain that food, and that food affordability is limited by incomes and food prices. **Methods:** In this research, socioeconomic characteristics, food security status and food environment (food availability, accessibility, and affordability) perception of households in Ecatepec, México, a marginal Mexico City conurbation area, were determined with the adequate survey. The collected data were analyzed by logistic regression to stablish the significant relationship among the independent variables (household food security status) with the socioeconomic features, in addition to food environment perception, in order to determinate which facts were significant with food security in this marginal area. **Results:** Educational level (P<0.001), household income (P<0.001), and belonging to a social assistance program (P<0.001) have a significant effect on food security status. Households with lower income, with food insecurity status, presented lower purchasing power. In contrast, households with food security and mild food insecurity were less likely to agree with the food that they can purchase. A better income, and therefore, a higher purchasing power was reflected in the need to access to more healthy food within their neighborhood. **Conclusion:** Results indicate that the food environment in this marginal area is benevolent, and households find a way to remain resilient in order to provide enough food for their families. Public policies must be focused on reducing poverty and giving more opportunities to promote social mobility.

Introduction

Food and Agriculture Organization (FAO) declared that food security status is present when people always have physical, social, and economic access to adequate, safe, and nutritive food which satisfies their dietetic needs and preferences for foods to carry out a healthy and active life (Food and Agriculture Organization, 2009). Nonetheless, the four pillars of food

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security (availability, accessibility, utilization, and stability) are strongly influenced by food system and food environment activities. When one or more than one of these pillars fail, there is a food insecurity situation. In addition, food environment comprises cultivated and built informal and formal spaces that are influenced by the socio-cultural and political environment and ecosystem within which they are embedded (Downs *et al.*, 2020). This implies that there is a dynamic interface between people as consumers and the food environment is understood as the places where people purchase food to prepare their meals. Consequently, the dietary behavior of food environment encompasses the accessibility, availability, convenience, affordability, desirability, and quality of foods (Herforth and Ahmed, 2015, McKinnon *et al.*, 2009). Subsequently, the elements that describe food accessibility are affordability, allocation, and preference, whereas the elements that describe food utilization are nutritional value, social value, and food safety (Ericksen, 2008).

Caspi *et al*. made the most intelligible interpretation of the food environment, establishing the relationship between food security pillars and the food environment (Caspi *et al.*, 2012). The availability and variety of food options are related to access to a healthy diet. The most intelligible interpretation of food environment was made by Caspi *et al*., establishing the relationship between food security pillars and food environment. In dimension access and diet availability and variety presented a relationship with healthy diet; food accessibility showed a constant inconsistency with dietary outcomes; affordability is related to the consumers' perception of yield affordability. There is no standardized measure of healthy food availability, and the affordability measure unequivocally does not predict healthier diets.

Food insecurity has a temporal and intensity dimension, whereas vulnerability has an external and internal dimension, and these dimensions need to be combined in order to understand the different interactions among different dimensions at multiple levels of the food systems, since they play a significant role in the livelihoods due to the accumulation of assets and for accessing food (Hart, 2009). Household food insecurity include several factors, such as psychological, macro and micronutrients intake like dietary factor, nutritional condition, and healthy impacts, affecting mainly low-income, welfare-recipients, college students and senior citizens. Beside these factors, demographic factors such as socioeconomic characteristics, large household, lower education level and poverty, have as well a strong impact on food insecurity (Sulaiman *et al.*, 2021). Education level and wage type of household head is one of the most important socioeconomic dimensions related to food insecurity beside infrastructural dimensions such as housing type and water installation, as reported in India (Anand *et al.*, 2019).

The objective of this research was to use personal interviews to gain a direct understanding of the food environment as perceived by households in a vulnerable area. The focus was on evaluating food accessibility, availability, and affordability in relation to their food security situation. Information about how the household contemplate the whole food environment in respect to these three factors (accessibility, availability, and affordability) is scarce and at the same time is very important to propose and enact public policies.

Materials and Methods

Data collection

In order to collect information about food security status and food environment perception, three questionnaires were applied: i) Food Security Mexican Survey (Villagómez-Ornelas *et al.*, 2014) to determine food security status of households; ii) socioeconomic information about scholar level, household income, and if they receive government support; and iii) food environment perception, asking about the availability of healthy foods, the easy access to food and the capacity to get foods; in summary, food availability, food accessibility, and food affordability. For food availability, people were asked if they always found the food that they want, if there was a great variety of foods,

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if they always found fruits and vegetables, If they must shop in multiple locations, there are alternatives for the foods they want if they do not find them in one place. For food accessibility, people were asked if they thought that there were enough places to buy foods, if the traveled distance was short, if they could buy healthy foods, if there were a great variety of fruits and vegetable, and if they did not walk five to ten minutes to buy foods. For food affordability, people were asked if they could buy the foods want, if due to the price they could not buy the foods that they wanted, if the healthy foods options were more expensive, if they bought the fruits and vegetables that they wanted, and if they did not have enough money to buy foods. These questions were asked employing a Likert scale where one "strongly disagreed" and ten "strongly agreed", considering a score of five 'as neither agree nor disagree'.

This study was estimated as exempted by the internal ethical committee board since there were no interventional procedures within the research protocol and the recollected personal private information would not be made public. Considering this, before starting the questioning, interviewers explained the objective of the study to obtain oral consent. Physical distancing and sanitary protocols were followed. A total of 471 surveys, conducted from August to November 2022, were analyzed. Surveys were conducted outside the main places to buy foods, places such as markets, supermarkets, and open-air markets. Participants were recruited through purposive snowball sampling.

Experimental design and data analysis

Descriptive analysis of the socioeconomic results by food security level was performed with the command PROC SURVEY in SAS v. 9.1 statistical software (SAS Institute, Cary), to determine the relationship between socioeconomic characteristics and food security level, reporting Rao-Scott χ^2 and P-value. The effect of food security level on Likert results for food environment was determined by the analysis of variance, and the significant difference (P<0.05) between means was determined by Tukey's honestly significant difference (HSD) employing the R Studio v. 4.2.1 platform.

Results

The results about food security status were as follows: just above half of the households were in food security status (51%), whereas the rest of surveyed families presented different degrees of food insecurity: mild (28%), moderate (15%), and severe (6%).

Table 1 shows the results for the socioeconomic aspects of households at different food security statuses. The education level of the family head or main source of income presented a marked influence on food security status (P<0.001) since for the total of surveys middle school was the higher degree of scholarship (30.85%). For households with severe food insecurity status, elementary school had the higher school attendance. For the level of estimated income (P<0.001), families in food security and both mild and moderate food insecurity declared to perceive incomes in D plus level ($342 to $583 USD), but families in severe food insecurity level declared lower incomes (level D, $136-$342). Finally, most families (75%) declared not receiving money from any social assistance program (P<0.001), irrespective of the food security level.

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Table 1. Distribution of sociodemographic characteristics (frequency and percent) by food security status

Variable	Total		Food secure		Mild food insecure		Moderate food insecure		Severe food insecure		P-value[a]
	N	%	N	%	N	%	N	%	N	%	
Education level											
Elementary	98	20.85	34	7.23	39	8.29	15	3.19	10	2.12	<0.001
Middle school	145	30.85	73	15.53	45	9.57	23	4.89	4	0.85	
High school	133	28.29	70	14.89	35	7.44	19	4.04	9	1.91	
College	94	20.00	65	13.82	19	4.04	5	1.06	5	1.06	
Household income											
C+	45	9.57	31	6.59	10	2.12	3	0.63	1	0.21	<0.001
C	6	1.27	1	0.21	3	0.63	1	0.21	1	0.21	
D+	267	56.80	127	27.02	100	21.27	26	5.53	10	2.12	
D	127	27.02	69	14.68	23	4.89	25	5.31	14	2.971	
E	25	5.31	14	2.97	2	0.42	7	1.48	2	0.42	
Social assistance											
Yes	117	24.89	42	8.93	46	9.78	23	4.89	6	1.27	<0.001
No	353	75.10	200	42.55	92	19.57	39	8.29	22	4.68	
Total	470	100.00	242	51.48	138	29.36	62	13.19	28	5.95	

[a]: Chi-square test [b]: Socioeconomic level in agreement with income per month: E <$136 USD, D from $136 to $342 USD, D+ from $342 to $583 USD, C from $583 to $1,759 USD, and C+ >$1,759 USD.

For food availability, in general, respondents with food security and mild food insecurity level presented significant (P<0.05) Higher scores indicate that they agree they can always find the food they want (8.49 and 8.25 scores, respectively), and households with higher food insecurity status agreed less (7.86 and 7.68 for moderate and severe food insecurity, respectively). The same pattern was observed in the satisfaction level for the variety of foods that the families can buy in their neighborhoods, where households with food security status presented a significant (P<0.05) higher level of satisfaction. For the item considered regarding whether they always find fruits and vegetables, the scores were similar across all food security levels (above 8.0), with no significant (P>0.05) difference for the food security level. When asked if they must shop for food in more than one place for the food that they want, only households with moderate and severe food insecurity status presented significant (P<0.05) lower scores about this item. Finally, when people were asked about the alternatives when they did not find the foods they wanted, households with severe food insecurity status presented a significant (P>0.5) lower score (**Figure 1**).

For food accessibility, all the respondents agreed that there were enough places in their neighborhoods to buy food, with no significant difference (P>0.05) for food security level. In the same manner, the satisfaction level score for the short distance that they must travel to find food, presented no significant (P>0.05) difference as well for the food security level. Nonetheless, for the item "I can buy healthy food prepared in my neighborhood", respondents with both moderate and severe food insecurity levels expressed higher significant (P<0.05) scores, whereas households with mild food insecurity and food security less agreed about this item. When people were asked about the variety of the foods that they found, the satisfaction level was above eight, with no significant (P>0.05) difference for the food security level. Finally, about the walking distance to buy their foods, no significant (P>0.05) difference was observed for the food security levels (**Figure 2**).

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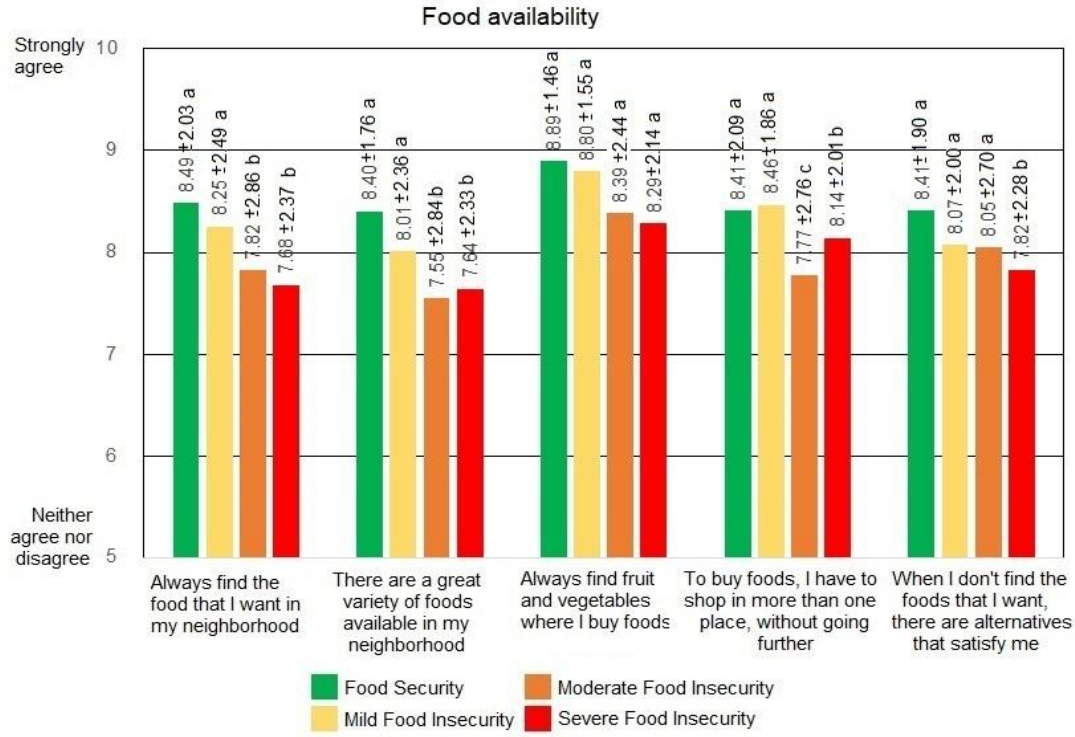

Figure 1. Satisfaction levels based on food security indicate that food availability a, b indicates no significant differences (P>0.05) among the food security levels.

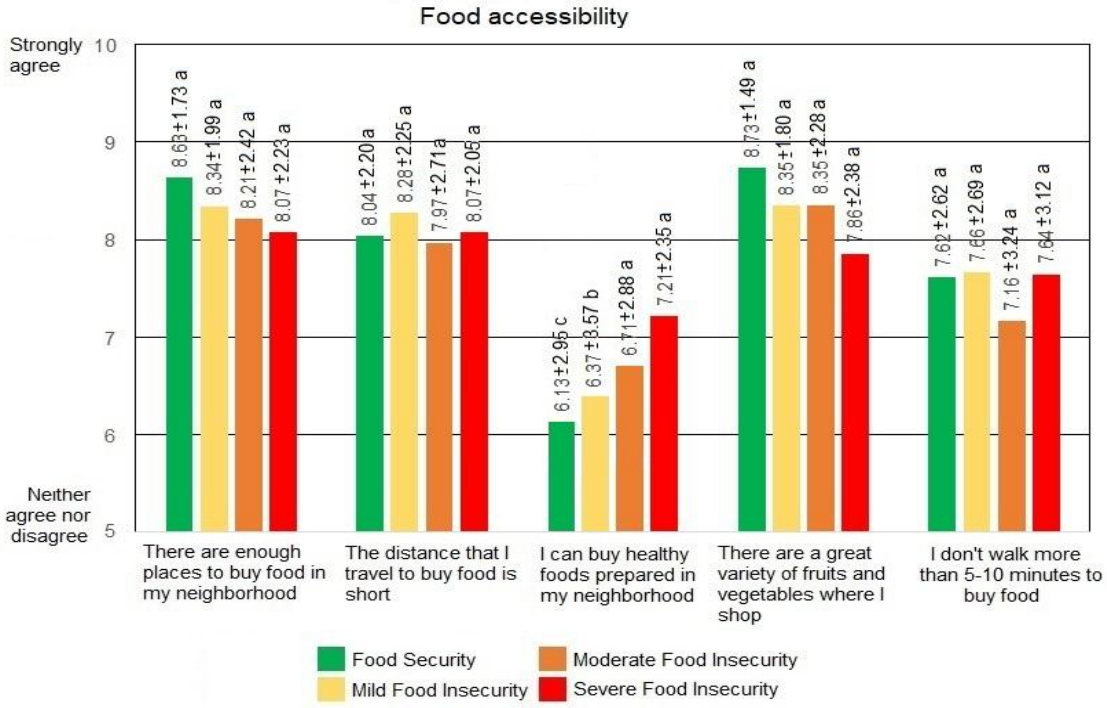

Figure 2. Satisfaction level by food security level for food accessibility a, b means with the same letter are not significant (P>0.05) different for the food security level.

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Regarding food affordability, the respondents agreed that they could buy the foods they wanted, being significantly (P<0.05) higher for households in food security status, and lower for households with moderate food insecurity status. The item "Due to the price, I cannot buy the foods I want" received lower satisfaction scores (close to 6.00), with no significant (P>0.05) difference for food security level. If they felt that healthy foods were expensive, households in moderate and severe food insecurity status presented significant lower scores. People were generally satisfied with the fruits and vegetables available in their neighborhoods, with no significant (P>0.05) difference for the food security level. Finally, the last item "I do not have enough money to buy the foods that I want" received as well the lower satisfaction scores, with no significant (P>0.05) difference for food security level (**Figure 3**).

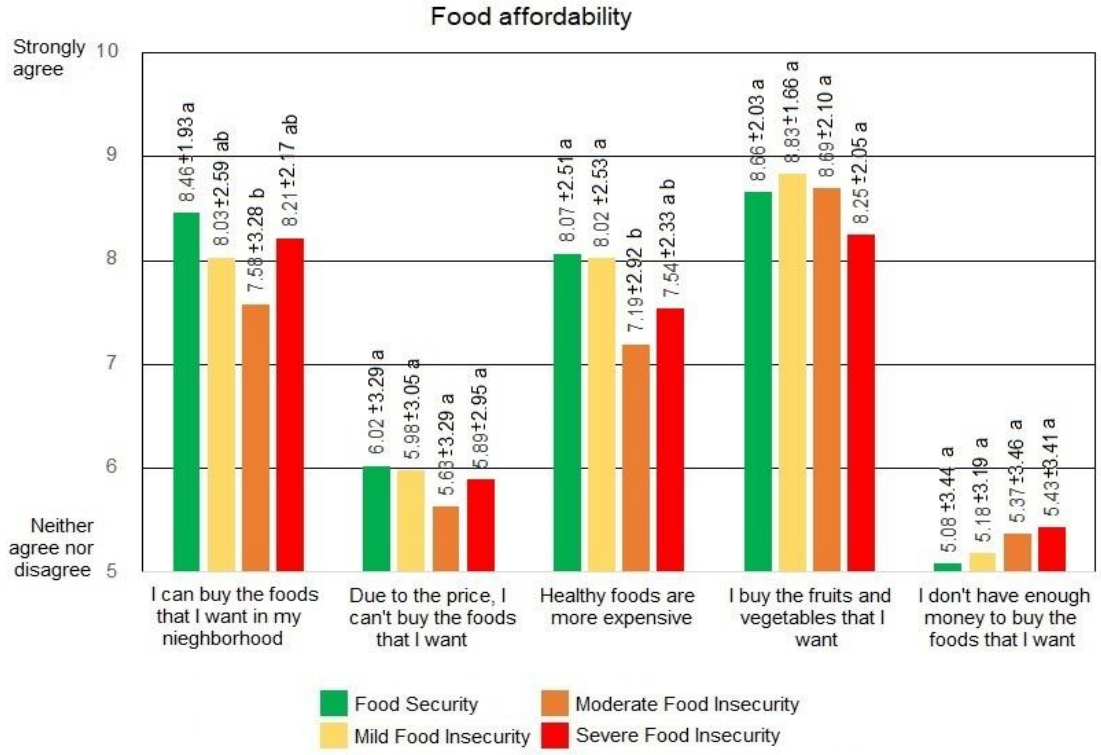

Figure 3. Satisfaction level by food security level for food affordability a, b means with the same letter are not significant (P>0.05) different for the food security level.

Figure 4 shows the simultaneous relationship between the perception of food availability, food accessibility, and food affordability at different food security levels of the surveyed households. In radial graph, for the overall average food availability perception axis, households in both food security and mild food insecurity levels agreed more with the fact that desirable foods can be regularly obtained within their neighborhood. In the overall average food accessibility axis, the level of satisfaction with the capacity to obtain food, regardless of any barriers, was very similar for all the food security levels. Finally, in the overall average food affordability axis, households with food security and mild food insecurity status were more likely to agree about their capacity to purchase enough food, that is, households in more drastic food insecurity situation seems to be resigned to their capacity to buy less food.

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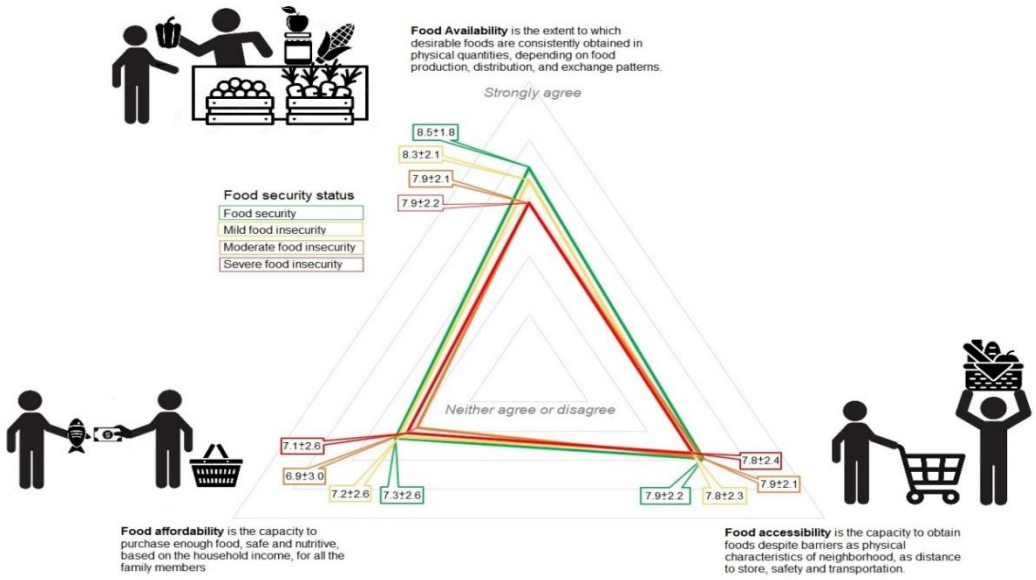

Figure 4. Comparison of the satisfaction level of food environment perception by food security status.

Discussion

Socioeconomic factors have a marked influence on food security. In México, as in many other developing countries, the educational level has an important effect on food security (De Haro-Mota *et al.*, 2016), since severe food insecurity conditions are related to lower educational levels as elementary school or middle school (Díaz-Carreño *et al.*, 2016, Félix-Verduzco *et al.*, 2018). In this way, the higher the educational level of the source of income to the households, the higher chance to be in food security level, since in the urban context households depend on food purchase to satisfy their needs (Mutisya *et al.*, 2016). The relationship between educational level and food security is inversely proportional to the capacity for spending to buy food (Cruz and Maldonado, 2017, Gil *et al.*, 2017). In developing countries such as Kenya, in rural areas, the probability of being food insecure decreases with increase in the average of schooling in a household, suggesting that education, regardless of household wealth status has an independent effect on food security in an urban poor situation (Mutisya *et al.*, 2016).

Receiving monetary social assistance is not always related to the direct improvement in food security, since although this economic support could enhance the consumption of higher nutritional value foods (Leroy *et al.*, 2010, Mundo-Rosas *et al.*, 2019), in localities with higher to medium marginality, there is a low diversity of food consumption, despite this kind of social assistance (Baca del Moral *et al.*, 2021). In certain occasions, obtaining access to social support can enhance food affordability, since individual access to food is strongly influenced by social variables such as gender positioning and power hierarchies within households (Capone *et al.*, 2013), although receiving economic support was not significant in food security status. In addition, in marginal areas with households with lower incomes, food insecurity is determined as well from the access dimension related to greater lags in basic services, such as drinking water, sanitation, energy, and storage (Mundo-Rosas *et al.*, 2019).

However, not all low-income households are in a food insecure situation (Carson and Boege, 2020). In developing countries, poverty does not automatically imply a food insecurity situation in households, since in México, around 30% of poverty households and around 20% of extreme poverty households are not in a food insecure situation (Félix-Verduzco *et al.*, 2018). In the same manner, households with a higher welfare status

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present a food insecurity situation, despite being in a minor proportion than households with lower welfare status (Mundo-Rosas *et al.*, 2019).

Regarding food environment perspective, the main perception was made throughout food access (availability, accessibility, and affordability). Food access involves many dimensions, including affordability, proximity, and cultural appropriateness, beside proximity to the food store (Bao *et al.*, 2020).

Food availability is described as the adequacy to supply healthy food, including the presence and prevalence of food retailers in neighborhoods, where purchase decision is more important than food availability, intrinsically constrained by the food retailers, because retailer selection is associated with price, location, convenience, and household demographics, among other factors (Kyureghian and Nayga, 2013, Vaughan *et al.*, 2017). In the present research, households with higher income related to a better scholarship were more pleased with the food availability within their neighborhood, replying that they always found the food they wanted in a great variety as well, although they must sometimes purchase food in more than one place; this implies that they have alternatives get food. Households with lower income presented lower purchasing power, and hence, the decision about the alternatives on what to buy was lower as well. This was because in general their answers were in a lower degree of agreement as compared with households with better food security status, probably trying to assuage the lack of resources to obtain enough food.

Food accessibility is the capacity to obtain food without any considerable physical or social impediment. Food access and consumption is a complex system that goes beyond spatial accessibility, since economic affordability, cultural elements, and individual differences, along with other components on the demand side, are just as important as price, quality, and service, on the supply side (Bao *et al.*, 2020). Food accessibility complements and builds on food availability by ensuring that food is not only available, but also households are able to obtain food, which is a strong intersection with both availability and affordability, serving as a bridge between them (Carson and Boege, 2020). In this research, according to the results, people thaught that there were enough retail stores, formal or informal, to obtain food, at a relatively short distance since most of them did not have to walk, and there was a great variety of fruit and vegetables. However, regarding access to healthy foods, households with food security and mild food insecurity were less likely to agree with the food that they could purchase. This probably means that a better income and hence a higher purchasing power was reflected in the need to access more healthy food within their neighborhood.

Food affordability is not related merely to the cost of food by itself, since it is not a static characteristic of food sources. This was because non-food expenses on household income should also be considered, which is better understood in conjunction with people, households, and neighborhood characteristics (Carson and Boege, 2020). In addition, food affordability is primarily determined by incomes, food prices, and the ability of households and individuals (Capone *et al.*, 2013) being related to the food that can be purchased in enough quantities to bring healthy food to the table, without interfering with other health-related expenses, such as medicines (Carson and Boege, 2020). These features can explain the observed results, where food security status affected only questions about buying the food that they can/want in their neighborhood, and that healthy foods are more expensive. Lower scores about lack of money to purchase foods and having enough money to buy foods obtained lower scores, with no difference among food security levels. First, definitively a lower income was associated with inferior scholarship resulting in lower money to purchase food, understandable in households with moderate and severe food insecurity status. In the same manner, the idea of healthy foods was associated with higher prices, however the healthy food concept was handled by different people. Nonetheless, irrespective of food security level, it

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seems that the people who have enough money can purchase enough food, including fruit and vegetables, but with different purchasing power due to the inherent differences in household income.

During COVID-19 pandemic, food acquisition patterns were changed drastically and job or salary losses besides unexpected medical expenses strained household budgets since the price of some foodstuffs increased. Given the required and recommended social distancing, the trips to food retailers were reduced, beside temporary or permanent closures. Furthermore, changes such as the limited public transportation contributed to reducing the access to available food sites (Carson and Boege, 2020). These changes in food production have an effect on the response to consumers' demand, impacting directly the food environment and disturbing food availability, quality, and affordability at both global and local markets, influencing indirectly as well income generation, social structures, and environmental change (Remans, 2016). Understanding how factors such as taste, price, convenience, knowledge, and availability influence food selection is essential. The interplay between these factors is complex. To gain insights into effective strategies for improving population health and nutrition, it is beneficial to consider using social-ecological models. These models illustrate how personal factors and the environment interact to influence behavior (Kelly *et al.,* 2011). These multifaceted factors must be considered to establish the most pertinent public political interventions to reduce food insecurity and concomitantly enhance the nutritional status of vulnerable households.

The only probable limitation of this research was, as in this kind of research, the sample; but the survey spots were at representative sectors of the studied area and were representative of the whole population. The strength of this study was that the face-to-face interview promoted reflexivity, instead of studies based on metadata analysis; this allows us the direct recording of the experience on how the people perceived physical and psychological food environment, with an understanding of the causes and consequences that generate the different situations of food insecurity among people in vulnerable conditions.

Conclusion

The food environment, related to availability, accessibility, and affordability, has a continuous interaction with people in charge of purchasing foods to prepare meals, where the socioeconomic factors are mainly related to households' income (depending on the scholarly level of the family head). This results in different statuses of food security. In this research, households with moderate or severe food insecurity presented less satisfaction with the food and variety that they could find (available), whereas irrespective of the food security status, the main tendency was to be satisfied with the food that they could buy (access). Most households did not agree about the price or lack of money to buy food (afford), which was an impediment. These results indicated that food environment in this marginal area is benevolent, and households find a way to remain resilient in order to provide enough food for their families. Public policies must be focused on reducing poverty and giving more opportunities to promote social mobility.

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Authors' contributions

V. Camacho-Vallejo conducted the research and wrote the paper; A. Totosaus analyzed data and wrote the paper. All the authors read and approved the final manuscript.

Conflict of Interests

All the authors declared no conflict of interests.

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