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Measuring the Potential and Realized (or Revealed) Spatial Access from Places of Residence and Work to Food Outlets in Rural Communities of Québec, Canada

Eric Robitaille [1,2,3,*], Gabrielle Durette [1], Marianne Dubé [1], Olivier Arbour [1] and Marie-Claude Paquette [1,4]

[1] Institut National de Santé Publique du Québec, Montréal, QC H2P 1E2, Canada; gabrielle.durette@inspq.qc.ca (G.D.); marianne.dube@inspq.qc.ca (M.D.); olivier.arbour@inspq.qc.ca (O.A.); marie-claude.paquette@inspq.qc.ca (M.-C.P.)
[2] Département de Médecine Sociale et Préventive, Université de Montréal, École de Santé Publique de l'Université de Montréal, Montréal, QC H3T 1A8, Canada
[3] Centre de Recherche en Santé Publique, Université de Montréal et CIUSSS du Centre-Sud-de-l'Île-de-Montréal, Montréal, QC H3T 1A8, Canada
[4] Département de Nutrition, Université de Montréal, Montréal, QC H3T 1A8, Canada
* Correspondence: eric.robitaille@inspq.qc.ca

Abstract: This study aims to bridge the gap between the potential and realized spatial access to food outlets in rural areas of Québec, Canada. By assessing both aspects, this research aims to provide a comprehensive understanding of the challenges faced by rural communities in accessing food resources and the effectiveness of existing interventions in addressing these challenges. A mixed methods approach was adopted to collect and analyze data, combining GIS-based spatial analysis with community-based surveys. The spatial analysis allowed for the quantification of the potential access metrics, while the community surveys provided valuable information on travel behaviors, preferences, and barriers experienced by residents when accessing food outlets. The results of the distance measurement calculations showed that for both the potential and realized distance measurements, convenience stores are more easily accessible than grocery stores and supermarkets. Thus, workers seem to have a strategy for minimizing the impact of long distances by combining work and grocery shopping. These results are measured for the realized accessibility to grocery stores and supermarkets and the principal retailer used. Finally, the results of the analyses show that there is a socio-economic gradient in the potential geographical accessibility from home to the food outlets. The importance of developing and strengthening the local food environment to make it favourable to healthy eating and supportive of food security is discussed.

Keywords: potential access; realized access; local food environment; accessibility

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1. Introduction

Individual food choices are influenced by various factors, including income, personal food preferences, and knowledge. However, environmental factors such as physical, economic, political, and socio-cultural environments also play a crucial role in determining food choices [1–3]. The World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC) emphasize the importance of healthy eating in population health and recommend the development or consolidation of a local food environment (LFE) that promotes healthy eating habits [4,5]. The LFE refers to the food supply available in municipalities and neighborhoods, including the accessibility to various types of food stores [6]. Experts have hypothesized that having a good-quality local food environment (LFE) can positively impact eating habits, while a poor-quality LFE could contribute to a poorer quality diet. Research suggests that in disadvantaged areas and low-income households, the characteristics of the local food environment have an even greater influence due to limited financial resources, lack of time, and transportation options for food shopping [7,8].

Due to the reduced food access caused by COVID-19 and the health measures implemented to control the epidemic, studies on the LFE have become increasingly popular in recent years [9–13].

Access to food is a fundamental human right and a critical determinant of health and well-being [6,14–17]. In rural areas, ensuring equitable access to food stores is often challenged by geographical dispersion, limited infrastructure, and the reduced availability of retail options [18–21]. In this context, understanding the spatial dynamics of food access becomes crucial for designing effective interventions to address food security and promote healthier dietary habits.

Food store access can be refined into two distinct concepts: the potential access and the realized (or "revealed") access [20,22–24]. These two different types of access have long been used in the field of access to healthcare services. As far back as 1978, Andersen and Aday distinguished between the measures of accessibility based on the availability of services (potential access) and the actual use of services (realized access) [25]. These concepts have often been used in healthcare services studies since the end of the 20th century to today [23,26–28]. More recently, these two concepts have also been applied to studies of food outlets [29]. On one hand, the realized access reflects the ability of individuals or communities to obtain and use available food resources. In other words, the realized access refers to the actual use of food outlets. It considers not only the physical proximity of food stores but also factors in transportation options, income levels, food affordability, cultural preferences, and mobility constraints that influence whether people can access and purchase food from these outlets. The realized access provides a more comprehensive understanding of the challenges and barriers people may face in acquiring and consuming food [30,31]. On the other hand, the potential access refers to the theoretical or geographical availability of all food retail outlets within a certain area, typically measured in terms of proximity or distance. Factors such as the number of grocery stores, supermarkets, farmers' markets, and convenience stores in an area can contribute to the potential access to food stores [19,29–31].

Previous studies in urban areas have shown that the potential access to food outlets is generally higher when compared to rural areas mainly due to the higher population density and greater concentration of retail outlets in urban areas [20,32–37]. Studies have shown that urban neighborhoods often have a higher density of supermarkets and grocery stores, which are associated with better access to fresh and healthy food options [32–36]. Supermarkets and grocery stores are less geographically accessible in rural areas. Several studies in various rural areas of the United States have measured the geographical accessibility of supermarkets and grocery stores, and the results of these studies show that the distance to the nearest store varies from 4.9 km to 32 km [31,38–41]. While the potential access is better in urban areas, the realized access can still be of concern due to factors such as income, transportation availability, and personal mobility that can hinder individuals from utilizing nearby food stores. Rural areas typically have a lower population density, which can result in fewer food retail options, especially supermarkets. This limited access can be exacerbated in remote or isolated rural regions. Studies have highlighted the existence of "food deserts" in rural areas, where residents may need to travel long distances to reach a well-stocked grocery store [33,35,42]. The results of several other studies also show that the potential access to convenience stores and small shops is greater in rural areas. Socio-economic disparities in geographical accessibility to food stores in rural areas have been identified in several studies [18,33,43–47].

The realized access to food stores in rural areas is influenced by factors such as transportation infrastructure, the availability of public transit, and owning a personal vehicle [24]. The lack of reliable transportation options can restrict individuals' ability to access food stores, leading to increased reliance on convenience stores that have limited food choices.

Based on the seminal work of Sharkey, Horel, and Dean (2010), this article presents a comprehensive analysis of the potential and realized (or revealed) spatial access of food

stores in rural areas of Québec, Canada [24]. This study aims to measure the spatial potential access (e.g., distance to food stores) and the spatial realized access (e.g., travel patterns) to food outlets in rural areas. The goal is to identify "access gaps" where the potential access is high, but the realized access is low. We also aim to explore the reasons behind these disparities by analyzing individual variables related to the degree of access (household variables; accessibility barriers; perceptions of food access). Previous studies have suggested that simple physical distance may not be an adequate measure of spatial accessibility to food outlets, as individual characteristics can be associated with accessibility measures. Measures of food deserts may thus exhibit bias [48]. Geographical accessibility to food stores is a less well-documented topic in the literature, and studies comparing the potential and actual access measures are even less so [21,31,49,50]. We believe that by establishing this portrait of actual accessibility, we will be able to propose interventions that can promote accessibility to outlets offering food related to healthy eating.

We suggest three hypotheses based on previous studies, as follows:

Hypothesis 1: *The potential access is expected to be greater than the realized access since the latter is not entirely determined by geographical considerations.*

Hypothesis 2: *Convenience stores are more accessible than grocery shops and supermarkets in rural areas based on the distance measurements of both the potential and realized locations.*

Hypothesis 3: *The analyses will show a socio-economic gradient in the potential geographical accessibility of households to food shops.*

This article is organized into three sections. The first section will describe the materials and methods used, including the survey data and data on the location of food stores. It will also explain how the indicators of the potential and realized access to stores were operationalized, and the strategies used for analysis. The second section will present the results of the analyses. Finally, the last section will provide a discussion and an overview of the strengths and limitations of the study, concluding with a final remark.

2. Materials and Methods

2.1. Data Source

The sample used in this study comes from a larger study assessing the impact of opening food cooperatives in areas classified as food deserts. When the Effets de l'implantation d'une coopérative alimentaire sur l'alimentation et la santé (EffICAS) study began, a provincial organization that supports food co-operative initiatives collaborated to identify some communities in the process of setting up such a project. This study therefore focused on small communities with a low population density on the north shore of the St. Lawrence River in Quebec, located 850 km northeast of Montreal. For more details on the protocol of this study, please consult Robitaille et al. (2022) [51].

The EffICAS study utilizes a natural experimental research design that combines sequential data collecting methods. Using surveys, the study collects, among other data, the different types of food stores where households have obtained their food supply in the past 30 days, before and after the co-ops open. The data used for the distance measurements are those before the opening.

2.2. Sample

2.2.1. Communities Sample

Two communities, Gallix and Rivière-Pentecôte, were selected based on their intention to establish a food co-operative between 2021 and 2023, their limited access to outlets that provide healthy food, namely supermarkets and groceries, and the presence of socio-economic sectors that are underprivileged. Please refer to Figure 1 for more details.

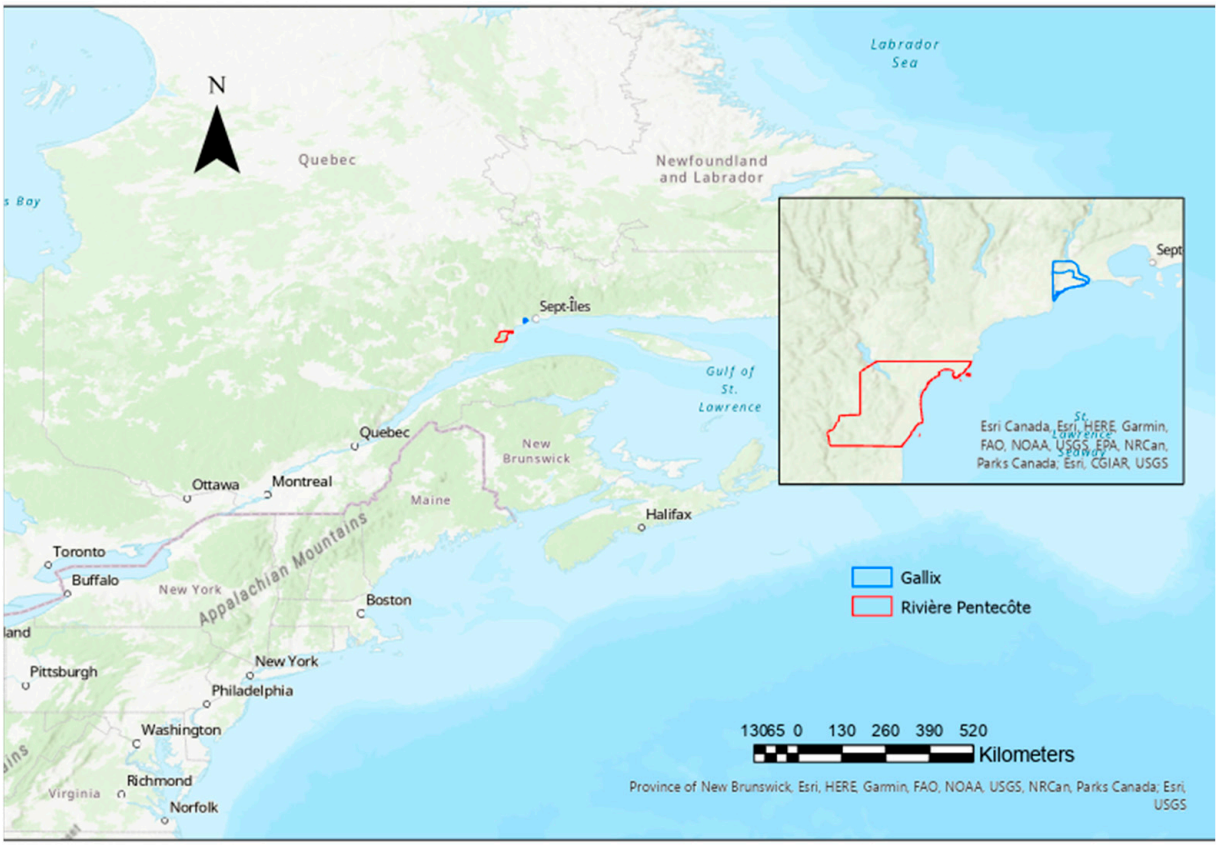

Figure 1. Localization of the communities.

The Gallix community consists of 304 households with a total of 674 inhabitants according to the 2016 Canadian census. There is no food store of any type in this community. Rivière-Pentecôte has 317 households, or 885 inhabitants, according to the same census. In this community, a convenience store-style food co-op has been in operation for about 15 years. It offers staples, ready-to-eat meals, and some fresh produce on-site and to order. This co-op is relocating due to its outdated location.

There is only one road that links one village to the other in the Côte-Nord region where the two communities are located. Due to the low density of the population, there are no opportunities for traffic jams. There is no frequent public transportation either: 99.5% of the survey respondents indicate using a car to go to their main grocery store.

2.2.2. Survey Respondents Sample

At the beginning of the EffICAS study, participants aged 18 years old and over were recruited in 2021, during the COVID-19 pandemic, via a Facebook campaign, polling firm, community posters, and local newspapers. The survey was filled out by the person responsible for food purchases for the household. Informed consent was obtained at the beginning of the questionnaire after participants were made aware of the details of the research project. The sample used to calculate potential and realized access to food outlets includes 82 participants: 28 participants live in Rivière-Pentecôte and 54 live in Gallix. The data were collected by using self-reported online or paper questionnaires according to participants' preferences [52].

2.3. Variable

2.3.1. Food Stores and Residential and Workplace Locations

Two lists of grocery and convenience stores were suggested in the EffICAS questionnaire. These lists were generated from keyword searches on the internet (e.g., grocery store

banners and gas stations on Google Maps, tourism websites about the region around the target communities, and others). Participants were asked to identify a maximum of five grocery stores and five convenience stores where they buy food at least one time per month. They were also asked which of the grocery stores they go to mainly ("Currently, when you make your biggest food purchases for the home, where do you mainly go?"). Official store names, full postal addresses, and coordinate points were then merged into a registry and matched with respondents' responses (Figure 2).

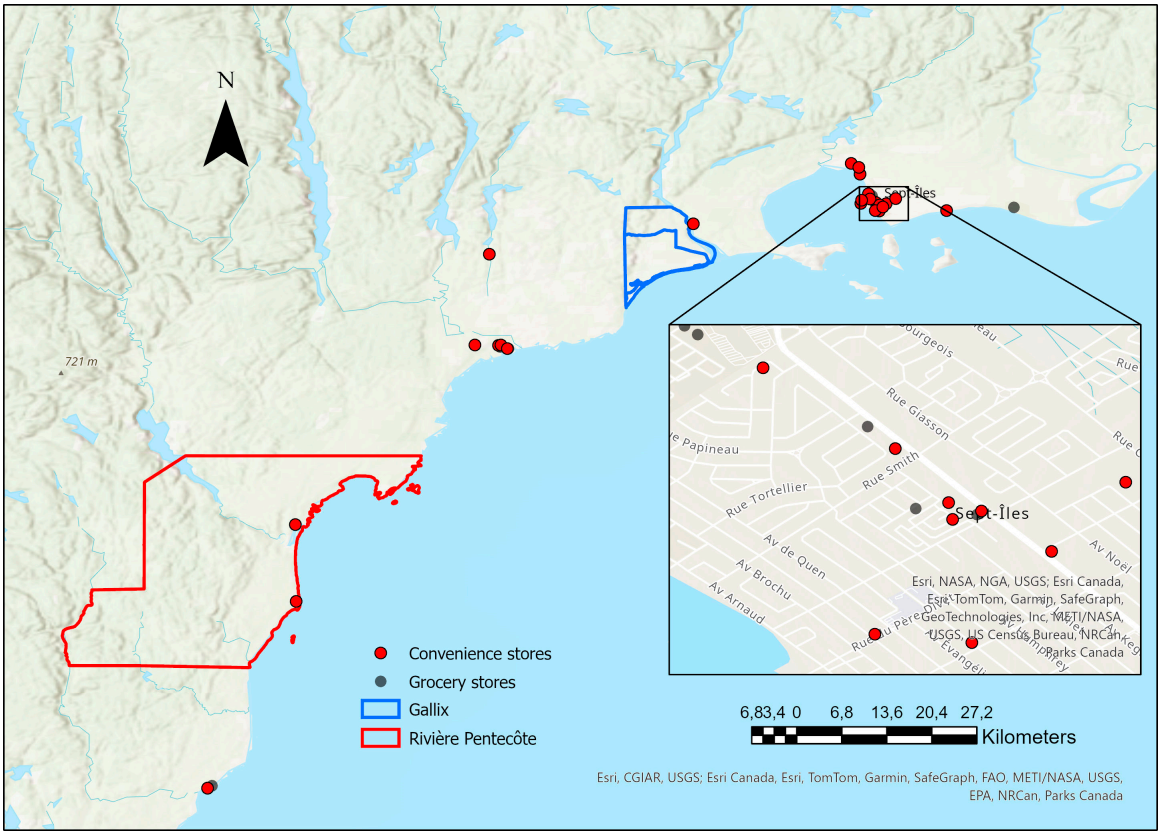

Figure 2. Food stores localization.

Residential and working places were also collected in the survey, by asking the complete postal address of the two places.

2.3.2. Spatial Access Variables

The spatial accessibility measures developed as part of this study are based on the work of Apparicio et al. (2017) [22]. These authors propose that the operationalization of a spatial accessibility measure is divided into 3 phases: the first is to choose a unit of origin which represents the location of the population. For this study, residential and work locations will be used. Using both places brings us closer to the concept of spatial activity space, which is increasingly used as a method of approximating individuals' exposure to the environment (e.g., local food environment) [36,53,54]. The second step includes choosing a measure of spatial accessibility. Researchers have used distance to the nearest point of sale; number of points in each area; distance to the nearest services; and gravity models and accessibility measures of the two-step floating catchment area (2SFCA) type and its variants. In this study, we want to explore the potential level of access to the stores. We chose the distance between the residence or workplace and the nearest point of sale in the areas under study for the potential access and outlets identified by participants for the realized measurement access, a measure of accessibility that has been used several times in the literature [55–57]. The final step consists of choosing a method for calculating distances.

With the development of spatial analysis tools, most spatial accessibility measures are based on the use of reticular distances, i.e., distances based on the geometry of road networks. This is closer to the actual distances travelled by individuals. Distance measurements will be calculated using ArcGIS Pro 3.1 software [58]. We are not considering different modes of transportation since most participants reported (99.5%) using a car to access food outlets.

Potential spatial access from residential and work locations to food outlets was calculated using survey and food outlet data. Participants were asked to enter their full home address. It was then possible to geolocate the entire sample using a batch geocoding tool available in Quebec, Adresses Québec [59]. Participants were also asked to identify their workplace via an interactive map (online questionnaire) or full address (paper questionnaire). We calculated the network distance between the place of residence, and workplace, to the nearest outlet under the study area (supermarkets and groceries stores, n = 11) (convenience stores, n = 40). Two types of variables are calculated: (a) a spatial access variable to stores that can promote healthy eating (grocery stores, supermarkets) and (b) a spatial access variable to less favorable food stores (convenience stores). All variables were calculated according to residential and work locations.

Realized spatial access from residential and work locations to food outlets was calculated using survey data. Participants were asked to identify the food stores in which they made food purchases. They were asked to identify a main food outlet (where they make most of their purchases) and secondary food outlets. They could identify up to 5 food outlets of each kind: groceries and convenience stores. To calculate realized geographical accessibility, we calculated the network distance between the place of residence, the workplace, and the nearest food outlets identified and used by the participants to buy food products. Six variables will be calculated: a spatial access variable to retail stores that can promote healthy eating (grocery stores and supermarkets) and an access variable to less favorable food stores (convenience stores). All variables were calculated according to place of residence and place of work [60].

All distance variables were calculated in ArcGIS Pro 3.1 using Network Analyst by constructing the Origin–Destination Cost Matrix [61].

2.3.3. Households Variables

The questions related to household characteristics come from the EffICAS study as well. The questions used have been derived from the survey questions used in the census [62] or Canadian Community Health Survey (CCHS) [63] These questions include the age, marital status, education level, housing tenure, household income, number of children in the household, and the mode of transportation used to reach food outlets.

2.3.4. Accessibility Barriers

Finally, questions were asked in the EffICAS survey about functional mobility and strength: "In general, do you experience difficulty lifting and carrying heavy loads (e.g., grocery bags)?"; "In general, do you have trouble walking and getting around in confined spaces (e.g., in a grocery store) (yes, no, does not know/prefers not to answer).

2.4. Analysis Strategy

Descriptive analyses of the calculated food access variables and the variables used to characterize the sample were performed. We calculated key summary statistics, such as the mean, median, standard deviation, and interquartile range (IQR) for both potential and realized access measures. Additionally, to determine whether the measures of potential and realized accessibility differ significantly, we conducted a Wilcoxon signed rank test. This test assessed whether the differences between the two are statistically significant. The Kruskal–Wallis test was used to determine whether there are significant differences between the groups formed by our participants and household variables with regard to the variables of interest (accessibility measures). A Shapiro–Wilk test was performed to test the normality of the distribution of the accessibility measures by individual and household

characteristics. The results of most tests showed that the distributions were not normal. This prompted us to select the non-parametric test. The Kruskal–Wallis test is suitable for data that do not follow a normal distribution [64]. We also performed a post hoc Dunn's test for two or more grouping variables to compare the accessibility variables across each pairing of the individual and household variables to determine the specific locations of the significant differences. To mitigate the potential for Type I errors, or false positives, the test applies the Bonferroni correction to these values, and the adjusted significance levels can be observed [65]. Analyses were conducted using SPSS 26 [66].

3. Results

3.1. Sample Characteristics

Table 1 details the characteristics of the sample including the age of the household respondents, level of education, number of people in the household, status of people in the household, presence of children in the household, annual household income, and two questions on the respondents' difficulties in circulating in confined spaces or carrying packages (e.g., grocery bags).

Table 1. Descriptive statistics of household and participants' demographic characteristics.

Characteristics	All (n = 82)
Age %	
18 to 39 years old	25.6
40 to 59 years old	42.7
60 years old and older	31.7
Educational level, %	
≤High school or below	48.0
>High school	48.0
Household size, %	
One member	11.0
Two members	51.0
Three members	7.3
Four members	13.4
More than four members	4.9
Household status, %	
Living alone	11.0
Living with People	58.5
Other	30.5
Children in household, %	
Yes	76.8
No	22.0
Household income level,($) %	
Less than 30,000	10.9
30,000 to 60,000	37.5
60,000 to 100,000	15.6
More than 100,000	35.9
Functional mobility and strength, Difficulty walking in confined spaces, %	
Yes	18.8
No	81.3
Difficulty lifting and carrying heavy loads %	
Yes	7.4
No	92.6

3.2. Objective Measures of Potential Food Access

Table 2 illustrates the mean, median and IQR values of the various potential measures of food store accessibility. For the study participants, the potential access to the convenience stores is higher than that of the grocery stores, both from the residential and workplace locations (workplace: 3.48 km; residence: 12.37 km), as illustrated by a lower mean distance. The potential access measures are higher when the workplace is used as an origin point

(3.48 km; 15.41 km). The measures of the potential access do not vary greatly from one participant to another, except for the measure of the distance from the places of work to the grocery stores and supermarkets (IQR: 0.81–36.27).

Table 2. Potential food outlet access (kilometers).

Potential Access	Mean (SD) [1]	Median	IQR [2]
Workplace to the nearest convenience store	3.48 (5.51)	0.96	0.46–3.65
Workplace to the nearest grocery store	15.41 (22.98)	1.60	0.81–36.21
Residence to the nearest convenience store	12.37 (7.05)	15.94	4.82–18.15
Residence to the nearest grocery store	26.82 (5.89)	25.68	22.87–31.94

[1] SD = standard deviation. [2] IQR = interquartile range (first to third quartiles).

3.3. Objective Measures of Realized Food Access

Table 3 illustrates the mean, median, and IQR values of the various realized groceries, supermarkets, and convenience stores. As with the potential access measures, the actual access to the convenience stores is higher than for the groceries and supermarkets, except for the distance between the workplace and the first grocery store (23.67 (19.28) vs. 10.92 (17.71)). The average distance between the workplace and the various stores is smaller than those measured from the place of residence for all the different food stores. The distance measures from the workplace to the grocery store identified by the participants as their main shopping location varies widely, with IQRs of 1.62–53.05. In addition, the distances between the residential or workplace locations and grocery stores identified as the main place of purchase are greater than those measured for the first stores used (Workplace to the first grocery store: 10.92 vs. Workplace to the principal grocery store: 25.64); (Residence to the first grocery store: 30.92 vs. Residence to the principal grocery store: 37.02).

Table 3. Realized food outlet access (kilometers).

Realized Access	Mean (SD) [1]	Median	IQR [2]
Workplace to the nearest convenience store visited	23.67 (19.28)	24.88	5.24–34.94
Workplace to the first grocery store	10.92 (17.71)	2.29	1.07–11.23
Workplace to the principal grocery store	25.64 (27.16)	4.93	1.62–53.05
Residence to the first convenience store	27.48 (12.23)	33.78	17.49–36.48
Residence to the first grocery store	30.92 (13.53)	28.17	23.61–36.48
Residence to the principal grocery store	37.02 (14.68)	36.22	28.82–41.40

[1] SD = standard deviation. [2] IQR = interquartile range (first to third quartiles).

3.4. Comparing Potential and Realized Access

Table 4 shows the results of the Wilcoxon signed rank tests. It reveals that there are significant differences between the potential and realized measurements of the various food stores, except for those measuring the distance between the workplace and the nearest grocery store. The biggest differences are between the workplace and the first convenience store (23.67 (19.28) vs. 3.48 (5.51)) and between the residence and the first convenience store (27.48 (12.23) vs. 12.37 (7.05)).

Table 4. Realized and potential food outlets access (kilometers).

Difference between Realized and Potential Access	Realized Access Mean (SD) [1]	Potential Access Mean (SD) [1]	*Z* and *p* Values
Workplace to the first convenience store	23.67 (19.28)	3.48 (5.51)	$Z = -4.51$ ***
Workplace to the first grocery store	10.92 (17.71)	15.41 (22.98)	$Z = 1.27$
Residence to the first convenience store	27.48 (12.23)	12.37 (7.05)	$Z = -5.38$ ***
Residence to the first grocery store	30.92 (13.53)	26.82 (5.89)	$Z = -2.99$ **

*** $p < 0.001$; ** $p < 0.01$. [1] SD = standard deviation.

3.5. Individual and Household Characteristics and Differences in Potential Access

An analysis was conducted to investigate if there are significant differences in the potential access to food stores according to the individual and household characteristics. Table 5 illustrates the results of these analyses. The Kruskal–Wallis H test shows that there are statistically significant differences in the measures of the potential grocery store accessibility (in terms of education (H = 5.50, $p < 0.04$), income (H = 12.73, $p < 0.005$), and difficulty in moving around grocery store aisles (H = 7.62, $p < 0.006$). Also, these results show that there are statistically significant differences in the measures of the potential convenience store accessibility from home (in terms of income (H = 13.83, $p < 0.003$), and difficulty lifting and carrying heavy loads (e.g., grocery bags) (H = 9.05, $p < 0.003$).

Table 5. Differences in potential access (kilometers) according to household and individual characteristics.

Characteristics	PWC	PWG	PRC	PRG
Age				
18 to 39	2.89	18.04	14.51	25.83
40 to 59	3.75	12.74	12.67	26.30
60 and older	4.91	23.61	10.22	28.31
Education,				
≤High school or below	3.13	15.52	10.18	**28.55** [a]
>High school	3.79	15.87	14.61	**25.01** [a]
Household size,				
One member	3.28	22.42	8.98	29.07
Two members	3.60	13.25	12.46	26.54
Three members	1.13	13.22	11.11	28.45
Four members	5.57	27.83	13.54	25.87
More than four members	0.98	1.34	16.53	25.63
Household status,				
Alone	3.28	22.42	8.98	29.07
With People	3.69	14.16	12.33	26.57
Other	3.21	14.49	13.65	26.49
Children, %				
Yes	3.60	15.13	11.73	27.11
No	3.13	15.99	14.40	25.83
Household income level,				
Less than 30,000	N.A.	N.A.	**3.06** [ab]	**33.24** [abc]
30,000 to 60,000	2.04	14.92	**13.36** [a]	**25.90** [a]
60,000 to 100,000	3.96	14.92	11.18	**28.03** [b]
More than 100,000	4.20	17.34	**15.56** [b]	**24.46** [c]
In general, do you experience. . .: Difficulty walking in confined spaces (e.g., in the grocery store),				
Yes	5.67	14.05	7.38	30.79
No	3.23	14.66	13.49	25.90
In general, do you experience. . .: Difficulty lifting and carrying heavy loads (e.g., grocery bags),				
Yes	9.86	26.68	**8.38** [a]	**29.26** [a]
No	3.13	14.87	**12.74** [a]	**26.59** [a]

Bold accessibility measures with the same subscript (a, b, or c) show a significant difference of at least $p < 0.05$. PWC: Workplace to the first convenience store; PWG: Workplace to the first grocery store; PRC: Residence to the first convenience store; PRG: Residence to the first grocery store.

The distances from home to the nearest grocery store are greater for the participants with no post-secondary education (≤High school or below: 28.55 vs. >High school: 25.01). The distances to the nearest convenience store are lower for the low-income participants (3.06) than for those with a slightly higher income (13.36) (post hoc Dunn's pairwise examinations were conducted, as evidenced by a robust statistical significance of $p < 0.002$, corrected utilizing the Bonferroni method) and much higher incomes (15.56) ($p < 0.003$). The

opposite is true for the distances to the grocery stores, which are lower for the households with higher incomes (24.46) and higher for the low-income households (33.24) ($p < 0.004$). Finally, the distances between home and the nearest convenience store are lower for the participants who have difficulty lifting and carrying heavy loads (e.g., grocery bags) (8.38 vs. 12.74). On the other hand, the distance between home and grocery store is longer for those who have difficulty lifting and carrying heavy loads (e.g., grocery bags) (Yes: 29.26 vs. No: 26.59).

3.6. Individual and Household Characteristics and Differences in Realized Access

Table 6 shows the results of the Kruskal–Wallis tests. Here, we wanted to know if there were significant differences in the realized access to grocery stores according to the individual and household characteristics of the households participating in the EffICAS study.

Table 6. Differences in realized access (kilometers) according to certain household and individual characteristics.

Characteristics	RWC	RWG	RWPG	RRC	RRG	RRPG
Age						
18 to 39	22.70	12.04	29.89	31.42	28.26	36.83
40 to 59	24.46	9.69	22.72	23.63	29.26	33.37
60 and older	23.15	15.03	24.58	28.43	35.29	41.92
Education						
≤High school or below	30.82	10.74	40.95	26.11	34.01	26.60
>High school	18.10	11.40	33.02	28.65	27.94	23.73
Household size						
One member	37.98	22.91	37.79	22.25	31.18	37.82
Two members	21.48	8.51	17.57	25.82	31.23	38.13
Three members	39.77	24.43	58.79	36.48	31.90	32.33
Four members	10.33	4.53	38.00	31.12	29.80	32.72
More than four members	15.79	1.87	2.15	34.14	25.79	39.92
Household status						
Alone	37.98	22.91	37.82	22.25	31.18	37.78
With People	20.92	8.99	38.62	24.98	31.60	18.82
Other	21.16	8.97	33.78	34.30	29.50	30.03
Children						
Yes	27.56	11.44	37.95	24.91	31.63	23.77
No	16.23	9.73	33.72	33.38	27.94	29.52
Household income level						
Less than 30,000	N.A.	N.A.	52.92	16.83	44.29	N.A.
30,000 to 60,000	35.14	13.25	38.56	28.15	32.38	28.35
60,000 to 100,000	16.34	9.15	39.13	22.65	28.42	24.09
More than 100,000	20.87	11.07	31.86	31.68	26.70	27.41
In general, do you experience. . .: Difficulty walking in confined spaces (e.g., in the grocery store)						
Yes	41.92	9.75	43.64	31.64	25.16	28.95
No	21.60	10.47	35.61	30.88	27.66	24.63
In general, do you experience. . .: Difficulty lifting and carrying heavy loads (e.g., grocery bags)						
Yes	55.23	17.91	31.92	**19.54** [a]	**41.04** [a]	26.98
No	22.65	10.58	37.54	**29.29** [a]	**28.43** [a]	25.57

Bold accessibility measures with the same subscript (a) show a significant difference of at least $p < 0.05$. RWC: Workplace to the first convenience store; RWG: Workplace to the first grocery store; RWPG: Workplace to the principal grocery store; RRC: Residence to the first convenience store; RRG: Residence to the first grocery store; RRPG: Residence to the principal grocery store.

There are significant differences in the measures of the realized accessibility to grocery stores in terms of the difficulty lifting and carrying heavy loads (e.g., grocery bags) (H = 4.52, $p < 0.03$). The distances between the home and the principal grocery store are greater for the three-person households (58.79) than for the two-person households (17.57) and households of four persons or more (2.15). Finally, the distances between home and the nearest convenience store are lower for the participants who have difficulty lifting and carrying heavy loads (e.g., grocery bags) (19.54 vs. 29.29) (H = 3.99, $p < 0.05$). On the other hand, the distance between home and grocery store is greater for those who have difficulty lifting and carrying heavy loads (e.g., grocery bags) (Yes: 41.04 vs. No: 28.43).

4. Discussion

The first objective of this paper is to comprehensively analyze the potential and realized (or revealed) spatial access of food stores in a rural area of Québec, Canada. The results of the distance measurement calculations showed that for both the potential and realized distance measurements, the convenience stores are more easily accessible than the grocery stores and supermarkets. The convenience stores are even more easily accessible from the participants' workplace than from home. These results are in line with several other studies which have shown that the accessibility to convenience stores and small shops is greater in both urban and rural areas [18,33,43–47]. As a result, supermarkets and grocery stores are less geographically accessible. The distances measured in this study are similar to those of other studies that have measured supermarket access in rural areas of North America. However, our measurements are higher than those taken in a study carried out in the Appalachian region in the USA (3.5 miles or 5.6 km from the nearest grocery store and 6.1 miles or 9.7 km from the nearest supermarket store) [31]. Distances are also greater than the ones reported by the Economic Research Service of the US Department of Agriculture (USDA) for the nearest supermarket (3.1 miles or 4.9 km) [39] as well as the ones found in the Brazos Valley in central Texas (8.9 miles or 12.9 km) [40]. Nevertheless, our results are similar to those reported by Connell et al. (2007) (30 miles or 48 km) in the Mississippi Delta [41], and by Meadow (2012) in rural areas of Fairbanks, Alaska, (20 and 12 miles or 32 and 19 km) [38].

On the other hand, the results of our study show that the distances to grocery stores and supermarkets are greater than the thresholds used in the operationalization of food desert indicators. Food deserts are areas where residents have limited access to affordable and nutritious food, often due to a lack of supermarkets or grocery stores within a given distance. The USDA defines a food desert as a "low-income tract in which at least 500 people or 33 percent of the population live more than 1 mile (in urban areas) or more than 10 miles or 16 km (in rural areas) from the nearest supermarket, supercenter, or large grocery store" [32]. This definition highlights the importance of both distance and income in determining the food desert status. From the results for the potential and realized distances from home to supermarkets or grocery stores (potential access: 26.82 km; realized access: 30.92 km; realized principal access: 37.02 km), we believe the food desert threshold of 10 miles is adequate for the region under study. The study participants are willing to travel much greater distances to acquire food products. The low density of the territory and the almost total use of the automobile seem to explain this phenomenon. The fact remains, however, that the distances travelled by people living in rural areas could prove problematic given the ageing population, which is expected to face activity limitations and the loss of autonomy in the future [67–69]. This finding is more problematic, as our research results show that the participants with mobility limitations are located significantly further away than those who report no disabilities.

The geographical access to food stores that promote healthy eating is better from the workplace. Thus, the workers seem to have a strategy for minimizing the impact of long distances by combining work and grocery shopping. These results are valid for the realized accessibility to grocery stores and supermarkets, the principal retailer used, but less so for convenience stores. According to Li and Kim (2020) "... a few studies extended the

spatial contextual units from residential neighborhoods to workplaces by incorporating commuting patterns to estimate the spatiotemporal healthy food accessibility" [70]. When we consider different places of exposure to different food outlets (e.g., workplaces and residential areas), the level of accessibility is higher, even in rural areas [71].

Another objective of this study was to identify whether there is a significant difference between the potential and realized access measures. For most of the accessibility measures operationalized in this study, the potential access measures are significantly shorter than the realized accessibility measures. We can hypothesize that the participants may use grocery stores for reasons other than the geographical proximity such as lower prices, greater product quality, better store atmosphere, etc. This finding is difficult to verify in other studies, as few have measured both the potential and realized accessibility to food outlets. These results are, however, consistent with the ones reported in the only study to have measured the potential and realized access to rural grocery stores in the Appalachian region in the USA [31].

Finally, the results show that there seems to be a socio-economic gradient in the potential geographical accessibility from home to the food stores. The participating households with very low incomes are located closer to convenience stores, but further away from grocery stores than the households with higher incomes. A gradient was also measured for education, but only for the potential access measure to the grocery stores and supermarkets. These results are also consistent with other studies in the United States [29,72–74]. In European countries, given that the population density is higher, even in rural areas, a study carried out in Germany showed that there were very few disparities in the geographical accessibility to food stores. The study found that the vast majority of communities were less than 15 min from groceries by car [67]. But Trembošová et al. (2023) found that scattered settlements in Slovakia and the Czech Republic lacked access to fresh, affordable food, leading to social disparities in diet and health problems [75].

The study includes several strengths. Firstly, thanks to the data available, we were able to measure the realized and potential accessibility to various food stores. To our knowledge, very few studies have presented results on both the realized and potential accessibility [31]. Secondly, it was possible to measure the accessibility to food outlets from residential and workplace locations. Once again, very few studies have reported on measures of geographical accessibility where the places of exposure were the places of work and residence [70,71]. Our results provide a better understanding of the realities of the accessibility to food stores in rural areas. In a literature review, Love et al. (2019) point out that the characterization of the food environment in its current framework is ill-suited to rurality. They also report that very few indicators exist to measure the food environment in rural areas [50].

This study also includes some limitations. Firstly, the samples used in the analyses are small [76–78]. Part of the reason for the small sample sizes is that the study took place in small communities. This is often the case in environmental rural studies. For example, one study conducted in the Appalachian region in the USA used a sample of 9 women and 50 food stores. In a recent literature review on the food environment in rural areas, Love et al. (2019) identified 25 studies. These 25 studies covered 3 to 26 communities. In another literature review on exclusively quasi-experimental designs focusing on the impact of the implementation of food stores on health, the sample sizes ranged from 79 to 423 [79]. In our studies, the small sample size limits the generalizability and the results need to be interpreted with caution. Secondly, it was possible to measure the distances between the workplaces and places of residence. However, it was not possible to generalize to the activity space, as we do not have data on the participants' journeys captured by GPS, for example [53]. A further limitation is that the distances measured for the realized accessibility indicators are based on optimal routes calculated by ArcGIS and not the actual routes taken by the study participants. Activity space and GPS use can improve the exposure measurements in food outlets by providing a more complete understanding of the individuals' food retail environments. Studies have shown that measurements based on

the activity space, which consider the movement and location of individuals beyond their homes, provide a more accurate representation of the exposure to food outlets than in-home measurements [80]. By using GPS trajectory data to create activity spaces, researchers can capture where individuals buy food and the types of food retailers they are exposed to [81]. This approach considers the variability of individuals' daily mobility patterns and provides a more realistic assessment of their exposure to different types of outlets [82]. In addition, measures based on activity space are associated with food shopping behaviours, such as where food purchases are made, confirming their usefulness in understanding individuals' interactions with the food retail environment [83]. Overall, incorporating activity space into exposure measures can improve our understanding of the relationship between individuals and their food environment.

Considering the main results of our studies, public health agencies and researchers recognize the importance of developing and strengthening the LFE to make it favourable to healthy eating [84–88]. Table 7 illustrates the types of promising interventions that could be implemented based on the main findings of our study.

Table 7. Promising interventions to improve physical access to healthy food.

Main Results	Promising Interventions
Convenience stores are even more easily accessible from workplaces than from homes	• Introducing new conventional sources of supply (e.g., supermarkets) [89–91] or alternative sources of supply (e.g., co-ops, solidarity grocery stores, public markets, and mobile markets) [92–94]. • Improving the in-store food offering (e.g., fruits and vegetables in convenience stores) [95,96].
Accessibility measures and potential access measures are significantly shorter than the realized accessibility measures	• Improving the in-store food offering (e.g., fruits and vegetables in convenience stores) [95,96].
Socio-economic gradient in the potential geographical accessibility	• Improving the in-store food offering (e.g., fruits and vegetables in convenience stores) [95,96], land use planning (e.g., zoning) [88], and increasing mobility (transportation infrastructure). • Introducing new conventional sources of supply (e.g., supermarkets) [89–91] or alternative sources of supply (e.g., co-ops, solidarity grocery stores, public markets, and mobile markets) [92–94].

Future research needs to consider the realized measures of accessibility to food outlets, as these may prove different from the potential measures of access, which are widely used in the literature. Work on activity spaces and the use of GPS are promising avenues. Our findings confirm the importance of including different exposure locations, for example, the workplace and school. This is particularly salient in rural areas, where distances are long for all kinds of amenities. Finally, in line with the measures developed in this study, further work should be carried out on the links between geographical access, food insecurity, and food consumption.

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provided to it, has examined the following research project and found that it complies with the ethical rules set out in the Policy on Research Involving Humans of the Université de Montréal. Certificat #CERSES-20-041-D.

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References

1. Raine, K.D. Determinants of Healthy Eating in Canada: An Overview and Synthesis. *Can. J. Public Health Rev. Can. Santee Publique* **2005**, *96*, S8–S14. [CrossRef]
2. Story, M.; Kaphingst, K.M.; Robinson-O'Brien, R.; Glanz, K. Creating Healthy Food and Eating Environments: Policy and Environmental Approaches. *Annu. Rev. Public Health* **2008**, *29*, 253–272. [CrossRef]
3. Giskes, K.; van Lenthe, F.; Avendano-Pabon, M.; Brug, J. A Systematic Review of Environmental Factors and Obesogenic Dietary Intakes among Adults: Are We Getting Closer to Understanding Obesogenic Environments? *Obes. Rev.* **2011**, *12*, e95–e106. [CrossRef]
4. Khan, L.K.; Sobush, K.; Keener, D.; Goodman, K.; Lowry, A.; Kakietek, J.; Zaro, S. Recommended Community Strategies and Measurements to Prevent Obesity in the United States. *MMWR Recomm. Rep. Morb. Mortal. Wkly. Rep. Recomm. Rep.* **2009**, *58*, 1–26.
5. Centers for Disease Control and Prevention. *Healthier Food Retail: An Action Guide for Public Health Practitioners*; Department of Health and Human Services: Atlanta, GA, USA, 2014.
6. Glanz, K.; Sallis, J.F.; Saelens, B.E.; Frank, L.D. Healthy Nutrition Environments: Concepts and Measures. *Sect. Sci. Health Promot.* **2005**, *19*, 330–333. [CrossRef]
7. Lytle, L.A. Measuring the Food Environment State of the Science. *Am. J. Prev. Med.* **2009**, *36*, S134–S144. [CrossRef]
8. Health Canada Measuring the Food Environment in Canada. Available online: https://www.canada.ca/en/health-canada/services/food-nutrition/healthy-eating/nutrition-policy-reports/measuring-food-environment-canada.html (accessed on 3 March 2020).
9. Barr, M.L.; Martin, C.; Luecking, C.; Cardarelli, K. Losses, Gains, and Changes to the Food Environment in a Rural Kentucky County during the COVID-19 Pandemic. *Nutrients* **2021**, *13*, 3929. [CrossRef]
10. Moran, D.; Cossar, F.; Merkle, M.; Alexander, P. UK Food System Resilience Tested by COVID-19. *Nat. Food* **2020**, *1*, 242. [CrossRef] [PubMed]
11. Thilmany, D.; Canales, E.; Low, S.A.; Boys, K. Local Food Supply Chain Dynamics and Resilience during COVID-19. *Appl. Econ. Perspect. Policy* **2021**, *43*, 86–104. [CrossRef]
12. Kent, K.; Alston, L.; Murray, S.; Honeychurch, B.; Visentin, D. The Impact of the COVID-19 Pandemic on Rural Food Security in High Income Countries: A Systematic Literature Review. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3235. [CrossRef] [PubMed]
13. Li, J.; Kim, C.; Cuadros, D.; Yao, Z.; Jia, P. Changes of Grocery Shopping Frequencies and Associations with Food Deserts during the COVID-19 Pandemic in the United States. *J. Urban Health* **2023**, *100*, 950–961. [CrossRef]
14. Rose, D. Access to Healthy Food: A Key Focus for Research on Domestic Food Insecurity. *J. Nutr.* **2010**, *140*, 1167–1169. [CrossRef]
15. Powell, L.M.; Slater, S.; Mirtcheva, D.; Bao, Y.; Chaloupka, F.J. Food Store Availability and Neighborhood Characteristics in the United States. *Prev. Med.* **2007**, *44*, 189–195. [CrossRef]
16. Penney, T.L.; Brown, H.E.; Maguire, E.R.; Kuhn, I.; Monsivais, P. Local Food Environment Interventions to Improve Healthy Food Choice in Adults: A Systematic Review and Realist Synthesis Protocol. *BMJ Open* **2015**, *5*, e007161. [CrossRef]
17. U.S. Department of Health and Human Services (HHS). Access to Foods That Support Healthy Dietary Patterns. Available online: https://health.gov/healthypeople/priority-areas/social-determinants-health/literature-summaries/access-foods-support-healthy-dietary-patterns (accessed on 15 September 2023).
18. Sharkey, J.R.; Dean, W.R.; Nalty, C.C.; Xu, J. Convenience Stores Are the Key Food Environment Influence on Nutrients Available from Household Food Supplies in Texas Border Colonias. *BMC Public Health* **2013**, *13*, 45. [CrossRef]
19. Sharkey, J.R. Measuring Potential Access to Food Stores and Food-Service Places in Rural Areas in the U.S. *Am. J. Prev. Med.* **2009**, *36*, S151–S155. [CrossRef]
20. Sharkey, J.R.; Horel, S.; Han, D.; Huber, J.C., Jr. Association between Neighborhood Need and Spatial Access to Food Stores and Fast Food Restaurants in Neighborhoods of Colonias. *Int. J. Health Geogr.* **2009**, *8*, 9. [CrossRef]
21. Losada-Rojas, L.L.; Ke, Y.; Pyrialakou, V.D.; Gkritza, K. Access to Healthy Food in Urban and Rural Areas: An Empirical Analysis. *J. Transp. Health* **2021**, *23*, 101245. [CrossRef]
22. Apparicio, P.; Gelb, J.; Dubé, A.-S.; Kingham, S.; Gauvin, L.; Robitaille, É. The Approaches to Measuring the Potential Spatial Access to Urban Health Services Revisited: Distance Types and Aggregation-Error Issues. *Int. J. Health Geogr.* **2017**, *16*, 32. [CrossRef] [PubMed]
23. Khan, A.A.; Bhardwaj, S.M. Access to Health Care. A Conceptual Framework and Its Relevance to Health Care Planning. *Eval. Health Prof.* **1994**, *17*, 60–76. [CrossRef] [PubMed]

24. Sharkey, J.R.; Horel, S.; Dean, W.R. Neighborhood Deprivation, Vehicle Ownership, and Potential Spatial Access to a Variety of Fruits and Vegetables in a Large Rural Area in Texas. *Int. J. Health Geogr.* **2010**, *9*, 26. [CrossRef]
25. Andersen, R.; Aday, L.A. Access to Medical Care in the U.S.: Realized and Potential. *Med. Care* **1978**, *16*, 533–546. [CrossRef] [PubMed]
26. Stansberry, T.T.; Tran, L.; Myers, C. Using Geographic Information Systems in Health Disparities Research: Access to Care Considerations. *Res. Nurs. Health* **2023**, *46*, 635–644. [CrossRef] [PubMed]
27. Guagliardo, M.F. Spatial Accessibility of Primary Care: Concepts, Methods and Challenges. *Int. J. Health Geogr.* **2004**, *3*, 3. [CrossRef] [PubMed]
28. Abdoellah, O.S.; Schneider, M.; Nugraha, L.M.; Suparman, Y.; Voletta, C.T.; Withaningsih, S.; Parikesit; Heptiyanggit, A.; Hakim, L. Homegarden Commercialization: Extent, Household Characteristics, and Effect on Food Security and Food Sovereignty in Rural Indonesia. *Sustain. Sci.* **2020**, *15*, 797–815. [CrossRef]
29. Sharkey, J.R.; Horel, S. Neighborhood Socioeconomic Deprivation and Minority Composition Are Associated with Better Potential Spatial Access to the Ground-Truthed Food Environment in a Large Rural Area. *J. Nutr.* **2008**, *138*, 620–627. [CrossRef]
30. Gomez, D.; Haas, B.; Doumouras, A.G.; Zagorski, B.; Ray, J.; Rubenfeld, G.; McLellan, B.A.; Boyes, D.M.; Nathens, A.B. A Population-Based Analysis of the Discrepancy Between Potential and Realized Access to Trauma Center Care. *Ann. Surg.* **2013**, *257*, 160. [CrossRef] [PubMed]
31. Thatcher, E.; Johnson, C.; Zenk, S.N.; Kulbok, P. Retail Food Store Access in Rural Appalachia: A Mixed Methods Study. *Public Health Nurs.* **2017**, *34*, 245–255. [CrossRef]
32. Lebel, A.; Noreau, D.; Tremblay, L.; Oberlé, C.; Girard-Gadreau, M.; Duguay, M.; Block, J.P. Identifying Rural Food Deserts: Methodological Considerations for Food Environment Interventions. *Can. J. Public Health* **2016**, *107*, eS21–eS26. [CrossRef]
33. Minaker, L.M. Retail Food Environments in Canada: Maximizing the Impact of Research, Policy and Practice. *Can. J. Public Health Rev. Can. Sante Publique* **2016**, *107*, 5632. [CrossRef]
34. Smith, D.M.; Cummins, S.; Taylor, M.; Dawson, J.; Marshall, D.; Sparks, L.; Anderson, A.S. Neighbourhood Food Environment and Area Deprivation: Spatial Accessibility to Grocery Stores Selling Fresh Fruit and Vegetables in Urban and Rural Settings. *Int. J. Epidemiol.* **2010**, *39*, 277–284. [CrossRef]
35. Nilsson, H. Population Decline and Changes in Food Store Access. *Reg. Stud.* **2023**, *57*, 946–960. [CrossRef]
36. Crawford, T.W.; Pitts, S.B.J.; McGuirt, J.T.; Keyserling, T.C.; Ammerman, A.S. Conceptualizing and Comparing Neighborhood and Activity Space Measures for Food Environment Research. *Health Place* **2014**, *30*, 215–225. [CrossRef]
37. Dai, D.; Wang, F. Geographic Disparities in Accessibility to Food Stores in Southwest Mississippi. *Environ. Plan. B Plan. Des.* **2011**, *38*, 659–677. [CrossRef]
38. Meadow, A.M. Assessing Access to Local Food System Initiatives in Fairbanks, Alaska. *J. Agric. Food Syst. Community Dev.* **2012**, *2*, 217–236. [CrossRef]
39. Rhone, A.; Ploeg, M.V.; Williams, R.; Breneman, V. Understanding Low-Income and Low-Access Census Tracts Across the Nation: Subnational and Subpopulation Estimates of Access to Healthy Food. Available online: http://www.ers.usda.gov/publications/pub-details/?pubid=93140 (accessed on 17 October 2023).
40. Dean, W.R.; Sharkey, J.R. Rural and Urban Differences in the Associations between Characteristics of the Community Food Environment and Fruit and Vegetable Intake. *J. Nutr. Educ. Behav.* **2011**, *43*, 426–433. [CrossRef] [PubMed]
41. Connell, C.L.; Yadrick, M.K.; Simpson, P.; Gossett, J.; McGee, B.B.; Bogle, M.L. Food Supply Adequacy in the Lower Mississippi Delta. *J. Nutr. Educ. Behav.* **2007**, *39*, 77–83. [CrossRef] [PubMed]
42. USDA Food Access Research Atlas. Available online: https://www.ers.usda.gov/data-products/food-access-research-atlas/documentation/ (accessed on 16 September 2023).
43. Bustillos, B.; Sharkey, J.R.; Anding, J.; McIntosh, A. Availability of More Healthful Food Alternatives in Traditional, Convenience, and Nontraditional Types of Food Stores in Two Rural Texas Counties. *J. Am. Diet. Assoc.* **2009**, *109*, 883–889. [CrossRef] [PubMed]
44. Kaufman, P.R. Rural Poor Have Less Access to Supermarkets, Large Grocery Stores. *Rural Am. Rural Dev. Perspect.* **1998**, *13*, 19–26.
45. Mah, C.L.; Pomeroy, S.; Knox, B.; Rynard, V.; Caravan, M.; Burgess, L.; Harris, R.; Minaker, L. An Assessment of the Rural Consumer Food Environment in Newfoundland and Labrador, Canada. *J. Hunger Environ. Nutr.* **2019**, *14*, 490–510. [CrossRef]
46. Lucan, S.C.; Gustafson, A.; Jilcott Pitts, S.B. The Concept of "Rural Food Deserts" Is Still Meaningful. *Child. Obes. Print* **2012**, *8*, 484–487. [CrossRef]
47. Robitaille, É.; Paquette, M.-C.; Cadieux, E.; Corbeil, D. Le Développement d'une Méthode Pour Localiser Les Déserts et Les Marais Alimentaires à La Suite de l'expérience de La Région de Lanaudière. In *Pour La Sécurisation Alimentaire au Québec: Perspective Territoriale*; Doyon, M., Klein, J.-L., Eds.; Presses de l'Université du Québec: Montréal, QC, Canada, 2019; pp. 43–60.
48. Bader, M.D.M.; Purciel, M.; Yousefzadeh, P.; Neckerman, K.M. Disparities in Neighborhood Food Environments: Implications of Measurement Strategies. *Econ. Geogr.* **2010**, *86*, 409–430. [CrossRef]
49. Ko, L.K.; Enzler, C.; Perry, C.K.; Rodriguez, E.; Mariscal, N.; Linde, S.; Duggan, C. Food Availability and Food Access in Rural Agricultural Communities: Use of Mixed Methods. *BMC Public Health* **2018**, *18*, 634. [CrossRef]
50. Love, P.; Whelan, J.; Bell, C.; McCracken, J. Measuring Rural Food Environments for Local Action in Australia: A Systematic Critical Synthesis Review. *Int. J. Environ. Res. Public. Health* **2019**, *16*, 2416. [CrossRef]

51. Robitaille, É.; Paquette, M.-C.; Durette, G.; Bergeron, A.; Dubé, M.; Doyon, M.; Mercille, G.; Lemire, M.; Lo, E. Implementing a Rural Natural Experiment: A Protocol for Evaluating the Impacts of Food Coops on Food Consumption, Resident's Health and Community Vitality. *Methods Protoc.* **2022**, *5*, 33. [CrossRef]
52. Kestens, Y.; Thierry, B.; Shareck, M.; Steinmetz-Wood, M.; Chaix, B. Integrating Activity Spaces in Health Research: Comparing the VERITAS Activity Space Questionnaire with 7-Day GPS Tracking and Prompted Recall. *Spat. Spatio-Temporal Epidemiol.* **2018**, *25*, 1–9. [CrossRef] [PubMed]
53. Kestens, Y.; Lebel, A.; Chaix, B.; Clary, C.; Daniel, M.; Pampalon, R.; Theriault, M.; p Subramanian, S.V. Association between Activity Space Exposure to Food Establishments and Individual Risk of Overweight. *PLoS ONE* **2012**, *7*, e41418. [CrossRef] [PubMed]
54. Shannon, J.; Christian, W.J. What Is the Relationship between Food Shopping and Daily Mobility? A Relational Approach to Analysis of Food Access. *GeoJournal* **2017**, *82*, 769–785. [CrossRef]
55. Black, C.; Moon, G.; Baird, J. Dietary Inequalities: What Is the Evidence for the Effect of the Neighbourhood Food Environment? *Health Place* **2014**, *27*, 229–242. [CrossRef] [PubMed]
56. Minaker, L.M.; Raine, K.D.; Wild, T.C.; Nykiforuk, C.I.J.; Thompson, M.E.; Frank, L.D. Objective Food Environments and Health Outcomes. *Am. J. Prev. Med.* **2013**, *45*, 289–296. [CrossRef] [PubMed]
57. Needham, C.; Sacks, G.; Orellana, L.; Robinson, E.; Allender, S.; Strugnell, C. A Systematic Review of the Australian Food Retail Environment: Characteristics, Variation by Geographic Area, Socioeconomic Position and Associations with Diet and Obesity. *Obes. Rev.* **2020**, *21*, e12941. [CrossRef] [PubMed]
58. ESRI ArcGIS Desktop: ArcGIS Pro 2019. Available online: https://www.esri.ca/fr-ca/products/gis-mapping-products/arcgis-pro/overview (accessed on 6 September 2023).
59. Ministère des Ressources naturelles et des Forêts Territoire/AdressesQuebec_Geocodage (GeocodeServer). Available online: https://servicescarto.mern.gouv.qc.ca/pes/rest/services/Territoire/AdressesQuebec_Geocodage/GeocodeServer (accessed on 6 September 2023).
60. Mahendra, A.; Polsky, J.Y.; Robitaille, E.; Lefebvre, M.; McBrien, T.; Minaker, L.M. Status Report—Geographic Retail Food Environment Measures for Use in Public Health. Available online: https://www.canada.ca/en/public-health/services/reports-publications/health-promotion-chronic-disease-prevention-canada-research-policy-practice/vol-37-no-10-2017/status-report-geographic-retail-food-environment-measures-use-public-health.html (accessed on 14 September 2018).
61. ESRI Generate Origin Destination Cost Matrix (Ready To Use). Available online: https://pro.arcgis.com/en/pro-app/latest/tool-reference/ready-to-use/itemdesc-generateorigindestinationcostmatrix.htm (accessed on 6 September 2023).
62. Government of Canada. 2021 Census Questionnaires. Available online: https://www12.statcan.gc.ca/census-recensement/2021/ref/questionnaire/index-eng.cfm (accessed on 20 December 2021).
63. Government of Canada. Canadian Community Health Survey—Annual Component (CCHS). Available online: https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3226 (accessed on 20 December 2021).
64. Kruskal, W.H.; Wallis, W.A. Use of Ranks in One-Criterion Variance Analysis. *J. Am. Stat. Assoc.* **1952**, *47*, 583–621. [CrossRef]
65. Field, A.P. *Discovering Statistics Using IBM SPSS Statistics and Sex and Drugs and Rock "n" Roll*, 4th ed.; SAGE: London, UK, 2013; ISBN 978-1-4462-4917-8.
66. IBM Corp. *Released 2019. IBM SPSS Statistics for Windows, Version 26.0*; IBM Corp: Armonk, NY, USA, 2019.
67. Neumeier, S.; Kokorsch, M. Supermarket and Discounter Accessibility in Rural Germany—Identifying Food Deserts Using a GIS Accessibility Model. *J. Rural Stud.* **2021**, *86*, 247–261. [CrossRef]
68. Schwartz, N.; Buliung, R.; Wilson, K. Disability and Food Access and Insecurity: A Scoping Review of the Literature. *Health Place* **2019**, *57*, 107–121. [CrossRef] [PubMed]
69. Gajda, R.; Jeżewska-Zychowicz, M. Elderly Perception of Distance to the Grocery Store as a Reason for Feeling Food Insecurity—Can Food Policy Limit This? *Nutrients* **2020**, *12*, 3191. [CrossRef]
70. Li, J.; Kim, C. Exploring Relationships of Grocery Shopping Patterns and Healthy Food Accessibility in Residential Neighborhoods and Activity Space. *Appl. Geogr.* **2020**, *116*, 102169. [CrossRef]
71. Salze, P.; Banos, A.; Oppert, J.-M.; Charreire, H.; Casey, R.; Simon, C.; Chaix, B.; Badariotti, D.; Weber, C. Estimating Spatial Accessibility to Facilities on the Regional Scale: An Extended Commuting-Based Interaction Potential Model. *Int. J. Health Geogr.* **2011**, *10*, 2. [CrossRef] [PubMed]
72. Dibsdall, L.A.; Lambert, N.; Bobbin, R.F.; Frewer, L.J. Low-Income Consumers' Attitudes and Behaviour towards Access, Availability and Motivation to Eat Fruit and Vegetables. *Public Health Nutr.* **2003**, *6*, 159–168. [CrossRef]
73. Walker, R.E.; Keane, C.R.; Burke, J.G. Disparities and Access to Healthy Food in the United States: A Review of Food Deserts Literature. *Health Place* **2010**, *16*, 876–884. [CrossRef]
74. Beaulac, J.; Kristjansson, E.; Cummins, S. A Systematic Review of Food Deserts, 1966–2007. *Prev. Chronic. Dis.* **2009**, *6*, A105.
75. Trembošová, M.; Jakab, I.; Forgáč, P. Shopping Behavior and Access to Food in the Areas of Slovakia with Dispersed Settlements: A Case Study. *Eur. Countrys.* **2023**, *15*, 66–98. [CrossRef]
76. Batey, L.; DeWitt, E.; Brewer, D.; Cardarelli, K.M.; Norman-Burgdolf, H. Exploring Food-Based Cultural Practices to Address Food Insecurity in Rural Appalachia. *Health Educ. Behav.* **2023**, *50*, 529–537. [CrossRef]
77. Dumitru, E.A.; Sterie, C.M.; Rodino, S.; Butu, M. Consumer Preferences in the Purchase of Agri-Food Products: Implications for the Development of Family Farms. *Agriculture* **2023**, *13*, 1478. [CrossRef]

78. Kerver, J.M.; Khiraya, Y.; Gryc, J.M.; Gardiner, J.C.; Comstock, S.S. Feasibility of a Food Delivery Intervention during Pregnancy in a Rural US Population: The PEAPOD Pilot Study. *Nutrients* **2023**, *15*, 816. [CrossRef]
79. Robitaille, É.; Chaput, S.; Paquette, M.-C. *Interventions Visant à Modifier L'accessibilité Géographique des Commerces D'alimentation et Impacts sur L'alimentation et Le Poids Corporel: Synthèse des Connaissances*; Institut national de santé publique du Québec: Québec, QC, Canada, 2019.
80. Marwa, W.L.; Radley, D.; Davis, S.; McKenna, J.; Griffiths, C. Exploring Factors Affecting Individual GPS-Based Activity Space and How Researcher-Defined Food Environments Represent Activity Space, Exposure and Use of Food Outlets. *Int. J. Health Geogr.* **2021**, *20*, 34. [CrossRef] [PubMed]
81. Widener, M.J.; Minaker, L.M.; Reid, J.L.; Patterson, Z.; Ahmadi, T.K.; Hammond, D. Activity Space-Based Measures of the Food Environment and Their Relationships to Food Purchasing Behaviours for Young Urban Adults in Canada. *Public Health Nutr.* **2018**, *21*, 2103–2116. [CrossRef] [PubMed]
82. Liu, B.; Widener, M.; Burgoine, T.; Hammond, D. Association between Time-Weighted Activity Space-Based Exposures to Fast Food Outlets and Fast Food Consumption among Young Adults in Urban Canada. *Int. J. Behav. Nutr. Phys. Act.* **2020**, *17*, 62. [CrossRef] [PubMed]
83. Plue, R.; Jewett, L.; Widener, M.J. Considerations When Using Individual GPS Data in Food Environment Research: A Scoping Review of 'Selective (Daily) Mobility Bias' in GPS Exposure Studies and Its Relevance to the Retail Food Environment. In *Geospatial Technologies for Urban Health*; Lu, Y., Delmelle, E., Eds.; Global Perspectives on Health Geography; Springer International Publishing: Cham, Switzerland, 2020; pp. 95–112. ISBN 978-3-030-19573-1.
84. Keener, D.; Goodman, K.; Lowry, A.; Zaro, S.; Kettel Khan, L. *Recommended Community Strategies and Measurements to Prevent Obesity in the United States*; Department of Health and Human Services, Centers for Disease Control and Prevention: Atlanta, GA, USA, 2009.
85. Pérez, E.; Roncarolo, F.; Potvin, L. Associations between the Local Food Environment and the Severity of Food Insecurity among New Families Using Community Food Security Interventions in Montreal. *Can. J. Public Health* **2017**, *108*, e49–e55. [CrossRef] [PubMed]
86. CDC Food Access through Land Use Planning and Policies. Available online: https://www.cdc.gov/nccdphp/dnpao/health-equity/health-equity-guide/pdf/health-equity-guide/Health-Equity-Guide-sect-3-4.pdf (accessed on 18 October 2023).
87. Desjardins, E.; Lubczynski, J.; Xuereb, M. Incorporating Policies for a Healthy Food System into Land Use Planning: The Case of Waterloo Region, Canada. *J. Agric. Food Syst. Community Dev.* **2011**, *2*, 127–139. [CrossRef]
88. VicHealth. *Land Use Planning as a Tool for Changing the Food Environment*; VicHealth: Victoria, Australia, 2021.
89. Sadler, R.C.; Gilliland, J.A.; Arku, G. A Food Retail-Based Intervention on Food Security and Consumption. *Int. J. Environ. Res. Public. Health* **2013**, *10*, 3325–3346. [CrossRef] [PubMed]
90. Rogus, S.; Athens, J.; Cantor, J.; Elbel, B. Measuring Micro-Level Effects of a New Supermarket: Do Residents Within 0.5 Mile Have Improved Dietary Behaviors? *J. Acad. Nutr. Diet.* **2018**, *118*, 1037–1046. [CrossRef] [PubMed]
91. Richardson, A.S.; Ghosh-Dastidar, M.; Beckman, R.; Flórez, K.R.; DeSantis, A.; Collins, R.L.; Dubowitz, T. Can the Introduction of a Full-Service Supermarket in a Food Desert Improve Residents' Economic Status and Health? *Ann. Epidemiol.* **2017**, *27*, 771–776. [CrossRef]
92. Abusabha, R.; Namjoshi, D.; Klein, A. Increasing Access and Affordability of Produce Improves Perceived Consumption of Vegetables in Low-Income Seniors. *J. Am. Diet. Assoc.* **2011**, *111*, 1549–1555. [CrossRef]
93. Evans, A.; Banks, K.; Jennings, R.; Nehme, E.; Nemec, C.; Sharma, S.; Hussaini, A.; Yaroch, A. Increasing Access to Healthful Foods: A Qualitative Study with Residents of Low-Income Communities. *Int. J. Behav. Nutr. Phys. Act.* **2015**, *12* (Suppl. S1), S5. [CrossRef]
94. Gorham, G. Effectiveness of Fresh to You, a Discount Fresh Fruit and Vegetable Market in Low-Income Neighborhoods, on Children's Fruit and Vegetable Consumption, Rhode Island, 2010–2011. *Prev. Chronic. Dis.* **2015**, *12*, 140583. [CrossRef] [PubMed]
95. Accordino, J.; Conte, A.W. Review Essay. *J. Am. Plann. Assoc.* **2023**. [CrossRef]
96. Steeves, E.A.; Penniston, E.; Rowan, M.; Steeves, J.; Gittelsohn, J. A Rural Small Food Store Pilot Intervention Creates Trends Toward Improved Healthy Food Availability. *J. Hunger Environ. Nutr.* **2015**, *10*, 259–270. [CrossRef]