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- 2 obesity in children of a rural community of Mexico; using a
- **3 Geographic Information System (GIS) approach**
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### 20 Abstract

21 **Background:** Food environment (FE) has been linked to obesity in urban areas, but there is limited information in rural areas, particularly in developing countries, where prevalence 22 of obesity is high. Objective: To determine the association between FE and childhood 23 24 obesity using Geographic Information Systems (GIS). Methods: A total of 218 children (8 10 y) participated in a cross-sectional study. Weight, height and body fat were measured. 25 Geolocation of convenience stores (CS) and participants' households was collected and 26 the amount of processed food (PF) in the stores was measured. The proximity to the 27 nearest CS and the number of CS within a 250m buffer from each participant's household 28 was calculated using GIS. Linear regression models between obesity measurements and 29 food environment were performed. Results: The combined prevalence of overweight and 30 obesity was 32%. A total of 91% of the children had access to a CS within 250 m. On 31 32 average, 48% of the shelf space of the CS were occupied with PF. A positive association between the density of CS with body fat % ( $\beta$ =0.145; 95CI: 0.048, 0.241, p=0.004), 33 abdominal fat % (β=0.206; 95%CI: 0.048, 0.241, p=0.003) and BMI-for-age z-score 34 (β=0.028; 95%CI: 0.005, 0.062, p=0.005) was found. Living closer to CS was associated 35 with increases in body fat% ( $\beta$ =-0.009; 95CI: -0.017, -0.001, p=0.025), abdominal fat % 36 (β=-0.012; 95%CI: -0.023, -0.001, p=0.033) and BMI-for-age z-score (β= -0.002, 95%CI: 37 -0.004, -0.001, p=0.003). Conclusion: In a rural community in Mexico, a high density and 38 low proximity to CS is associated with obesity in school-aged children. 39

40 Key Words: Childhood obesity, food environment, GIS, rural areas

## 42 Introduction

43 Almost thirty percent of Mexican children are either obese or overweight. According to nutrition and health surveys, prevalence of childhood obesity has stabilized in urban areas 44 while it still rising in rural areas of Mexico <sup>1,2</sup>. Overweight and obese children have an 45 increased risk of oxidative stress, inflammation and insulin resistance and they are more 46 likely to remain obese throughout their life <sup>3</sup>. Obesity is the result of the balance between 47 energy intake and expenditure and a complex interaction with socioeconomic, 48 physiological and genetic factors<sup>4</sup>. In addition, new insight has proved that food 49 environment, which has been defined as the entire environment that influence food 50 selection and food intake<sup>5</sup>, plays a key role in the etiology of obesity<sup>6,7</sup>. The food 51 environment includes food stores and food service establishments, such as convenience 52 stores (CS), supermarkets, local markets, restaurants, fast food stands, among others <sup>8,9</sup>. 53 54 In the developing world, it is also possible to find small CS or neighborhood CS, and these stores represent an important economic model for the retailing business<sup>10</sup>. In Mexico and 55 some parts of Central America, these small CS are called "tienditas" or "misceláneas", are 56 usually family-owned, and are mainly run by the women in the households<sup>11</sup>. By definition, 57 "tienditas" are convenience stores that provide rapid access to essential products such as 58 food staples (tortillas, rice, beans, eggs, bread, sugar, vegetables, canned foods), 59 toiletries (soap, detergents, toothpaste, toilet paper), processed foods (candy, chips, 60 cookies), and some sell other items such as school supplies<sup>11</sup>. 61

52 Studies addressing the association between food environment and obesity have 53 shown contrasting results among ethnicities, age groups, areas (urban vs rural) and 54 countries <sup>12-18</sup>. For instance, proximity to supermarkets in Indiana, USA, has been

associated with a healthier diet and negatively associated with overweight and obesity in 65 children in adolescents  $(3 - 18 y)^{-14-16}$ . In contrast, availability of CS within a 0.25 mile 66 (400m) buffer was associated with a greater risk of overweight and obesity in 6-7 year old 67 girls living in Northern California <sup>17</sup>. In addition, it has been observed that income and 68 ethnicity are not only associated with the location, size and number of stores present in 69 the food environment, but also with the selection of available food<sup>18</sup>. It is important to 70 71 consider that most of the studies on this topic have come from developed countries, in urban settings, and have been done in adult populations. Interestingly, even though 72 Mexico has one of the highest rates of obesity worldwide, there is limited information 73 concerning the association between food environment and obesity, and the available 74 information is from urban areas. For instance, one study in two urban settings found that 75 the number of mobile food vendors around schools was positively related with children's 76 BMI<sup>19</sup>. In rural settings from developing countries, most families get their food from CS 77 and it is common for children to play a role in household food purchasing <sup>11</sup>. 78

Using Geographic Information Systems (GIS) provides a reliable and objective measurement on food environment <sup>20</sup>. A large list of proxies have been used to evaluate food environment, such as the stores within a given radius, the proximity to the nearest food store and the shelf-length of highly processed food and non-processed foods <sup>21</sup>. A major challenge is to identify proxies that better represent food environment and that consider social, racial, physical and age-related factors in a community or an individual.

6 Given the high rates of overweight and obesity in Mexico and the large proportion 6 of the population living in rural communities, the main objective of this cross-sectional

study is to assess the association between obesity and food environment in children ofrural Mexico.

### 90 Methods

#### 91 **Population and study design**

A cross sectional study was conducted among 218 children (8 -10 years) from a 92 rural community named Santa Cruz in the municipality of El Marques within the state of 93 Queretaro, Mexico. The community has a population of 3902, the ethnicity is 94 predominantly mestizo (mixed-race individual), and agriculture is the main economic 95 activity. The nearest supermarket is in the city of Queretaro (nearest metropolitan center), 96 35 km away from El Margues, so people from the community usually buy their food from 97 small CS ("tienditas" or "misceláneas"). Children's information was collected from August 98 2016 until May 2017. 99

Children were recruited from the elementary school in the community. Parents were 100 asked to attend a meeting where the study procedures were explained. Those that agreed 101 to participate, signed consent forms and were included in the study. Also, children 102 103 provided their assent to participate. Children who were under a prescribed physical activity or diet regimen were excluded from the study. This study was conducted according 104 to the guidelines of the Declaration of Helsinki and all procedures involving human 105 106 subjects were approved by the Bioethics Committee of the Universidad Autónoma de Querétaro (UAQ). 107

#### 108 **Demographic questionnaire**

A demographic questionnaire was answered by the caretaker. The questionnaire included information related to their living conditions (number of rooms in the house, inside running water, home appliances, among others), main mode of transportation, family income and caregiver's level of education. The information in the questionnaire was used to determine the socioeconomic level of the participants' households.

#### 114 *Physical activity*

Physical activity was estimated using a validated questionnaire specifically for Mexican populations<sup>23</sup>. According to the compendium of physical activities of Ainsworth<sup>24</sup>, the intensities of the physical activities were categorized in three according to the number of the metabolic equivalent of task (METS): light (<3 METS), moderate (3–6 Mets) and vigorous activity (>6 Mets). The resulting hours of each type were divided into days of the week to obtain daily hours practiced of each type of activity.

#### 121 Anthropometry and body composition

122 Children were transported with their mothers from the community to the Nutrition Clinic at the UAQ. Weight, height and waist circumference were measured twice with a 123 precision of 0.1 g or 0.1 cm respectively, in all children by trained personnel following the 124 World Health Organization (WHO) procedures <sup>25</sup>. Children were weighed barefoot and 125 wearing light clothes, using a calibrated digital scale (SECA, mod 813 Hamburg, 126 Germany). Height was measured using a stadiometer (SECA, mod 206 Hamburg, 127 Germany). Nutritional status was calculated based on the WHO criteria of BMI-for-age for 128 children aged 5-19 years using the Anthroplus software (Geneva: WHO, 2009). 129 130 Underweight was defined as two z-scores below the WHO reference median, overweight

as one standard deviation above the WHO reference median and obese as two standard 131 deviations above the reference median of the BMI-for-age z-score (BMIz)<sup>26</sup>. Whole body 132 composition was also measured by a certified technician using Dual-energy X-ray 133 absorptiometry (DXA) (Hologic Mod Explorer, 4500 C/W QDR, INC 35 Crosby Drive, 134 Bedford, MA 01730, USA). Body fat percent and body fat content (Kg) were recorded from 135 the values provided by the DXA. Abdominal fat percent and abdominal fat content (Kg) 136 were estimated following procedures described by Hill *et al*<sup>27</sup>. High body fat for girls was 137 considered above 30% and above 25% for boys<sup>28,29</sup>. 138

#### 139 Geographical data

The geolocation of each participant's household, of all the CS available in the 140 community, and of the school in the community were obtained using "Open Data Kit tool" 141 142 that was preinstalled in android OS devices equipped with a Global Positioning System (GPS) chip. We identified through a community audit, two types of stores in the 143 community. The first stores that were identified were the "tienditas" or "misceláneas", 144 typical family owned found in Mexico. The second type of food stores found were "food 145 venues", which are local or ambulant small stalls that usually sell 1 or 2 products, such as 146 "aguas frescas" (sugar sweetened fruit drinks), homemade fried chips, candies, among 147 others. For the purpose of this study, we analyzed only CS, since this is where the 148 inhabitants acquire most of their food <sup>30</sup>. The community audit was done by foot and data 149 collection was obtained from August 2016 until May 2017. 150

#### 151 In Store Availability

Using a measuring tape, a two person team measured the shelf-length (m) of Processed Foods (PF) and Non or Minimally Processed Foods (NMPF) to the nearest cm

<sup>31</sup>. The PF were defined as those foods processed to help preserve and enhance nutrients 154 and freshness, foods that combined ingredients (such as flavor, sweeteners, spices and 155 preservatives) for safety and taste, and ready-to-eat foods with minimal or no needed 156 preparation<sup>32</sup>. These PF included foods such as sugar sweetened beverages, salty 157 snacks (chips, popcorn), cookies, pastries, candies (chocolates, hard candy and gum), 158 ice cream, dairy products (except milk), instant soup, doughnuts, box bread, ready-to-eat 159 160 cereals, ham, sausages, and canned products. The NMPF included fresh fruits and vegetables, unprocessed chicken, beef or pork, eggs, milk, maize tortillas, beans, rice, 161 162 and water, among others.

#### 163 Food Store Access

A GIS database was constructed geocoding all the CS and the participants' 164 households using ArcMap 10 (Redlands, CA) (Figure 1). To determine the best density 165 (number of stores/area) proxy for the food environment, four circular buffers of 150 m, 200 166 m, 250 m and 300 m radius were defined around each household. The WGS1984 167 coordinate system with a fuller projection was used to geocode addresses and calculate 168 distances and buffers. The number of stores and the shelf length of each type of food (PF 169 and NMPF) within each buffer was quantified. The length of the buffers was determined 170 based on key GIS data collection information and the characteristics of the community, 171 such as the extension, population and number of stores<sup>33</sup>. The proximity was assess using 172 the Euclidean distance (straight-line distance), to evaluate distance between each 173 participant's household and the nearest convenience store. 174

#### 175 Statistical analysis

A descriptive analysis of the demographic variables was performed. As a first step, we assessed which density measure best correlated with obesity. For this purpose, a set of linear regression models between the different measurements of obesity (i.e. BMIz, abdominal and total body fat percent) with the number of stores in 150 m, 200 m, 250 m and 300 m buffers were performed. The 250 m buffer was selected to calculate the density of CS because it had the highest coefficient with body fat (b=0.16), abdominal fat (b=0.22) and BMI (b=0.03).

183 Normality of the independent variables was confirmed by visual inspection and the 184 Shapiro-Wilk test. Linearity of the association was confirmed visually inspecting the data 185 with a LOWESS graph and by plotting the regression residuals. Also, data analysis of all 186 variables where checked for outliers.

We evaluated the relationship between in-store food availability (i.e. total shelf length of PF and NPF) and the different measurements of obesity. We performed a linear model assessing the association between obesity and food environment (i.e. density and proximity of CS), while controlling for the different components of food environment and possible confounders (i.e. sex, age, caregiver's educational level, physical activity and proximity to school). All statistical analyses were performed by SPSS v23.0 (SPSS Chicago, IL, USA).

To evaluate if "other food venues" have an influence on the measurements of obesity, we carried out sensitivity analysis. We calculated the density and proximity, this time including "other food venues" together with the CS in the linear models (i.e. any food venue or convenience store in a 250m buffer or the shortest distance to any "other food venues" or CS).

### 199 **Results**

The general characteristics of the children who participated in the study are shown in Table 1. Of the total population, 55% percent of the studied children were girls, and 52% of the children had an elevated percentage of body fat. The main mode of transportation inside the community in all participants was walking. More than 90% of the households had low SES, more than 29% of the caregivers did not complete elementary school and 91% of the households had access to at least 1 CS within 250 m for their households.

A total of 58 food venues were found in the whole community: 40 CS and 18 other food venues such as two "tortillerías" (stores that only sell tortillas), one pastry shop, two butcheries and one poultry shop, one fast food restaurant and 11 street vendors that sold different kinds of food such as "tamales", corncob, peanuts, and salty deep-fried "churros". Sixty-two percent ( $\pm$  16 SD) of the shelf-space in the CS contains PF, which represents an average of 16.73 m ( $\pm$  9.3 SD) of the shelf-space (Table 2).

As summarized in Table 3, children with high body fat percent had access to more CS compared to children with normal body fat percent. No differences were observed in proximity to CS in children depending on their body fat percent.

As observed in Table 4, when adjusting for confounding (sex, age, caregiver's educational level, physical activity and proximity to school), the density of CS was positively associated with all the measurements of obesity (body fat %, abdominal fat % and BMIz). The proximity to CS was negatively associated with all the measurements of obesity, an increase of 100 meters in the proximity to the nearest convenience store was

associated with lower body fat -0.9% (95%CI -1.7% and -0.1%) abdominal fat -1.12%
(95%CI -2.3% and -0.1%) and BMI-for-age-z-score -0.2 (95%CI -0.4% and -0.1%). Also,
the shelf-meters of both PF and NMPF were positively associated with higher BMIz.
However, no differences were observed between groups when analyzing the PF/NMPF
ratio.

The sensitivity analysis showed no variations in the coefficient or the direction of the associations between density and proximity with the measurements of obesity after including "other food venues".

### 229 **Discussion**

In the present study, the food environment of a rural community of Mexico was evaluated. To the best of our knowledge, the results show for the first time the relationship between obesity and measures of food environment in a rural setting in Mexico, where no supermarkets are available, and where its habitants are compelled to buy their food in small CS. In this community, a high density and low proximity to CS was associated with obesity in children, and they were exposed on average to 11.5 CS within 250 m from their household.

The food environment of this community differs importantly from other studies in different countries. The main reason of these differences is that most of the studies that have evaluated food environment and its relationship with obesity, have been done in high income countries, in both urban and rural communities. There is limited research of this type in rural communities from lower-medium income countries, such as Mexico. This has to be taken into consideration when comparing the results from a rural community in

Mexico to those from other settings in high income countries with different contexts. For 243 instance, in a community in Texas, near the border between Mexico and the United states, 244 three CS could be found within a 1600 m buffer of the participants' households<sup>7</sup>. In 245 Denmark, in metropolitan areas only 54% of the population had one or more CS within a 246 250 m buffer and in non-metropolitan areas only 22% of the population had one or more 247 CS within a 250 m buffer <sup>34</sup>. In the city of New Orleans in the US, 38% of the studied 248 249 households had one store within 1600 m buffer and 62% had the nearest store farther than 1600 m buffer<sup>35</sup>. In contrast, in the present study, 91% of the children living in the 250 studied community had access to at least 1 CS in a 250 m buffer. Thus, when comparing 251 with other populations and areas in developed countries, the children of this rural 252 community had access to a higher number of CS in their environment. 253

Higher density and proximity of food stores was associated with a higher BMI, and 254 with higher body and abdominal fat in 8-10 year children living in a rural setting. Most of 255 the studies that have evaluated the association of food environment and obesity have 256 been done in adults and in urban areas, and only a few studies have been done in rural 257 settings and in children<sup>7,19,36-39</sup>. Results of studies in adults in both urban and rural area 258 are similar to the results of the present study. For instance, in urban settings in the US, 259 proximity, and frequent use of CS, are associated with higher BMI in adults and 260 households<sup>37,40,41</sup>. Food swamps with a higher density of establishments selling high 261 calorie food and lower density of establishments selling healthier food are predictors of 262 adult obesity, particularly in counties with income inequality and low mobility<sup>42</sup>. 263

264 Similarly, studies in rural communities have found that limited access to healthy 265 foods is one of the main contributors to a poor diet and obesity<sup>43</sup>. Studies that have

evaluated the role that the food environment has on childhood obesity have produced 266 inconsistent result <sup>44,45</sup>. In Canada, 58% of children had access to one CS within 800 m 267 walking, and proximity and density was not associated with obesity<sup>46</sup>, while children living 268 near a CS in Guam were most likely to have higher BMI z-score compared to those that 269 lived farther away<sup>47</sup>. Similarly, the presence of one or more CS around participants 270 households (a block around or in a 1600 m buffer) in different cities in the US was 271 positively associated with obesity in both children and adolescents<sup>6,7</sup>. In addition, the 272 presence of CS near schools has also been associated with obesity in different countries 273 <sup>19,38,48</sup>. In Mexico, for instance, the number of mobile food venues around both, public and 274 private schools, was positively associated with obesity<sup>19</sup>). Thus, the evidence suggests 275 that the density of CS near children's households and schools is strongly associated with 276 higher BMI. 277

The association between the density of food venues and obesity in the population 278 studied may be explained by different social and psychological factors. It is more likely 279 that children living close to a higher density of stores can find a store in their way to their 280 destination (i.e. school, family member house, while playing in the street) and therefore 281 have increased access to CS and food products compared with children living far away 282 from CS<sup>49,50</sup>. Also, children sharing a higher density of stores are exposed to visual cues 283 284 more often, both outside and inside the stores, where advertisement as promotions, free toys, and colorful labels of their food products may be found <sup>51,52</sup>. 285

In the present study, shelf-space dedicated to PF, which tend to be more energy dense, was higher than NMPF, and the shelf-space of both was associated with obesity in children. However, no association was observed of PF/NMPF with any measure of

obesity. These results suggest that the density and proximity of CS are better predictors 289 290 of obesity than the proportion of PF/NMPF. To our knowledge, no studies have evaluated the relationship between shelf-space of specific foods and obesity in Mexico, but there is 291 evidence in developed countries. Studies in both Australia and the United States have 292 shown that shelf-space dedicated to energy dense food and less healthy foods is greater 293 in neighborhoods with low SES<sup>39,53</sup>. Rural stores in Australia had lower shelf space of 294 295 fruits and vegetables and higher shelf space of soft drinks compared to urban stores, and rural areas in this country have high prevalence of overweight and obesity<sup>54</sup>. 296

Some limitations of the study need to be addressed. The cross-sectional design of 297 the study does not allow to draw conclusions about causality. Even though associations 298 299 between food environment and obesity were observed, these associations were small. Since obesity is a multifactorial disease, other factors, such as genetics, may be more 300 important. In addition, there may be behaviors that were not measured in the study, such 301 as the routes the children take to visit family members that may influence their exposure 302 to the food environment of the community. Another limitation is the small sample size of 303 the participants. Also, no information of how often children actually shop in the CS is 304 available, or what type of food they actually purchase. Despite adjusting for proximity to 305 the school, children shared similar food environments near their houses and their school, 306 307 and thus, the assumption of independence of residuals might be violated. Physical activity was measured using self-reported data and this may be subject to recall bias. 308

The main strength of the study was the assessment of all the CS available to the community, providing better estimates for the associations found. Another strength of the study was using DXA to measure body composition as an indicator of obesity. Also, the

present study is one of the few addressing the relationship between "tienditas" and childhood obesity in rural communities, where supermarkets are not available.

Future studies in rural communities should include information regarding how often the children buy food in the CS, what type of food they purchase, and how children move within the community, around their households and their school.

317

### 318 Conclusion

319 Georeferenced locations provide a useful approach to assess the relationship between food environment and obesity by modelling spatial accessibility (density, 320 proximity to CS and exposure to processed foods). The results show that food 321 environment near participants' households is associated with obesity in 8-10 year old 322 children living in a rural community in Mexico. In a country where prevalence of childhood 323 obesity is one of the highest in the world, understanding the food environment will 324 contribute to shape the environment to promote and support healthy eating and thus, 325 prevent childhood obesity. 326

### **Author Contributions**

328 OPG, MCP and GAZ conceived and designed the study. YTP and GAZ carried out 329 the field work, YTP, JLR, JEEP, CALG, CMD and GAZ analyzed and interpreted data, 330 and OPG, CALG and JLR gave important intellectual advice. OPGO, GAZ and YTP 331 drafted the manuscript. All authors were involved in revising the paper and had final 332 approval of the submitted and published versions.

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#### 337 Conflict of interest

338 The Authors declare that there is no conflict of interest.

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### **Table 1.** Main characteristics of the study participants and according to body fat

475 percentage (normal/high).

	Total (n=218)			Normal body fat (n=105)			High body fat (n=113)		
Characteristics									
	Mean ± SD <sup>1</sup>			Mean ± SD			Mean ± SD		
Age (months)	100.6	±	18	97.14	±	18.07	104	±	18.34
Physical activity level									
Moderate physical activity (h/week)	8.57	±	7.53	8.93	±	8.06	8.24	±	7.02
Intense physical activity (h/week)	3.37	±	4.15	3.59	±	5.00	3.15	±	3.14
Anthopometry and body									
Weight (kg)	27.07	±	8	23.36	±	4.94	30.5	±	8.4*
Height (cm)	125.3	±	10	122.94	±	9.28	127	±	9.84*
Waist circumference (cm)	59.07	±	9	54.12	±	5.2	63.7	±	9.25*
Height for age (z-score)	-0.72	±	1	-0.89	±	1.02	-0.56	±	0.88
BMI <sup>2</sup> for age (z-score)	0.33	±	1	-0.34	±	1.06	0.96	±	1.02*
Body fat (%)	28.77	±	7	23.42	±	3.57	33.7	±	4.78*
Abdominal fat (%)	27.82	±	10	20.33	±	4.32	34.8	±	7.62*
	n		%	n		%	n		%
Caregiver's educational level									
No formal education	5		4.4%	14		6.4%	9		8.6%
Incomplete elementary school	28		24.8%	50		22.9%	22		21.0%
Complete elementary school	56		49.6%	114		52.3%	58		55.2%
Middle school or more	24		21.2%	40		18.3%	16		15.2%
<sup>476</sup> <sup>1</sup> SD: Standard Deviation; <sup>2</sup> BMI: Body Mass Index									

\*Different with t-test or Chi squared-test with Bonferroni correction for multiple

478 comparisons between normal and high body fat (>30% girls and >25% boys).

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# 482 **Table 2.** Linear meters of non or minimally and process foods from the convenience

# 483 stores of the community

	Mean	SD <sup>1</sup>	Median	Minimum	Maximum	
Non or Minimally Processed	10.2	10.82	8 00	0	15 32	
Foods	10.2	10.02	0.90	0	10.02	
Processed Foods	16.72	9.32	16.78	0	22.57	
1 CD: Ctandard Daviation						

<sup>1</sup> SD: Standard Deviation

### **Table 3.** Density and proximity to convenience stores of the study participants according to body fat percentage

486 (normal/high).

	Total (n=218)		Normal b	oody fat (n=105)	High body fat (n=113)		
	Mean (SD) <sup>1</sup>	Median (range)	Mean (SD)	Median (range)	Mean (SD)	Median (range)	
Density (n CS²/250 m buffer)	11.5 (8.5)	11 (0 - 28)	9.6 (7.8)	10 (0-25)	12.8 (8.7) *	13 (0 - 28)	
Proximity to closer store (m)	126.5 (107.2)	86.92 (5.5 - 683.8)	142 (106.7)	100.6 (5.8 - 378.5)	115.6 (107.0)	79.4 (5.6 - 682.8)	
	<sup>2</sup> 00 0 ·						

<sup>1</sup> SD: Standard Deviation; <sup>2</sup> CS: Convenience stores

\*Different with t-test with Bonferroni correction for multiple comparisons between normal and high body fat

Table 4. Association between food environment and measurements of obesity.

	Body fat %			Abdominal fat %			BMIz <sup>3</sup>		
	β¹	95% CI <sup>2</sup>	p*	β	95% CI	р	β	95% CI	p
CS <sup>4</sup> Density (n/250 m buffer)	0.145	(0.048; 0.241)	0.004	0.206	(0.069; 0.343)	0.003	0.028	(0.005; 0.062)	0.005
Proximity (m)	-0.009	(-0.017; -0.001)	0.025	-0.012	(-0.023; -0.001)	0.033	-0.002	(-0.004; -0.001)	0.003
Food Access in CS (250m buffer)									
Shelf-space PF⁵ (m)	0.071	(-0.249; 0.392)	0.662	0.047	(-0.409; 0.502)	0.845	0.002	(0.000; 0.003)	0.008
Shelf-space NMPF <sup>6</sup> (m)	0.055	(-0.105; 0.216)	0.497	0.049	(-0.178; 0.277)	0.661	0.072	(0.009; 0.135)	0.025
Ratio PF/NMPF	0.210	(-0.592; 0.479)	0.125	0.266	(-0.121;0.654)	0.174	-0.012	(-0.061; 0.037)	0.662

<sup>1</sup> β: beta regression coefficient; <sup>2</sup> BMIz: body mass index z-score; <sup>3</sup>CI: 95% confidence interval; <sup>4</sup>CS: convenience stores;

<sup>5</sup>PF: processed foods; <sup>6</sup>NMPF: non or minimally processed foods

\*Adjusted by: sex, age, caretaker's educational level, physical activity and proximity to school