Physical access to healthy food in context: Adapting current conceptualizations to a Latin American city

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Conflict of interest statement

The authors declare no conflicting interests.

Abstract

The retail food environment is increasingly recognized as a key determinant of eating behavior and health outcomes. The present work aimed at conceptualizing adequate physical access to food in Montevideo, the capital city of a Latin American country. The conceptualization was developed following three key steps: i) analysis of observational data on food purchasing behavior from primary and secondary data sources, ii) development of an initial definition, iii) validation and refinement of the definition in a workshop with key local stakeholders. Primary data was obtained from a telephone survey with 505 residents of Montevideo to explore food purchasing patterns of two food groups recommended by the Uruguayan dietary guidelines. Secondary data corresponded to surveys previously conducted in the country, one on household income and expenditure and another on mobility. Primary and secondary data highlighted the diversity of food outlets where residents of Montevideo purchase their food. Small neighborhood stores were identified as key sources of healthy foods, especially for residents of low socio-economic status. Regarding food shopping trips, walking was identified as the main transportation mode. The median travel time was estimated to be 10 minutes or lower, regardless of the socio-economic status of the household. Areas with adequate physical access to healthy food in Montevideo were defined as those where residents have access within 600 meters to outlets selling all the following food groups: fruits and vegetables, meat, eggs, milk, or culinary ingredients. The methodological approach presented in the current study can be used by other authors to adapt current conceptualizations of physical access to healthy food to their local context.

Research highlights

- A conceptualization of adequate physical access to food in Montevideo was developed.
- It was based on observational data on food purchasing behavior from primary and secondary sources.
- A workshop with key stakeholders was held to validate the conceptualization.
- The methodological approach can be used by adapt conceptualizations to the local. context.

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Abstract

The study aimed at conceptualizing adequate physical access to food in Montevideo. The conceptualization was developed following three key steps: i) analysis of observational data on food purchasing behavior, ii) development of an initial definition, iii) validation and refinement with key local stakeholders. Primary data was obtained from a telephone survey with 505 residents to explore food purchasing patterns. Secondary data corresponded to surveys on household expenditure surveys and mobility. Observational data highlighted the diversity of food outlets where residents of Montevideo purchase their food. Small neighborhood stores were identified as key sources of healthy foods, especially for residents of low socio-economic status. Regarding food shopping trips, walking was identified as the main transportation mode. The median travel time was estimated to be 10 minutes or lower. Areas with adequate physical access to healthy food in Montevideo were defined as those where residents have access within 600 meters to outlets selling all the following food groups: fruits and vegetables, meat, eggs, milk, or culinary ingredients. The methodological approach presented in the current study can be used by other authors to adapt current conceptualizations of physical access to healthy foods to their local context.

Keywords: *food environment; retail food environment; food access; food desert*

1. Introduction

The retail food environment, defined as the food outlets where people acquire their foods, has a key role in ensuring access to healthy foods for everyone from a physical, economic, and social perspective (Mattioni et al., 2020; Vieira et al., 2018). It is increasingly recognized as a key determinant of eating behavior and health outcomes (Mattioni et al., 2020; Winkler et al., 2020). Physical accessibility to healthy foods is one of the most widely used dimensions to characterize the retail food environment (Konapur et al., 2022; Sawyer et al., 2021). It refers to the ease of reaching food retail outlets selling healthy foods, considering distance, travel time, and/or cost (Caspi et al., 2012; Penchansky & Thomas, 1981).

Since the 1990s the literature has documented the existence of areas with limited physical accessibility to healthy foods, commonly known as "food deserts" (Beaumont et al., 1995; Cummins & Macintyre, 2002). Despite the lack of a consensual definition and criticisms to the simplicity of the term (Ares, Turra, et al., 2024; Widener, 2018), several studies have reported that living in an area with limited access to healthy food is associated with lower dietary quality and an increased risk of obesity and non-communicable diseases (Cooksey-Stowers et al., 2017; Garg et al., 2023; Hager et al., 2017). However, other studies have found no or limited associations between physical accessibility to healthy food and health outcomes (Fitzpatrick et al., 2019; Key et al., 2023; Zhen, 2021).

Heterogeneity in the conceptualization of adequate physical access to healthy food may partly explain these non-consensual results (Ares, Turra, et al., 2024; Titis et al., 2022; Ver Ploeg et al., 2015). In addition, some of the current conceptualizations do not take into account the complexity of modern food environments and citizens' food purchasing behaviors (Ares, Turra, et al., 2024; Widener, 2018). This is particularly relevant for food environment research in the regions of the world where most of the world's population live, as most studies have been conducted in high income countries in North America and Europe (Ares, Turra, et al., 2024; Turner et al., 2018,

2020). In particular, conceptualizations of adequate physical access to healthy food in the Global South are a gap in the literature. Two aspects of the conceptualizations deserve special consideration: the types of outlets regarded as source of healthy foods (i.e., the opportunities to access healthy food), and the criteria for estimating proximity to an outlet (i.e., the maximum travel cost).

Most published studies on physical access to healthy food have regarded supermarkets and large grocery stores as the key indicator of the availability of healthy foods (Ares, Turra, et al., 2024). However, studies conducted in emerging countries in Latin America and Africa have identified small neighborhood stores, such as behind-the-counter grocery stores, farmers markets, butchers' shops, and informal outlets as highly relevant sources of healthy foods (Battersby, 2012; Battersby & Crush, 2014; Chuvileva et al., 2024a; Crush et al., 2019; Farah et al., 2023a; Ortiz-Hernández et al., 2022). Therefore, the application of current conceptualizations of physical access to healthy food may lead to inaccurate conclusions in Latin American and African countries. Food environment research in these settings should consider the characteristics of the local retail food environments.

Thresholds to define proximity to healthy outlets largely differ across studies, ranging from 250 meters to 4 km in urban settings and from 2.4 to 24 km in rural settings (Ares, Turra, et al., 2024). Diverse criteria have been used to select these thresholds, including the distribution of data on proximity to outlets. In addition, some studies have regarded driving as the main transportation mode for food purchasing trips. Local information about citizens' travel behavior for making food purchases (i.e., choice of transportation mode and travel time) is needed to develop context-appropriate proximity thresholds (Kerr et al., 2012; Mcentee, 2009).

In this context, the aim of the present work was to conceptualize adequate physical access to healthy food in Montevideo, the capital city of Uruguay, based on food purchasing behaviors. For this purpose, the following specific objectives were set: i) to identify the main outlets where

residents of Montevideo purchase their foods, ii) to characterize their trips to food outlets, iii), to develop a context-appropriate definition of adequate physical access to healthy food.

Uruguay is a high-income country located in the southeastern coast of South America. It is the second smallest country in the continent and stands out in the region by its high gross domestic product (US$ 20,795), high human development (0.804), low poverty rate (10.1%), and low inequality (Gini Index = 0.394) (Instituto Nacional de Estadística, 2024; The World Bank, 2023a, 2023b; United Nations Development Program, 2023). Montevideo, the capital city, is located in the central southern region of the country. It has an area of 526 km^2 and a population of 1,308,657 inhabitants who mostly live in urban areas (98.9%) (Catálogo de datos geográficos de Montevideo, 2024). The city concentrates approximately half of the country's population and the most important administrative, political and economic centers at the national level. It is administratively divided in 8 municipalities that largely differ in their socio-economic characteristics.

2. Methods

The methodological strategy was inspired by the approach proposed by Jabareen for building conceptual frameworks (Jabareen, 2009). It involved three key steps: i) analysis of observational data on food purchasing behavior of residents of Montevideo from primary and secondary sources, ii) development of an initial definition of adequate physical access to healthy food, iii) validation and refinement of the definition. The study was part of a larger research project approved by the ethics committee of (blinded for review) (Protocol No 101900-000043-22). All data analyses of primary and secondary data were performed using R software (R Core Team, 2024).

2.1. Secondary data sources

2.1.1. National Survey on Household Income and Expenditure

The National Survey on Household Income and Expenditure (*Encuesta Nacional de Gastos e Ingresos de los Hogares*), conducted in 2016-2017, was used to gather information on the food outlets where households acquire food and beverages in Montevideo. This survey is run every 10 years approximately by the National Institute of Statistics (Instituto Nacional de Estadística, 2017). Its main purpose is to collect data on private consumption structure, to develop the official Consumer Price Index and to measure monetary poverty in the country (Instituto Nacional de Estadística, 2017). A subset of the total survey sample representative of households located in Montevideo was considered for the analysis. This subset consists of 2,382 households and 75,012 acquisitions of food and beverages (excluding foods consumed at restaurants, cafés or other establishments that sell meals) made in 34 different outlets (e.g., supermarkets, grocery stores, butchers' shops, fruit and vegetable stores, farmers' markets, bakeries). Descriptive statistics on the total acquisitions of food and beverages made by type of outlet and by households' income quintiles were estimated.

2.1.2. Montevideo Metropolitan Area Mobility Survey

The Montevideo Metropolitan Area (MMA) Mobility Survey (*Encuesta de Movilidad del Área Metropolitana de Montevideo*), conducted in 2016, was used to obtain a preliminary overview of the characteristics of shopping trips. The MMA includes the city of Montevideo (the capital of Uruguay) and some districts of adjacent jurisdictions (Canelones and San José). This official mobility survey was conducted by the local governments of the MMA. It was collected through home-based interviews by expert interviewers and is representative of the population residing in the area. The information collected from the sample is generalized to the rest of the sampling frame by applying expansion factors calculated for each household (Mauttone & Hernandez, 2017). As expansion factors respond to the weight of each household, when applying these weights to a subset of the sample, this subset will also be representative of the corresponding

subset of the sampling frame. For this paper, a subset of the survey that included people residing within Montevideo's administrative borders was used. This subset remained representative of the city of Montevideo and comprised 1,145 households, 5,946 individuals, and 7,124 trips. For this work the focus was placed on trips for "household shopping," a category that encompasses trips to buy products consumed by all household members. This category is different from the rest of the shopping trips, which include purchases for individual consumption (for instance, clothing). The survey gathered information on 518 trips with the purpose of "household shopping." These trips were not exclusively for food shopping, as they could include other types of consumption such as cleaning products. The way a trip is defined in the mobility survey means that each trip to a store where goods for collective household consumption can be purchased is considered as a separate trip. As a result, if a person visited multiple outlets, each visit was recorded as a separate trip, with the previous location serving as the origin. That said, it is important to note that the majority of households' shopping trips originate from the household (see results section).The survey also gathered basic socioeconomic data such as gender, age, income, and employment status. Descriptive statistics for the time to the destination of trips for "household shopping" were calculated.

2.2. Telephone survey

A telephone survey with 505 residents of Montevideo was conducted by a specialized survey company in May 2024. Trained interviewers contacted potential respondents registered in their databases. Adult individuals, residents of Montevideo and involved in food purchasing for the household were eligible for participation. Quotas for municipalities were established to capture differences in purchase behaviors across areas of the city with different socio-demographic characteristics. The response rate of eligible participants was 75.7%. Participants were diverse in terms of age, gender, educational level, place of residence and socio-economic level

(Supplementary Material Table 1). Compared to the general population, the sample overrepresented females, older participants, and people from high-income households.

The questionnaire, composed of closed (Yes/No) and multiple-choice questions was developed to explore purchasing patterns of two groups of natural foods, recommended by the Uruguayan dietary guideline (Ministerio de Salud Pública, 2016): fruits and vegetables, and meat. Focus on these food groups was justified by their short shelf life and the fact that their consumption has been reported to be highly susceptible to economic food access difficulties (Brunet et al., 2024; Machín et al., 2024). The full questionnaire is shown in the Supplementary Material Table 2. The questions included in the present research were related to the food outlets where fruits, vegetables and meat were purchased, and the characteristics of the trips to the outlets in terms of transportation mode and travel time. A series of socio-demographic questions were included to characterize participants. Socio-economic status was calculated based on a national socio-economic index, which calculates a score based on place of residence, household composition, education level, employment, and possession of goods (Centro de Investigaciones Económicas, 2023).

Descriptive statistics were used to summarize the data. Chi-square tests with 5% significance level were used to explore differences in the distribution of type of outlet where households of different socio-economic level purchase fruits and vegetables, and meat.

2.3. Development of a definition of adequate physical access to healthy food

Based on the results of a recent scoping review, the definition was decomposed into three elements (Ares, Turra, et al., 2024): i) outlets regarded as source of healthy foods; ii) proximity thresholds; and iii) socio-economic requirements for areas without adequate physical access to healthy food. The development of the definition was performed by the researchers in a group meeting where results from the studies were presented and discussed.

2.4. Validation and refinement of the definition

The definition was validated with key stakeholders related to social protection, food and nutrition policy. Based on local knowledge, invitation letters were sent by email to a wide range of stakeholders including the academia, governmental organizations related to public health and social protection, the local government, international organizations, and civil society organizations.

A total of 31 local stakeholders attended a 2 hours in-person worskshop. None of the stakeholders was involved in the development of the definition. First, the research team made a presentation of the overarching research project, the process for developing the definition, and the proposed definition. At the end of the presentation, participants were asked to complete a short online questionnaire by scanning a QR code. The questions captured participants' opinions about the three main elements of the definition: outlets source of healthy food, distance thresholds and socio-economic requirements for areas without adequate physical access to healthy food. For each of the elements, they were presented with the proposal and asked to indicate the changes they would make using open-ended questions. After answering the questions, participants were asked to indicate their affiliation using a multiple-choice question. A field for other comments was available at the end of the questionnaire. A group discussion was held in the last part of the workshop. The research team analyzed the comments from the validation workshop and introduced changes to the definition, which are described in the Results section.

3. Results

3.1. Outlets where residents of Montevideo purchase foods

Data from the National Survey on Household Income and Expenditure showed that supermarkets, grocery stores, farmers' markets, and fruit and vegetable stores accounted for more than 83.9% of all the acquisitions of foods and beverages in Montevideo (Figure 1a). Supermarkets, farmers'

markets, grocery stores and fruit and vegetable stores were the primary source of fruit and vegetables (Figure 1b), whereas supermarkets and butchers' and poultry shops were the main source of meat (Figure 1c). The contribution of supermarkets to food purchases increased with households' income, whereas an opposite trend was found for small food outlets such as grocery stores and butchers (Figure 1).

Results from the telephone survey also showed the coexistence of different types of food outlets as source of fruits, vegetables and meat (Table 1). Eighty-nine percent of the participants reported purchasing fruits and vegetables at farmers' markets, supermarkets, and fruit and vegetable stores. Meanwhile, 92% of the participants reported purchasing meat at supermarkets or butchers' shops. Significant differences in the relevance of the different types of food outlets with the socio-economic status of the household were found for both fruits and vegetables (c^2=35.4, p<0.001) and meat (c^2= 24.5, p=0.002). The relevance of supermarkets increased with socio-economic status, whereas the relevance of small neighborhood stores, such as fruit and vegetable stores and butchers' shops decreased (Table 1).

3.2. Characterization of trips to food outlets in Montevideo

According to the MMA mobility survey, the average travel time for a "household shopping" trip was 12 minutes, with almost 80% of those trips involving walking less than 10 blocks and originating from the household. When considering only walking trips, the average travel time was approximately 8 minutes. The average travel time for all the trips varied with the socio-economic status of the household (Table 2). While trips undertaken by residents of medium socio-economic status households were close to 13 minutes, those living in households in low socio-economic status lasted 10 minutes on average. Meanwhile, for individuals in high socio-economic status households, the average travel time was 11.5 minutes.

According to results of the telephone survey, walking was the main mode of transportation for purchasing fruits, vegetables and meat. The percentage of participants who reported making

227 walking trips to food outlets was 62.2% for fruits and vegetables and 52.1% for meat. Driving was
228 the second most relevant means of transportation, mentioned by 24.8% of the participants for
229 purchasing fruits and vegetables and 30.7% for meat. The rest of the means of transportation
230 were seldom mentioned.

231 The great majority of the trips to food outlets had their origin in the household: 85.2% for
232 fruits and vegetables and 81.9% for meat. Participants reported travelling a median of 7.0 min to
233 purchase fruits and vegetables and 9.5 min to purchase meat. Figure 2 shows the distribution of
234 travel time to food outlets according to the socio-economic status of the household. Participants
235 from low socio-economic status households tended to report longer and more heterogeneous
236 travel times to the outlet where they usually purchased fruits and vegetables, and meat. The
237 median travel time to the outlet where fruits and vegetables or meat are usually purchased were
238 10.0 or lower, regardless of the socio-economic status of the household. For fruits and vegetables,
239 median travel times corresponded to 10.0, 8.0 and 5.0 min for participants in low, medium and
240 high socio-economic status households, respectively. For meat, the median travel times were
241 identical, except for participants in high socio-economic status households. The median travel
242 time to the outlet where meat is usually purchased for these participants was 8.5 min.
243

244 **3.3. Definition of adequate physical access to healthy food in Montevideo**

245 Primary and secondary data sources showed consistent results on food shopping and travel
246 behaviors, despite time mismatch (2016-2024). The following sub-sections present the rationale
247 underlying each of the three key elements of the proposed conceptualization of adequate access
248 to healthy food.
249

250 *Outlets regarded as source of healthy foods*

251 Primary and secondary data highlighted the diversity of food outlets where residents of
252 Montevideo purchase their foods. Small neighborhood stores, such as behind-the counter grocery

stores, fruit and vegetable stores, and butchers' shops, were identified as the key source of fresh foods (fruits and vegetables, meat), especially for residents of low socio-economic status. These results indicate that it would not be appropriate to regard supermarkets and large grocery stores as indicators of the availability of healthy foods, as currently done by most definitions of food deserts included in the scientific literature (Ares, Turra, et al., 2024). Considering that the availability of foods in small grocery stores in Montevideo is highly heterogeneous (Ares, Alcaire, et al., 2024), it would not be feasible to regard this type of outlet as an indicator of the availability of specific healthy foods, such as fruits, vegetables and meat. Therefore, physical access to healthy food in the context of Montevideo was placed on physical access to outlets selling specific foods rather than on specific types of outlets.

The Uruguayan dietary guidelines recommend following a diet based on natural or minimally processed foods (fruits, vegetables, meat, eggs, milk) and culinary preparations (Ministerio de Salud Pública, 2016). The following foods were regarded as necessary to follow the recommendations: fruits and vegetables, eggs, meat, pasteurized or powdered milk, and culinary ingredients. Therefore, residents of an area with adequate physical access to healthy foods should be able to access food outlets selling all the food groups mentioned above.

Proximity thresholds

Based on primary and secondary data, Montevideo residents make most of the food purchasing trips from household, which stresses the importance of the food environment of their neighborhood of residence. Walking was identified as the main transportation mode for food purchasing. Based on the distribution of travel time, 10 minutes was regarded as an adequate time threshold representing the purchasing habits of the average Montevideo residents. This threshold was equal or lower than the travel time reported by participants to reach the outlet where they purchase fruits, vegetables and meat, regardless of their socio-economic status.

The threshold for travel time was transformed into a distance threshold considering average walking speed. The average walking speed on footways reported for elderly individuals (3.6 km/h) was considered as a conservative criterion (Silva et al., 2014). Based on these considerations, 600 meters could be regarded as a distance threshold for adequate physical access to healthy food.

Socioeconomic requirements

The last element of the definition was related to the inclusion of socio-economic requirements. It was decided not to include such requirements for the identification of areas without physical access to healthy foods. This approach acknowledges that limited physical access to healthy foods can affect population groups living in areas of different socio-economic status, including residents of low-income households living in areas categorized as medium or high-income.

3.4. Validation and refinement of the definition

The proposed definition of adequate physical access to healthy food was well-received by the participants of the workshop. Most of the comments were related to the complexity of the topic and the need to consider additional dimensions of the food retail environment, such as variety and prices, for getting an in-depth understanding of how it influences dietary patterns. Only a few participants made specific suggestions of change in the definition, which were mostly related to the food outlets regarded as source of healthy foods. Three participants stated that areas where residents lack physical access to meat should be regarded as having inadequate physical access to healthy food, regardless of the accessibility of other foods. Meat was regarded as a key source of iron in childhood and highlighted as a key component of the dietary habits of the Uruguayan population (Köncke et al., 2023). One participant also highlighted the need to incorporate access to processed products targeted at specific segments of the population, such as sugar-free

303 products. No concrete suggestions for changes in the proximity threshold and inclusion of socio-
304 economic indicators were received.

305 Based on the comments from the workshop, areas with adequate physical access to healthy
306 food in Montevideo were defined as those where residents have access within 600 m to outlets
307 selling all the following food groups recommended by the Uruguayan dietary guideline: fruits and
308 vegetables, meat, eggs, milk, or culinary ingredients.

309

310 **4. Discussion**

311 The present work intended to advance food retail environment research in the majority world by
312 conceptualizing adequate physical access to food in Montevideo, the capital city of a Latin
313 American country. The conceptualization was informed by observational data on food purchasing
314 behavior.

315 Primary and secondary data sources confirmed that current conceptualizations of adequate
316 physical access to food and food deserts, mostly focused on supermarkets and large grocery
317 stores (Ares, Turra, et al., 2024), are not appropriate to the Montevideo context. Regarding these
318 outlets as indicators of the availability of healthy foods would lead to inaccurate conclusions as
319 small neighborhood stores, such as small grocery stores, fruit and vegetable stores, and butchers'
320 shops, were identified as highly relevant sources of healthy foods for the residents of Montevideo.
321 The relevance of small neighborhood stores has been reported in previous studies conducted in
322 low- and middle-income countries in Africa and Latin America (Battersby & Crush, 2014; Chuvileva et
323 al., 2024; Crush et al., 2019; Farah et al., 2023; Ortiz-Hernández et al., 2022).

324 In the context of Montevideo, it would not be appropriate to regard specific types of food
325 outlets as proxy of the availability of healthy foods, mainly due to the large heterogeneity in the
326 food supply of small outlets (Ares, Alcaire, et al., 2024). Instead, physical access to healthy foods
327 should be analyzed based on food outlets selling specific types of foods, recommended by the

Uruguayan dietary guidelines. This decision acknowledges the complexity of the modern food environment, characterized by a wide range of different types of outlets selling foods that largely vary in their food healthfulness (Winkler et al., 2020). A similar approach has been used in studies conducted in different countries, including Canada, the USA and Slovak Republic (Bao et al., 2020; Križan et al., 2015; Lebel et al., 2016).

Focus on outlets selling specific foods entails that physical access to healthy food cannot be evaluated based on secondary data sources, such as administrative records and commercial databases (Lebel et al., 2017; Lytle & Sokol, 2017). Instead, field observations are needed, which are not cost-effective when dealing with large geographic areas. In this sense, it is important to highlight that challenges for conducting food environment research in Montevideo based on secondary data sources have been recently identified (Vidal et al., 2024). Administrative records and Google maps lacked validity, as they did not capture a large proportion of the small neighborhood stores available in the city, particularly in low socio-economic status areas.

Results showed that most trips for purchasing fresh foods depart from the household and rely on walking as mode of transportation. This suggests that the food environment of the neighborhood of residence may be the most relevant in shaping food purchase decisions, as assumed by most studies on the topic (Ares, Turra, et al., 2024). A distance threshold for adequate physical access to food outlets was defined based on observational data. This criterion is expected to have higher ecological validity compared to arbitrary thresholds used in other studies (Ares, Turra, et al., 2024; Ver Ploeg et al., 2015). The distance threshold (600 meters) is close to the lower bound of the thresholds reported in the scientific literature for urban food deserts, which range between 250 meters and 4 km (Ares, Turra, et al., 2024). The selected distance has been regarded as walkable for elderly individuals (Alves et al., 2020) and is aligned with the seminal work by UK Department of Transport on core accessibility for food shopping, among other activities (DFT, 2009). It also aligns with literature on accessibility to similar opportunities such as

353 primary schools, which ranges between 15 and 30 minutes depending on transportation mode
354 (DFT, 2009; Hernandez, 2018; Moreno-Monroy et al., 2018).

355 Given that the threshold was derived from travel times, it can be easily adapted to other
356 transportation modes when studying physical access to food of specific types of households, i.e.,
357 households with automobile. It should be highlighted that caution is needed when defining time
358 thresholds based on observational data because the observation may include suppressed trips
359 or trips that are longer than desired. In other words, a person may travel 30 minutes to buy food
360 because they live in a deprived area with low accessibility to healthy food outlets. In addition, it
361 should be highlighted that people may decide not to shop at the closest food outlet due to
362 considerations related to price, quality, and variety, among others (Chrisinger et al., 2018;
363 Drewnowski et al., 2012; Kerr et al., 2012; Laska et al., 2010; Thornton et al., 2017).

364 Socio-economic indicators have been frequently considered for identifying areas without
365 adequate physical access to healthy food (Ares, Turra, et al., 2024). In the present work, it was
366 decided not to incorporate socio-economic indicators, as previously recommended by Ver Ploeg
367 et al. (2012). These authors acknowledged that households may lack adequate physical access
368 to healthy foods, regardless of the socio-economic characteristics of the area where they reside.
369 This may be the case of low-income households living in areas of the city categorized as medium
370 or high-income. This is a frequent methodological decision in the accessibility literature with a
371 strong conceptual base and it is the most preferred -sometimes due to information availability-
372 empirical approach. These measures are known as place-based accessibility measures that
373 assign values to aerial units according to the potential interaction from this unit to the remainder
374 areas of an urban agglomeration. To do so, they take into account urban form (where are the
375 individuals and the opportunities) and transport system performance (for instance, public transport
376 network or walking speed) (Geurs et al., 2009). As with other place-based measures, the
377 proposed conceptualization of physical access to healthy food in Montevideo enables to analyze
378 how the socio-economic status of the household moderates the effect of lack of physical access

to healthy food on dietary patterns and health outcomes. This is feasible by assigning the access measure of the aerial unit to individuals who reside in those areas.

The next step of the current project involves the application of the proposed conceptualization to the retail food environment of Montevideo. Service areas around food outlets could be created to identify areas with (in)adequate physical access to healthy foods. This approach enables an individualized analysis of physical access to food of individual households. It avoids the drawbacks associated with considering large units of analysis, which may underestimate the difficulties faced by residents of the area to access healthy foods (Chen, 2017; Widener, 2018). Considering the low validity of secondary databases in the city (Vidal et al., 2024), the most feasible approach would be to apply the definition to specific areas of the city, such as specific neighborhoods.

In closing, a series of limitations of the present work should be acknowledged. The study was based on self-reported data, which are susceptible to reporting inaccuracies and social desirability bias. The use of primary and secondary data intended to increase validity. Although there was a temporal mismatch between both types of data, it should be highlighted that results were largely consistent. Although the telephone survey included a sample of participants with diverse socio-demographic characteristics, it was notrepresentative of the population of the city of Montevideo. In addition, the study was restricted to the capital city of Montevideo. Further research is needed to assess the applicability of the proposed definition of adequate physical access to healthy food to other cities in the country.

5. Conclusions

The present study conceptualized adequate physical access to healthy food in the context of a Latin American capital city based on the characteristics of the local food retail environment and the food purchasing behaviors of the city residents. This approach overcomes many of the challenges highlighted in the food environment literature. Future studies should identify areas

without adequate physical access to healthy food and explore the experiences of people living in such areas of Montevideo. Results from such studies would inform the development of context-appropriate public policies to improve access to healthy foods in the city and promote healthier eating patterns. Finally, the approach presented in the current study can be used by other authors to adapt current conceptualizations of physical access to healthy food to their local context.

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Table 1. Percentage of participants of the telephone survey (n=505) who reported purchasing fruits and vegetables and meat in different types of outlets, at the aggregate level and according to the socio-economic status of the household.

Type of outlet	Total	Socio-economic status of the household (*)		
		Low	Medium	High
Fruits and vegetables				
Farmers' markets	37.8%	36.1%	39.8%	36.2%
Fruit and vegetable stores	27.3%	31.3%	31.4%	20.9%
Supermarkets	24.2%	13.3%	17.7%	36.2%
Grocery stores	5.0%	10.8%	4.9%	2.6%
Others	2.0%	2.4%	2.2%	1.5%
Does not purchase the category	3.8%	6.0%	4.0%	2.6%
Meat				
Supermarket	47.3%	38.6%	41.2%	58.2%
Butchers'	44.4%	51.8%	51.3%	33.2%
Grocery store	1.2%	3.6%	0.4%	1.0%
Others	2.6%	3.6%	1.8%	3.1%
Farmers' markets	0%	0%	0%	0%
Does not purchase the category	4.6%	2.4%	5.3%	4.6%

Note: (*) Socio-economic status was calculated based on a national socio-economic index, which calculates a score based on place of residence, household composition, education level, employment, and possession of goods.

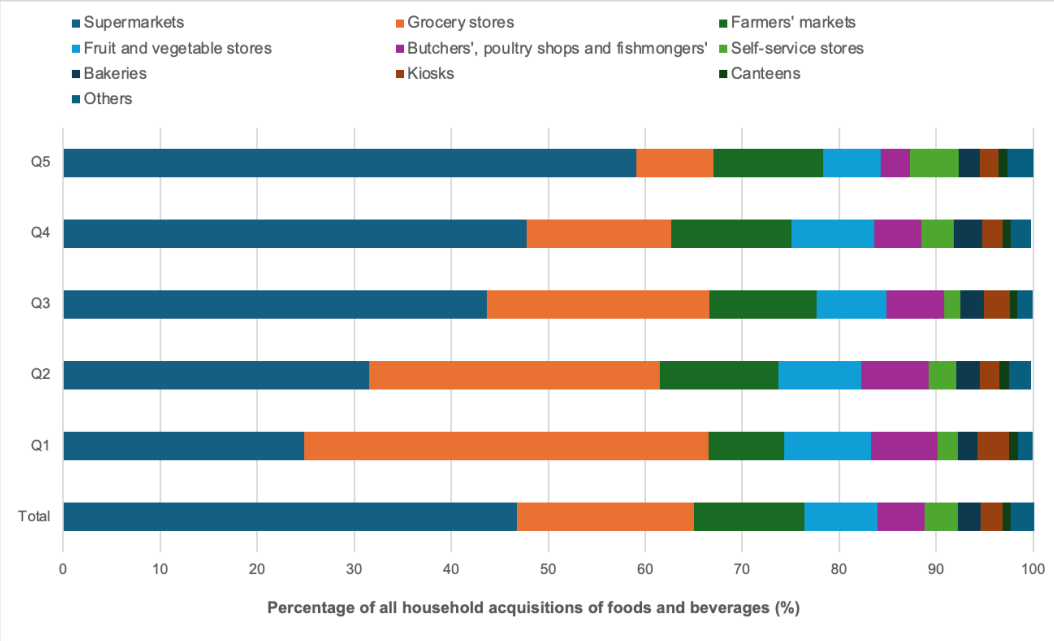
Table 2. Average household shopping travel time by household socio-economic status for all the trips and household-based trips (in minutes) according to the Montevideo Metropolitan Area Mobility Survey conducted in 2016.

Socio-economic status of the household (*)	All trips	Trips originated in the household
High	11.5	10.1
Medium	13.0	11.0
Low	10.3	9.2
Total	11.9	10.3

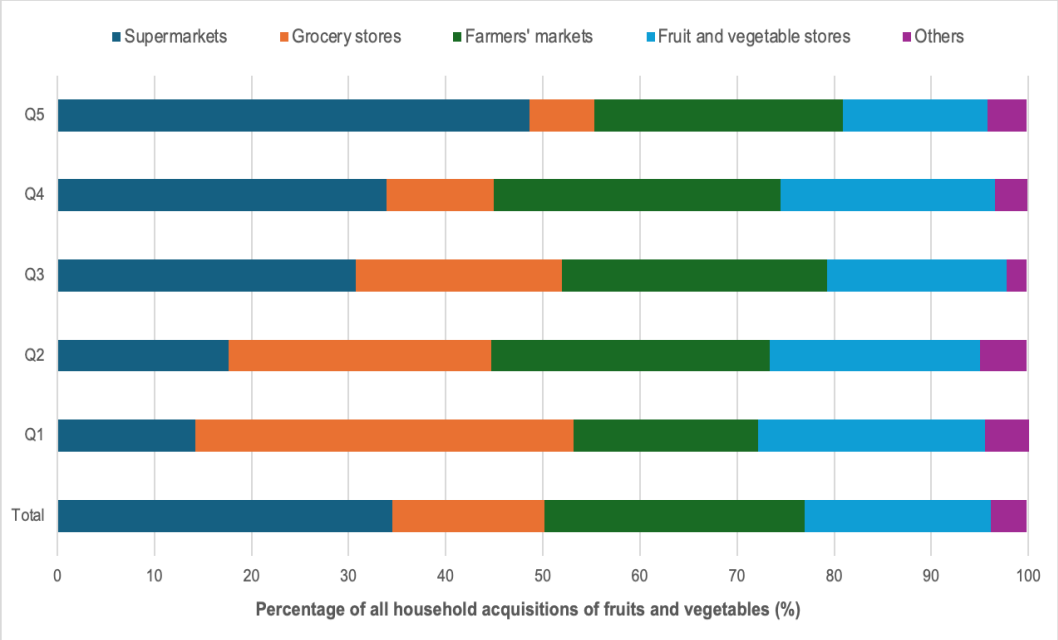
Note: (*) Socio-economic status was calculated based on a national socio-economic index, which calculates a score based on place of residence, household composition, education level, employment, and possession of goods.

Figure 1. Outlets where different foods and beverages are acquired according to the National Survey on Household Income and Expenditure 2016-2017, for all households and by household income quintile (Q1-Q5): (a) all foods and beverages, (b) fruits and vegetables, (c) meat.

(a)



(b)


Supermarkets
Grocery stores
Farmers' markets
Fruit and vegetable stores
Others
Q5
Q4
Q3
Q2
Q1
Total
0
10
20
30
40
50
60
70
80
90
100
Percentage of all household acquisitions of fruits and vegetables (%)

(c)

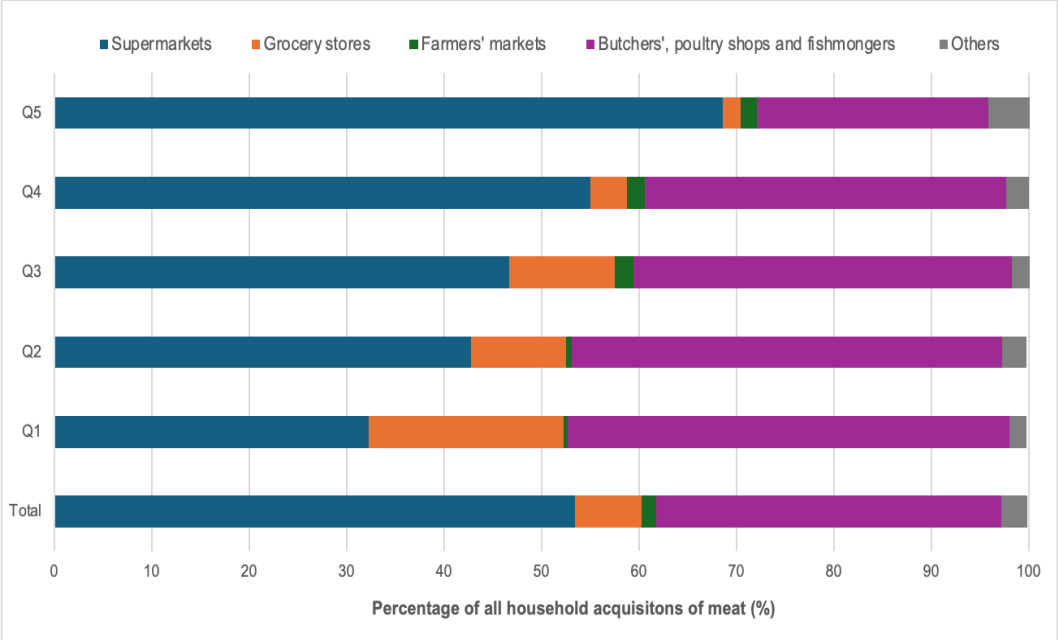
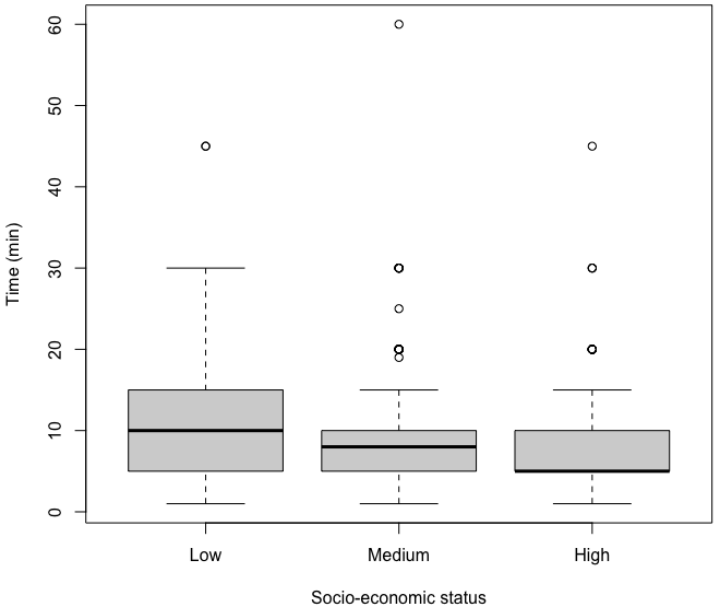

Supermarkets
Grocery stores
Farmers' markets
Butchers', poultry shops and fishmongers
Others
Q5
Q4
Q3
Q2
Q1
Total
0
10
20
30
40
50
60
70
80
90
100
Percentage of all household acquisitons of meat (%)

Figure 2. Distribution of travel time (in minutes) to the outlets where fruits and vegetables (a) and meat (b) are usually purchased by household socio-economic status, reported by participants of the telephone survey (n=505).

(a)



(b)