CANADIAN JOURNAL *of* PUBLIC HEALTH
REVUE CANADIENNE *de* SANTÉ PUBLIQUE

Supplement 1 Volume 107 (2016) Supplément 1

Retail Food Environments in Canada

ESTABLISHED IN 1910 cjph.cpha.ca ÉTABLI EN 1910

CANADIAN JOURNAL *of* PUBLIC HEALTH
REVUE CANADIENNE *de* SANTÉ PUBLIQUE

TABLE OF CONTENTS • TABLE DES MATIÈRES

Retail Food Environments in Canada

PUBLISHER/ÉDITEUR

Canadian Public Health Association/
Association canadienne de santé publique
Ian Culbert, Executive Director/Directeur général

ISSN 0008-4263

BUSINESS OFFICE/SIÈGE SOCIAL

Canadian Journal of Public Health /
Revue canadienne de santé publique
404-1525 avenue Carling Avenue
Ottawa, Ontario, Canada K1Z 8R9
Tel./Tél. : 613-725-3769
Fax/Téléc. : 613-725-9826
E-mail/Courriel : cjph@cpha.ca
journal.cpha.ca

STAFF/PERSONNEL

Louise Potvin (Editor-in-Chief/Rédactrice-en-chef)
Karen Craven (Assistant Editor/Rédactrice adjointe)
Debbie Buchanan (Editorial Assistant/Adjointe à la rédaction)

Minister of Health Ministre de la Santé

Ottawa, Canada K1A 0K9

Supplément spécial sur les milieux de vente d'aliments au détail de la Revue canadienne de santé publique

En tant que ministre fédérale de la Santé et comme médecin, je sais à quel point il peut être difficile pour les Canadiens de manger sainement. C'est pourquoi le gouvernement prend des mesures concrètes pour les aider à faire des choix sains et judicieux en matière d'alimentation pour eux-mêmes et pour leurs familles. Pour ce faire, nous adoptons une approche globale axée sur la saine alimentation qui comprend de nouvelles dispositions réglementaires, politiques et lignes directrices.

La saine alimentation est un partenariat et nous appuyons des initiatives comme le présent supplément, qui se penche précisément sur les milieux de vente d'aliments au détail, là où la plupart d'entre nous achetons la majeure partie de nos aliments. Je suis aussi encouragée par la gamme de nouvelles recherches de pointe menées au Canada décrites dans ce supplément, qui font partie intégrante d'une approche fondée sur les données probantes pour nous aider à faire de bons choix alimentaires.

Augmenter l'offre d'aliments nutritifs et l'accès à ceux-ci afin de combattre l'obésité juvénile est aussi une de nos priorités stratégiques clés. Par l'entremise du document intitulé *Freiner l'obésité juvénile : Cadre d'action fédéral, provincial et territorial pour la promotion du poids santé*, Santé Canada collabore avec les provinces, les territoires et les intervenants pour s'attaquer à ces enjeux.

Au nom de Santé Canada, je remercie les chercheurs et les spécialistes des programmes et des politiques qui contribuent ensemble à ces efforts louables, de même que la Revue canadienne de santé publique qui a préparé ce supplément spécial. Il ne fait aucun doute que ces enjeux sont complexes. Il reste encore beaucoup à apprendre, mais je suis inspirée par tous les travaux réalisés jusqu'à présent.

Jane Philpott

L'honorable Jane Philpott, C.P., députée
Ministre de la Santé

Canada

Minister of Health | Ministre de la Santé

Ottawa, Canada K1A 0K9

CJPH Special Supplement on Retail Food Environments in the Canadian Journal of Public Health

As the federal Minister of Health and as a physician, I know it can be challenging for Canadians to make healthy eating choices. That is why our government is taking real and significant action to support Canadians in making healthy, informed food choices for themselves and their families. We are doing this by taking a comprehensive approach to healthy eating that includes new regulations, policies, and guidance.

Healthy eating is a partnership and we are supportive of initiatives like this supplement which focusses specifically on food retail environments, places where most of us make the majority of our food purchase decisions. I am also encouraged by the collection of new and leading-edge research in Canada profiled in this supplement, which is an important evidence-based approach to support us all in making good food choices.

Increasing the availability and accessibility of nutritious foods to deal with childhood obesity is also a key policy priority. Health Canada is collaborating with provinces, territories, and stakeholders through the document *Curbing Childhood Obesity: A Federal, Provincial, and Territorial Framework for Action on Healthy Weights* to address these issues.

On behalf of Health Canada, I thank the researchers and program and policy practitioners who are working together to contribute to this valuable work, and the *Canadian Journal of Public Health* for developing this special supplement. There is no doubt the issues are complex. While there is still much to learn, I am inspired by all the work done to date.

Jane Philpott

The Honourable Jane Philpott, P.C., M.P.
Minister of Health

Canada

OPENING COMMENTARY

Retail food environments in Canada: Maximizing the impact of research, policy and practice

Leia M. Minaker, MSc, PhD

ABSTRACT

Retail food environments are gaining national and international attention as important determinants of population dietary intake. Communities across Canada are beginning to discuss and implement programs and policies to create supportive retail food environments. Three considerations should drive the selection of food environment assessment methods: relevance (What is the problem, and how is it related to dietary outcomes?); resources (What human, time and financial resources are required to undertake an assessment?); and response (How will policy-makers find meaning out of and act on the information gained through the food environment assessment?). Ultimately, food environment assessments should be conducted in the context of stakeholder buy-in and multi-sectoral partnerships, since food environment solutions require multi-sectoral action. Partnerships between public health actors and the food and beverage industry can be challenging, especially when mandates are not aligned. Clarifying the motivations, expectations and roles of all stakeholders takes time but is important if the impact of food environment research, policy and practice is to be maximized. The articles contained in this special supplementary issue describe ongoing food environments research across Canada and fill some of the important gaps in the current body of Canadian food environments literature.

KEY WORDS: Food; environment; public health; diet

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS1–eS3
doi: 10.17269/CJPH.107.5632

Retail food environments are gaining national[1] and international[2] attention as important determinants of population dietary intake. While the evidence on the extent to which different features of the food environment are associated with dietary intake and obesity is mixed,[3–5] stronger associations are typically seen when researchers use comprehensive and nuanced food environment measures,[3] as well as high-quality dietary measures.[4]

Many Canadian communities are interested in creating food environments that support healthy eating. The federal, provincial and territorial governments have prioritized policy to increase access to nutritious foods.[1] The Ontario Professional Planners Institute's recommendations, that planners consider food access when designing communities,[6] are reflected in some communities' official plans (e.g., Region of Waterloo and the City of London). Food policy councils are emerging in many Canadian cities, and creative retail food environment interventions, like zoning regulations,[7] healthy corner stores[8] and mobile good-food vending trucks,[9] are being discussed and implemented. It should be noted that in the midst of all these activities, the predominant food environment analogy is still the *food desert*: marginalized neighbourhoods with inadequate geographic access to sources of nutritious foods, like grocery stores. In Canada, however, *food swamps* – marginalized neighbourhoods whose food environment is dominated by fast-food outlets and/or convenience stores[10] – seem to be a more appropriate analogy to describe urban areas. *Food mirages* – neighbourhoods where nutritious foods are available but not affordable[11] – may also be a relevant analogy. How we frame problems within the Canadian food environment matters for developing appropriate solutions. For example, to fix a food desert, policy-makers could create incentives for grocery stores to open in marginalized, underserved areas. To solve food swamps, on the other hand, the density of fast-food outlets or convenience stores could be reduced through zoning regulations, or healthy corner store programs could be implemented to increase the availability, affordability and appeal of nutritious foods in corner stores.[7] Food mirages will not be solved through intervening in the food environment at all, but instead require economic solutions such as living wage policies. In Canada, some of these solutions are far more politically palatable than others.

So where does research currently fit into the development of policy options to create healthy food environments? Retail food environments research is the younger sibling of the built environment and health research family, which itself is a relatively new field of public health inquiry.[12] As such, food environment assessments are typically done to raise awareness of the issue. Findings can be used to position poor diets as a logical response to the current food environment, thereby challenging the victim-blaming, individual responsibility paradigm so prevalent in Western society.

Author Affiliations

Propel Centre for Population Health Impact, University of Waterloo, Waterloo, ON
Correspondence: Leia M. Minaker, PhD, Propel Centre for Population Health Impact, University of Waterloo, 200 University Avenue W, Waterloo, ON N2L 3T1, Tel: 519-888-4567, ext. 32756, E-mail: lminaker@uwaterloo.ca
Acknowledgements: My thanks to the many mentors, colleagues and students who have helped shape my thinking about food environments research, policy and practice. It has been an honour and delight to work alongside this passionate group whose food environment work reflects their overall concern for building equity in Canada. I also gratefully acknowledge the support of the Canadian Cancer Society Research Institute [Major Program Grant #701019] to the Propel Centre for Population Health Impact.
Conflict of Interest: None to declare.

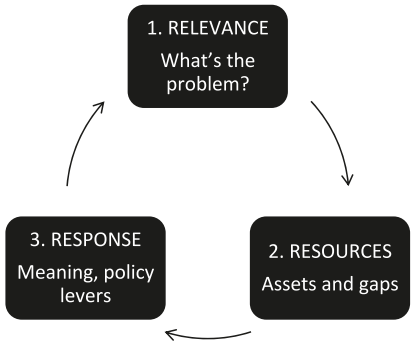

Figure 1. Factors to consider when deciding on a food environment assessment

Notably, because more than 500 measures of the food environment exist,[13] the importance of carefully selecting measures and presenting findings cannot be overstated. Figure 1 shows three considerations that should drive food environment assessment: resources, relevance and response. *Resources* refers to the assets and gaps that communities should identify before conducting a food environment assessment. In cities, assessing food environment features within stores and restaurants is often significantly more resource-intensive than assessing geographic access to food, such as the density of fast-food outlets around schools or the relative proportion of "healthy" to "less healthy" food outlets in an area. In rural and remote areas, in-store measures may be more feasible because there may be limited access to a specialist in geographic information systems and only one or two stores to assess. *Relevance* refers to how food environment problems are defined. Ideally, the food environment feature assessed should be theoretically and empirically related to a dietary outcome of interest. Some food environment features are more strongly associated with dietary or health outcomes than others,[3,14] and these associations can be moderated by community context. Finally, *response* refers to the ability of policy-makers to find meaning out of and act on the information provided. There are thousands of food environment features that are measurable, but not all measures are equal in terms of their ability to raise awareness or inform policy priorities. For example, the Nutrition Measures Survey in Stores (NEMS-S), which has been adapted for use in different Canadian contexts,[15] is an inventory-type measure that assesses the availability, quality and affordability of commonly consumed foods and more nutritious versions of those foods. The NEMS-S provides a score in each of three domains related to nutritious food: availability, quality and affordability. The score by itself is meaningless to policy-makers, who have no frame of reference for the statement, "The average NEMS-S score for food availability in this neighbourhood is 11." As a general rule, all data collected in a food environment assessment should be useable and presented in a compelling way.

Response also refers to policy levers that can be used to change the food environment. For example, it is within municipal jurisdiction to implement a menu-labelling policy,[16] and it is within urban planners' jurisdiction to specifically define land use for food retail spaces and create zoning regulations that alter the mix of food sources. Table 1 shows examples of different types of policy-relevant evidence that can be generated through food environment assessment. These three factors – resources, relevance and response – are equally important in determining the most appropriate food environment assessment to use, from data collection to knowledge translation to action planning.

Finally, any solution proposed to improve the retail food environment will require multi-sectoral action. The topic of multi-sectoral and public–private partnerships is both current and contentious in Canada's public health community. The tactics used by the food industry to sell non-nutritional foods have been compared with those used by the tobacco industry.[17] Voluntary policies adopted by the food industry to improve the nutritional quality of foods have shown questionable effectiveness (see, e.g., the 2015 Lancet Obesity Series). Corporations have a legal responsibility to maximize profit for their shareholders[18]; food industry rhetoric about balanced lifestyles is unhelpful at best. The truth is, different actors have different mandates and motivations. Recognizing this reality will serve to clarify where actors are aligned and where they are opposed, which will help reveal which types of policy and program options are feasible within a given timeframe. Navigating public–private partnerships can be challenging, although tools have been created to help guide public health actors in partnership development.[19]

Within this context, this supplement describes the state of food environments evidence and policy in Canada. First, Minaker and colleagues synthesize 88 peer-reviewed studies on Canadian food environments. With only one paper published before 2005 and 75% of papers published between 2010 and 2015, the field of food environments research in Canada is rapidly expanding. Gilliland and colleagues report a significant association between a novel space–time characterization of food swamp exposure and non-nutritious food purchasing among a sample of 9–13 year olds in Middlesex-London, ON. Lebel and colleagues also report on a novel food environment exposure: a combination of geographic access and consumer nutrition environment measures to characterize food environments in rural Quebec. Their study supports the use of consumer nutrition environment measures to accurately characterize the food environment in rural areas. The paper by Polsky and colleagues provides the first evidence on the association between features of the food environment and relevant outcomes (in this case, diabetes incidence) in a population-based urban cohort over time. They find that *relative* (rather than *absolute*) measures of the food environment are more strongly associated with diabetes incidence among younger adults living in areas with a high volume of fast-food restaurants. Mercille and colleagues' paper also finds evidence for the association between *relative* food environment and diet-related outcomes, among urban-dwelling, older men. Importantly, this study examines the moderating effect of diet knowledge on the relationship between food environments and diet quality, and finds a significant moderating effect among older women. The paper by Le and colleagues finds that the majority of 10- to 14-year-old children in Saskatoon do not have easy access to healthy food retail outlets and that lower neighbourhood healthy food prices are associated with decreased odds of being overweight. The next two qualitative research articles address food environment perceptions among children (Engler-Stringer and colleagues) and new Canadians (Rodriguez and colleagues). These articles represent some of the first published

Table 1. Examples of food environment assessments and potential implications

Example of food environment assessment finding	Type of measure	Purpose and potential policy or program implications
High school students in our community have an average of 12 fast-food outlets within a 5-min walking distance.	Geographic information systems (density of fast-food outlets around high schools within 5-min walk buffer).	• Raising awareness • Zoning regulations
20% of regular grocery stores have at least one candy-free checkout aisle, compared with 10% of discount grocery stores.	In-store inventory measure to assess presence of candy in checkout aisles.	• Raising awareness • Grocery industry policy on healthy checkouts
It costs $250 to feed a family of 4 a nutritious diet in our community. This makes up 35% of social assistance payments.	Nutritious food basket costing.	• Raising awareness • Raise social assistance payments • Reduce cost of nutritious foods
16% of corner stores in our province have fresh fruits and vegetables available; 100% have soft drinks and potato chips.	In-store inventory measure to assess food availability in corner stores.	• Raising awareness • Healthy corner store programs • Programs to enhance distribution of nutritious foods

qualitative investigations of food environment perceptions and interactions in Canada. Skinner and colleagues draw upon their experience of a food costing project in northern Ontario to reflect on challenges in food environment assessment for the remote, northern Canadian context, and conclude that input from local stakeholders is key to developing and implementing appropriate food environment assessments in this context. Finally, Mah and colleagues describe concrete examples of municipal policy options to promote healthy food environments, such as zoning regulations, mobile vending and healthy corner store interventions, institutional procurement and food policy councils.

The articles in this supplement fill some of the gaps identified in the scoping review by Minaker and colleagues, and set the stage for future intervention and policy research on food environments.

REFERENCES

1. Public Health Agency of Canada. *Curbing childhood obesity: A federal, provincial and territorial framework for action to promote healthy weights*. Vol. 2012. Ottawa, ON: Public Health Agency of Canada, 2010. (Accessed June 18, 2015).
2. Ni Mhurchu C, Vandevijvere S, Waterlander W, Thornton LE, Kelly B, Cameron AJ, et al. Monitoring the availability of healthy and unhealthy foods and non-alcoholic beverages in community and consumer retail food environments globally. *Obes Rev* 2013;14(S1):108–19. PMID:24074215. doi:10.1111/obr.12080.
3. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18:1172–87. PMID:22717379. doi:10.1016/j.healthplace.2012.05.006.
4. Kirkpatrick SI, Reedy J, Butler EN, Dodd KW, Subar AF, Thompson FE, et al. Dietary assessment in food environment research: A systematic review. *Am J Prev Med* 2014;46(1):94–102. PMID:24355678. doi:10.1016/j.amepre.2013.08.015.
5. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Pub Health* 2014;14:522. PMID:24884443. doi:10.1186/1471-2458-14-522.
6. Ontario Professional Planners Institute. *Planning for food systems in Ontario: A call to action*. Vol. 2011. Toronto, ON: Ontario Professional Planners Institute, 2011.
7. Québec en Forme. Modifying the built environment to promote healthy eating among youth. Available at: http://www.quebecenforme.org/media/103607/08_research_summary.pdf. Updated 2012. (Accessed December 12, 2014).
8. Kwan A. *Corner stores in Toronto are getting a new kind of power wall: Fresh fruit. The Globe and Mail*. 2015 Jul 10. Available at: http://www.theglobeandmail.com/news/toronto/corner-stores-in-toronto-are-getting-a-new-kind-of-power-wall-fresh-fruit/article25419254/ (Accessed July 10, 2015).
9. City of Ottawa. New MarketMobile bus brings affordable produce to Ottawa neighbourhoods. Available at: http://ottawa.ca/en/news/new-marketmobile-bus-brings-affordable-produce-ottawa-neighbourhoods. Updated 2014. (Accessed April 5, 2016).
10. Fielding JE, Simon PA. Food deserts or food swamps?*Arch Intern Med* 2011;171(13):1171–72. doi:10.1001/archinternmed.2011.279. PMID:21747012.
11. Breyer B, Voss-Andreae A. Food mirages: Geographic and economic barriers to healthful food access in Portland, Oregon. *Health Place* 2013;24:131–39. PMID:24100236. doi:10.1016/j.healthplace.2013.07.008.
12. Mowat DL. Healthy Canada by Design: Translating science into action and prevention. *Can J Public Health* 2015;106(1):eS3–S4. doi:10.17269/CJPH.106.4720.
13. National Cancer Institute. *Measures of the food environment*. Vol. 2012. U.S. National Institutes of Health. Available at: http://epi.grants.cancer.gov/mfe/instruments (Accessed July 3, 2015).
14. Minaker LM, Raine KD, Wild TC, Nykiforuk CIJ, Thompson ME, Frank LD. Objective food environments and health outcomes. *Am J Prev Med* 2013;45(3):289–96. PMID:23953355. doi:10.1016/j.amepre.2013.05.008.
15. Minaker LM, Raine KD, Wild TC, Nykiforuk CIJ, Thompson ME, Frank LD. Construct validation of 4 food-environment assessment methods: Adapting a multitrait-multimethod matrix approach for environmental measures. *Am J Epidemiol* 2014;179(4):519–28. PMID:24264292. doi:10.1093/aje/kwt272.
16. Mah CL, Vanderlinden L, Mamatis D, Ansara DL, Levy J, Swimmer L. Ready for policy? Stakeholder attitudes toward menu labelling in Toronto, Canada. *Can J Public Health* 2013;104(3):e229–34. PMID:23823887. doi:10.17269/CJPH.104.3708.
17. Mialon M, Swinburn B, Sacks G. A proposed approach to systematically identify and monitor the corporate political activity of the food industry with respect to public health using publicly available information. *Obes Rev* 2015;16(7):519–30. PMID:25988272. doi:10.1111/obr.2015.16.issue-7.
18. Bakan J. *The Corporation: The Pathological Pursuit of Profit and Power*. New York, NY: Simon and Schuster, 2005.
19. Kraak VI. *Public health and food and beverage industry engagement: A tool to assess partnership opportunities and challenges*. The Healthy People and Communities Steering Committee's Multi-Sectoral Partnerships Task Group, 2014.

RÉSUMÉ

Les environnements alimentaires au détail attirent l'attention à l'échelle nationale et internationale en tant qu'importants déterminants des apports alimentaires des populations. Les communautés de tout le Canada commencent à discuter et à appliquer des programmes et des politiques de création d'environnements alimentaires au détail favorables. La sélection des méthodes d'évaluation des environnements alimentaires devrait reposer sur trois éléments : la pertinence (Quel est le problème et en quoi est-il lié aux résultats nutritionnels?); les ressources (De quelles ressources en main-d'œuvre, en temps et en argent a-t-on besoin pour mener une évaluation?); et la réponse à donner (Comment les responsables des politiques trouveront-ils un sens à l'information obtenue par l'évaluation des environnements alimentaires et comment en prendront-ils acte?). En bout de ligne, les évaluations des environnements alimentaires devraient être menées dans le contexte d'un ralliement des acteurs et de partenariats multisectoriels, puisque les solutions aux problèmes des environnements alimentaires exigent une action multisectorielle. Les partenariats entre les acteurs de la santé publique et l'industrie des aliments et boissons peuvent être difficiles, surtout quand les mandats ne correspondent pas. Il faut du temps pour clarifier les motivations, les attentes et les rôles de chacun, mais il est important de le faire si l'on veut maximiser l'impact de la recherche, des politiques et des pratiques liées aux environnements alimentaires. Les articles du présent supplément décrivent les travaux de recherche en cours sur les environnements alimentaires au Canada et comblent des lacunes importantes dans la littérature canadienne actuelle sur le sujet.

MOTS CLÉS : nourriture; environnement; santé publique; régime alimentaire

SCOPING REVIEW

Retail food environments research in Canada: A scoping review

Leia M. Minaker, MSc, PhD,[1] Alanna Shuh, BSc,[1] Dana L. Olstad, RD, PhD,[2] Rachel Engler-Stringer, PhD,[3] Jennifer L. Black, PhD,[4] Catherine L. Mah, MD, PhD[5]

ABSTRACT

OBJECTIVES: The field of retail food environments research is relatively new in Canada. The objective of this scoping review is to provide an overview of retail food environments research conducted before July 2015 in Canada. Specifically, this review describes research foci and key findings, identifies knowledge gaps and suggests future directions for research.

METHODS: A search of published literature concerning Canadian investigations of retail food environment settings (food stores, restaurants) was conducted in July 2015 using PubMed, Web of Science, Scopus, PsychInfo and ERIC. Studies published in English that reported qualitative or quantitative data on any aspect of the retail food environment were included, as were conceptual papers and commentaries.

SYNTHESIS: Eighty-eight studies were included in this review and suggest that the field of retail food environments research is rapidly expanding in Canada. While only 1 paper was published before 2005, 66 papers were published between 2010 and 2015. Canadian food environments research typically assessed either the socio-economic patterning of food environments ($n = 28$) or associations between retail food environments and diet, anthropometric or health outcomes ($n = 33$). Other papers profiled methodological research, qualitative studies, intervention research and critical commentaries ($n = 27$). Key gaps in the current literature include measurement inconsistency among studies and a lack of longitudinal and intervention studies.

CONCLUSION: Retail food environments are a growing topic of research, policy and program development in Canada. Consistent methods (where appropriate), longitudinal and intervention research, and close partnerships between researchers and key stakeholders would greatly advance the field of retail food environments research in Canada.

KEY WORDS: Food; environment; inequalities; Canada; review

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS4–eS13
doi: 10.17269/CJPH.107.5344

Unhealthy diets, which are common in Canada,[1,2] are important modifiable primary risk factors for many non-communicable diseases.[2–4] Dietary behaviours and their downstream effects on health are constrained and embedded within individuals' social, economic and physical environments.[5–9] Indeed, poor diets may be a logical response to current food environments, which typically promote the purchase of energy-dense, nutrient-poor foods.[10] The food environment includes geographic access to retail food sources as well as marketing within those sources.[8]

Food environments, which are often (although inconsistently) associated with dietary behaviours and downstream effects on health status,[7,11–15] are a rapidly expanding area for both research and policy and program development in North America.[5–9] Although several peer-reviewed literature reviews have summarized the state of the evidence on associations between retail food environments and health,[7,11–13,15–17] none has focused specifically on Canadian retail food environments. This is important, because existing reviews of Canadian retail food environment studies have found that Canada may face unique food environment issues. For example, unlike the situation in the US,[18] there is a lack of evidence for the widespread existence of "food deserts" in Canadian cities (neighbourhoods that are simultaneously materially deprived and have low geographic access to nutritious, affordable food sources).[8,19] On the other hand, urban "food swamps" (neighbourhoods that are both materially deprived and have high geographic access to food retailers perceived as promoting mainly minimally nutritious food options such as fast food outlets and convenience stores) seem to be common.[8,19] Therefore, initiatives like the US Department of Health and Human Services Healthy Food Financing Initiative,[9] which aims to ameliorate food deserts by promoting fresh, nutritious food provisioning, may not be useful within the urban Canadian context. However, research in Canada's northern and remote communities has not yet used objective measures of the retail food environment.[20,21] Therefore, while these communities may well be considered food deserts by local residents, no empirical evidence

Author Affiliations

1. Propel Centre for Population Health Impact, University of Waterloo, Waterloo, ON
2. Centre for Physical Activity and Nutrition Research, School of Exercise and Nutrition Sciences, Faculty of Health, Deakin University, Geelong, VIC, Australia
3. Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK
4. Food, Nutrition and Health, University of British Columbia, Vancouver, BC
5. Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL

Correspondence: Leia Minaker, PhD, Propel Centre for Population Health Impact, University of Waterloo, 200 University Ave W, Waterloo, ON N2L 3T1, Tel: 519-888-4567, ext. 32756, E-mail: lminaker@uwaterloo.ca

Acknowledgement: LMM acknowledges the support of the Canadian Cancer Society Research Institute [Major Program Grant #701019] to the Propel Centre for Population Health Impact. DLO is supported by a Canadian Institutes of Health Research Fellowship.

Conflict of Interest: None to declare.

Table 1. Literature search strategy

Topic	Search terms
Food environment	Food environment OR nutrition environment OR retail food OR neighbourhood OR neighborhood OR environment OR food desert* OR food swamp OR food availability OR food cost OR food affordability OR food pric* OR food quality
Retail food outlets	Supermarket OR grocery store OR convenience store OR corner store OR dollar store OR fast food OR restaurant OR food store OR bodega OR tienda
Dietary intake	Food OR fruit OR vegetable OR diet* OR nutrition OR processed food
Weight- and health-related outcomes	Obes* OR overweight OR BMI OR body mass index OR waist circumference OR anthropometric OR health OR cardiovascular OR cancer OR diabetes OR hypertension OR disease OR illness
Socio-economic status	Income OR disparity OR equity OR inequity OR inequality OR disadvantage OR poverty OR depriv* OR marginaliz*
Canada	Canada OR Canadian OR British Columbia OR Alberta OR Saskatchewan OR Manitoba OR Ontario OR Quebec OR Nova Scotia OR New Brunswick OR Prince Edward Island OR Newfoundland OR Yukon OR Northwest Territories OR Nunavut

* A Boolean search function indicating truncation, allowing multiple forms of a given word (e.g.,depriv* identifies deprived, deprivation).

has yet quantified the extent of food deserts in northern Canada or the impacts on nutritional health.[8,19]

As Canadian public health decision-makers and practitioners[8,22–25] and non-governmental organizations (NGOs)[26] are increasingly recognizing their role in creating and supporting healthy food environments, there is an urgent need to synthesize Canada-specific food environments literature to support evidence-based decision-making. Therefore, the objective of this scoping review is to provide an overview of peer-reviewed Canadian retail food environments research and commentary by describing emerging research topics and findings, identifying knowledge gaps and suggesting future directions for research and practice.

METHODS

Conceptual framework

Glanz and colleagues' widely-cited conceptual model of community nutrition environments theoretically underpins the current review.[27] The model specifies various environmental variables that influence eating patterns, including the *community* nutrition environment, which is typically reflected in measures of geographic food access, and the *consumer* nutrition environment, which includes the availability of nutritious foods, in-store marketing and the availability of nutrition information in restaurants. Individual socio-demographic factors are thought to moderate or mediate relationships between food environments and eating patterns. This review focuses on features of *community* and *consumer* nutrition environments (hereafter the retail food environment).

Search

PubMed, Web of Science, PsychInfo, ERIC and Scopus were searched in July 2015 for peer-reviewed articles published in English up to and including June 2015. A broad range of terms relevant to the retail food environment were used in various combinations, and these are presented in Table 1. Reference lists of included articles were also scanned. Articles with relevant titles were collected and reviewed (see Study Selection, below).

Inclusion and exclusion criteria

Studies published in English that reported qualitative or quantitative findings on some aspect of the retail food environment were included, as were conceptual papers and commentaries. Studies concerning retail food environments situated within organizations such as schools and worksites were excluded, as were studies in recreational centres, since institutional procurement contracts and other operating policies add additional structural considerations that are beyond the scope of this review.[28,29] Quantitative studies that did not concern a specific retail food environment setting as a function of a specific geographic area were excluded (e.g., studies that examined the overall Canadian food supply or food marketing in Canada).

Study selection

After removing duplicates, we scanned the titles of 420 articles. Initial exclusion was based on the title scan, after which the abstracts of the 191 remaining articles were reviewed to remove those articles that did not meet the inclusion criteria. Figure 1 shows a flow chart of included and excluded studies.

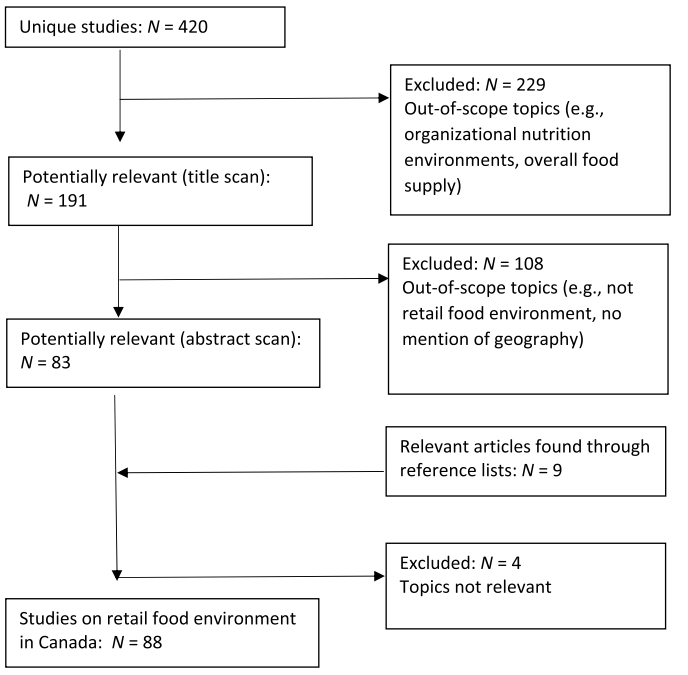

Figure 1. Flow chart of included and excluded studies

The full texts of the remaining 83 articles were reviewed in full by two authors working independently. An additional 9 articles were identified through citation searching of the 83. Four articles were removed during the full-text review. Relevant information (i.e., study population and setting, sample size, design, area-level covariates, outcomes, food environment measures and findings) was transferred from the included studies into a piloted Excel database. We verified all extracted data. Discrepancies were resolved within the research team by consensus.

Synthesis

We developed an a priori coding framework based on findings from two previous non-peer reviewed reviews of the Canadian retail food environments literature,[8,19] which found that the majority of retail food environment studies in Canada were related to 1) associations between retail food environment features and behavioural, anthropometric or health outcomes, and/or 2) area-level socio-economic patterning of retail food environments. A third category was used to capture all "Other" relevant articles. The Other category included articles related to methodological development, qualitative research, intervention research, or critical commentary. The first two categories were not originally considered mutually exclusive, but after full-text extraction of data it was determined that each article could be definitively included in one category.

RESULTS

A total of 88 studies met all inclusion criteria and were included in this scoping review. Of these, 33 studies examined associations between retail food environment features and behavioural or health outcomes, 28 studies examined area-level socio-economic patterning of retail food environments, and 27 studies addressed other topics (Supplementary Table 1; see ARTICLE TOOLS section on journal site). The earliest study was published in 1997, and the remaining 87 studies were all published after 2005, with 66 (75%) published since 2010. Figure 2 shows the number of studies published by year and by category.

Associations between retail food environment features and behavioural, anthropometric or health outcomes

Of the 33 studies examining associations between retail food environment features and behavioural, anthropometric or health-related outcomes, 23 (70%) examined food environments within cities ($n = 7$ Montreal and/or Quebec City; $n = 7$ Greater Toronto Area, of which 2 also examined food environments in Vancouver; $n = 4$ London; $n = 2$ Edmonton; $n = 2$ Ottawa; $n = 1$ Region of Waterloo), 4 examined the retail food environment within provinces ($n = 2$ Ontario; $n = 1$ Alberta; $n = 1$ Nova Scotia), and 6 examined retail food environments at a national level. Half ($n = 3$) of the national studies examined retail food environments around schools. All but one study[30] were cross-sectional. About a third ($n = 13$) controlled for area-level socio-economic variables and about a quarter ($n = 8$) controlled for area-level demographic variables in analyses, which is important because of the potential for these variables to confound associations between food environment exposures and relevant outcomes.

In terms of exposure measures, all but two studies examined the community nutrition environment. Of these, 30 (97%) used density measures (e.g., number of food stores per census tract) to define retail food environment exposures and eight (26%) used proximity measures, such as closest distance from home to retailers. All studies that used proximity measures to define food environment exposure also used density measures. Only one study used measures of the consumer nutrition environment[31] (e.g., linear shelf space of fruits and vegetables), and two used activity space measures (i.e., people-based measures rather than place-based measures, which consider people's retail food environment exposures based on their daily travel patterns) to define food environment exposures.[32,33] Four studies used perceived measures of the food environment to define retail food environment exposure (two of which used both perceived and objective retail food environment measures[31,34]).

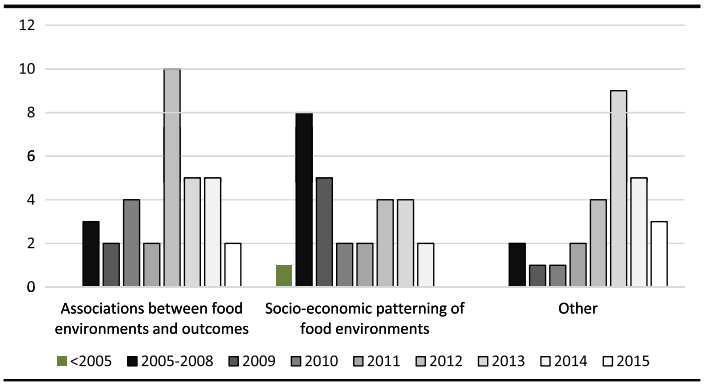

Figure 2. Number of studies of the retail food environment published by year and by topic

Finally, in terms of outcomes, 18 studies (55%) examined associations between retail food environments and weight-related outcomes, of which 15 used self-reported measures (typically body mass index [BMI]). About 18% examined associations between retail food environments and health-promoting dietary behaviours (e.g., fruit and vegetable consumption), 18% examined minimally nutritious dietary behaviours (e.g., fast food consumption), 18% examined disease outcomes (e.g., cardiovascular disease), and one examined associations with food insecurity.[34]

Overall, four studies (12%) found no association between retail food environment features and outcomes, 15 (45%) found mixed (i.e., some significant and some non-significant) results, and 14 (42%) found all significant associations. Significant associations were typically seen in the directions hypothesized by study authors. For example, a higher density of fast-food outlets around the home was associated with fast-food purchasing frequency among adolescents in London, ON,[35] and cardiovascular disease was positively associated with fast-food outlet density among adults living in Toronto.[36] Studies were diverse in terms of study populations, sample size, design, outcomes of interest and findings by area-level exposures of interest (socio-economic status, demographic characteristics and food environment exposures) (Supplementary Table 1).

Area-level socio-economic patterning of retail food environments

The majority of studies (75%) examined retail food environments within cities or counties, four (14%) examined food environments

Table 2. Other retail food environment research

Author (year)	Main findings
Methodological contributions	
Olstad et al. (2014)	This article reported on the process of creating a Report Card on Healthy Food Environments and Nutrition for Children for use in Canada. The Report Card was intended to be a metric assessing the extent to which current environments and policies support or create barriers to improving children's dietary behaviours. To develop the Report Card, the research team reviewed evidence-based indicators of supportive vs. not supportive policies and environments with an Expert Advisory Committee. The Report Card included 42 indicators and benchmarks that can be used to monitor the state of children's food environments and policies.
Clary et al. (2013)	This article compared alternative methods of establishing the validity of secondary geospatial data and proposed a new method (representativity) that may be more appropriate for validating secondary data sources of food environment data. Traditional and "relaxed" measures of sensitivity and positive predictive value were compared with a representativity score, which was calculated as $((TPs + \|FPs - FNs\|)/(TPs + FNs))$, where TP represents true positive, FP represents false positive and FN represents false negative. Traditional and relaxed measures indicated moderate capacity of the Enhanced Points of Interest (EPOI) (DMTI Spatial ®) secondary database to detect actual food outlets, with no evidence of systematic differences across 12 Montreal census tracts. Using representativity, the EPOI was found to have good validity. The authors argue for future research to make theoretically justified decisions about validity metrics based on the research objectives and methods used to assess food environment exposures. Additional files of note include 1) Standard Industry Classification code- and name-based assignment methods used to categorize food outlets, and 2) a classification tool aimed at facilitating categorization of food outlets found on site.
Minaker et al. (2013)	This article assessed the construct validity of four retail food environment measures along three constructs (food availability, food affordability and food quality) using multitrait-multimethod matrices, which are a traditional psychometric tool for evaluating construct validity. Measures included both objective and residential perceptual data, and food environment data were aggregated to 250 m, 500 m, 1000 m and 1500 m around respondents' households ($n = 2397$). Convergent validity (correlations between measures purportedly assessing the same construct) between objective measures decreased as geographic scale increased, and convergent validity between objective and perceived measures tended to slightly increase with increasing geographic scale. This article concluded that the construct validity of food environment measures varied by geographic scale, and that both measures and geographic aggregation of food environment variables should be theoretically justified on the basis of research objectives and hypothesized causal mechanisms.
Healy and Gilliland (2012)	This article examined the magnitude of distance errors and accessibility misclassification that result from using different types of address proxy common in public health research across urban, suburban, small town and rural southwestern Ontario. In terms of address proxies, using shortest path network distances from each resource to the residential address proxy this study found that lot centroids are the most accurate, followed by geocoded points, then street segment centres, postal codes, dissemination blocks, weighted dissemination areas, dissemination area and, finally, census tracts. Across neighbourhood types, junk food outlets (fast-food and convenience stores) accounted for the smallest number of positional discrepancies (compared with public recreation places, grocery stores, schools and hospitals), whereas grocery stores had a larger number of positional discrepancies than junk food places and public recreation places but a smaller number than schools and hospitals. This study also found that, in general, the smaller the distance threshold the greater percentage of addresses are misclassified, and the larger the geographic area of the unit of aggregation the greater the percentage of misclassified addresses. The article concluded with the importance of identifying and quantifying spatial errors so that research findings can be critically examined, and policies and programs can be evidence-based. Finally, postal codes were not recommended for use in rural and remote areas in Canada.
Seliske et al. (2012)	This article compared the validity of geospatial data from two databases (InfoCanada and the Yellow Pages) with observed data (using global positioning systems [GPS]). This study measured differences in the geographic information system (GIS) and GPS-derived locations using Euclidean (straight-line) distances. For both GIS databases, the percentage of discrepancies increased with smaller buffers. The Yellow Pages directory provided a greater proportion of listed food service places in the 1 km buffer, but the positional error did not differ between GIS databases. In total, about half of food service places were positioned within 25 m of their true location, and about 75% were positioned within 50 m.
Minaker et al. (2009)	This article described the development and implementation of food environment assessment tools designed to assess food service outlets on and around the University of Alberta. It categorized food service outlets as outlets selling Asian food, burger outlets, cafeterias, coffee shops, pizza places, sandwich shops, sit-down restaurants and smoothies outlets, according to observed consumer nutrition environment similarities within categories. The authors found that outlets with higher convenience (e.g., shorter wait times for foods) and higher value (kcal/dollar of commonly ordered items) tended to have fewer healthy foods available and promoted. In addition, this research found that unhealthy foods were far more available and more heavily promoted than healthier options in this setting.
Qualitative research	
Mannion et al. (2014)	This qualitative study from Calgary relied on go-along interviews with 5 recent Sudanese refugees to Canada and a qualitative focus group ($n = 8$ female Sudanese refugees). The objective of the study was to explore the acceptability of a nutrition resource developed to help recently immigrated Sudanese refugee women identify and purchase healthy foods and navigate grocery stores. The findings suggested that dietary acculturation is a relational process and is grounded in women and mothers as dietary gatekeepers of their families. One emergent theme was that grocery stores sold foods that were safe to eat, which, for this group of women, meant good food to eat. Navigating the grocery store was challenging for many participants because of language barriers as well as a lack of familiarity with many available foods. Finally, low transportation access, which many participants experienced (none had a driver's licence, for example), affected grocery store access.
Dyck-Ferau et al. (2013)	This qualitative study from the main reserve land of Alexander First Nation in Alberta relied on asset-mapping activities with a convenience sample of two high school students and seven grade 6 children. The study's objective was to understand extra-individual factors that influence the lifestyle behaviours of First Nations' children, including food consumption. Youth reported commonly consuming snacks from the convenience store (the only store on the reserve), where healthy food availability was limited. Food quality also was noted as a deterrent of food choice, as youth reported mice soiling certain food products. The convenience store was reportedly used by all residents, and although the food selection was limited, the store was highly accessible, open year-round with extended hours of operation.
McPhail et al. (2013)	This qualitative study relied on data from interviews with 51 teenagers (aged 12–19) recruited from rural towns across Canada. It explored the ways in which obesity is constructed as a rural disease in the Canadian context and demonstrated how understandings of food deserts and related rural obesity rely on classist imaginings of obesity as a working-class embodiment.
Pal et al. (2013)	This ethnographic and cost assessment study aimed to illustrate the costs associated with procuring traditional foods compared with the costs associated with buying store-bought foods in remote northern Ontario First Nations communities. Compared with the cost/kg of locally available store meats, the estimated cost/kg of traditional foods was higher for some hunting trips and lower for other hunting trips. The authors conclude that programs and policies to improve food affordability in northern remote communities should also include support of land-based food acquisition.

Continued

Table 2. (Continued)

Author (year)	Main findings
Skinner et al. (2013)	This study used qualitative, semi-directed interviews with 51 First Nations adults living in Fort Albany, ON, to explore participants' perceptions of food security and adaptive strategies used at individual and household levels to deal with food insecurity. Within this community, the high cost of store foods and the high prevalence of low household income were identified as barriers to accessing food. Store foods transported from the south were seen as foods that did not support community independence and self-sufficiency. Participants also noted that a grocery store opening in their community might help to improve food security and provided suggestions for the creation of non-traditional food retail in the community, such as a non-profit farmers' market, community garden and community greenhouse. Geographic access to high-quality, affordable foods was perceived as lacking, especially because there were only winter roads connecting the community to more southern communities.
Vahabi et al. (2013)	This cross-sectional, mixed-methods study explored perceived barriers in accessing safe, nutritious and culturally appropriate foods among a convenience sample of 70 adult Spanish/Portuguese speakers who had immigrated to Toronto, ON, in the previous five years. The majority of participants reported that discount grocery stores (where they predominantly shopped) were often far from home and were considered inaccessible without a car or nearby public transit, especially in the winter months. Geographically inaccessible discount grocery stores were a factor perceived to contribute to participants' food insecurity. In addition, language barriers were perceived as impeding access to nutritious foods in supermarkets, because participants were unable to read food labels and/or ask for certain foods. Finally, preferred cultural foods were often unavailable in nearby supermarkets.
McPhail et al. (2011)	This qualitative study explored reasons for fast-food consumption among a large cross-national sample ($n = 132$) of rural and urban Canadian teenagers. Qualitative findings show that fast-food consumption is not merely a function of geographic proximity to or density of fast food outlets but, rather, that teenagers engage in complex ways with different dimensions of choosing to consume or refrain from consuming fast foods. In this study, fast-food consumption did not seem to be related to the location of fast-food outlets nor to teens' socio-economic categories. Notably, this study found that teens approached fast food with a complex collection of social factors, individual preference and moral dictates. Moralistic notions of health – teens' conceptions of fast food as unhealthy and "bad" – were very salient in their consumption choice.
Retail food environment intervention research	
Fuller et al. (2015)	This study examined healthy and less healthy food purchasing over one year using grocery store sales data. The Good Food Junction (GFJ) (a not-for-profit, full-service cooperatively owned grocery store) was opened in a deprived neighbourhood in Saskatoon, SK, in a former food desert. The authors compared store members' total amount spent ($) in 11 food categories – fruit, vegetables, meat and alternatives, dairy, grain, sugar-sweetened beverages, non-nutritive beverages, snack foods, prepared foods, flavouring and non-food items – by neighbourhood residence. Consumers who were residents of the former food desert neighbourhood spent significantly more on vegetables and significantly less on meat and on prepared foods compared with consumers who were not residents. The authors concluded that residents of the former food desert appeared to be accessing the grocery store for more healthy food purchases compared with their non-resident counterparts.
Lotoski et al. (2015)	This research examined awareness and use of the GFJ. Quantitative surveys with 365 primary household food shoppers living within a 750 m road network buffer of the GFJ were used to assess residents' awareness, use and mode of transportation to and from the GFJ, as well as to collect demographic data. The authors found that 95% of residents were aware of the GFJ, and 69% had shopped there at least once. Respondents identifying as Aboriginal were more likely than non-Aboriginals to have ever shopped at the GFJ. Aboriginal respondents also had higher odds of using GFJ as their primary grocery store compared with non-Aboriginal respondents. The authors concluded that the GFJ was able, and perhaps necessary, to serve as an important source of food for residents of marginalized neighbourhoods in a previous food desert.
Galloway et al. (2014)	This commentary addressed the federal government's Nutrition North Canada program, which purportedly aims to improve the food environment in northern, remote communities. This program is a federal subsidy to remote and semi-remote food retailers to make fresh, nutritious food more widely available and affordable in these communities. The author argues that the current reporting structure of the program made it impossible to determine whether stated objectives are being met. Similarly, an evaluation of whether the affordability of such foods has improved was considered impossible due to a lack of transparency in how the subsidy operates. Specific challenges to evaluation include: no indication of how subsidy rates are calculated; actual costs to shippers are not disclosed, and; the degree to which retailers pass along savings to consumers are unknown.
Hobin et al. (2013)	This between-groups experimental study evaluated the effect of "toy premiums" on 6–12 year old children's ($n = 337$) fast-food choices. Children were significantly more likely to select the healthier meals when toys were offered only with meals that met nutritional criteria, and the effect varied by sex and age. Younger children had higher odds of ordering the healthier meal than older children, and females had higher odds of ordering the healthier meal than males.
Mah et al. (2013)	This mixed-methods study assessed the feasibility of municipal jurisdictions adopting a menu labelling policy in Toronto, ON. First, a population-based telephone survey with 1,699 Torontonians found that 71% of respondents had eaten out at a restaurant and/or fast food outlet at least once in the previous week, 54% reported that it was important to have nutritious food when eating out, and 78% reported that they would use nutrition information on menu boards at least sometimes if it was available. A follow-up survey with 256 independent restaurant operators found that 72% were not interested in providing nutrition information to consumers, 76% reported believing that it was too expensive to provide such information on menus, 57% felt some responsibility to provide it, and 42% indicated interest in a pilot program. Finally, in-depth key informant interviews were completed with executives and key decision-makers at chain and franchise restaurants ($n = 9$). The findings from the interviews revealed that while industry generally supported the provision of nutrition information, it did not support displaying information on menus because of a perceived negative impact on business profitability.
Mead et al. (2012)	This article described the impact of a community-based, multi-institutional nutrition and lifestyle intervention implemented in three Inuit communities in Nunavut and three Inuvialuit communities in the Northwest Territories. Following an intervention that improved healthy food availability in local stores, and community-wide and point-of-purchase interactive activities, researchers found that the intervention group ($n = 246$ adults) had significantly lower frequency of unhealthy food acquisition before adjustment for confounders but no significant difference after adjustment. Second, the intervention had significantly increased self-efficacy and intentions for healthy eating. The authors also examined outcomes by socio-demographic and weight category subgroups. The intervention group significantly increased healthy eating intentions and decreased unhealthy food acquisition among overweight participants. Those with higher socio-economic status (SES) had significant improvements in healthy eating and psychosocial intentions compared with participants with low SES. The intervention significantly increased food knowledge and the use of healthier preparation methods among participants with a moderate material style of life score compared with those with a low material style of life, and among highly educated participants compared with participants with less education. Finally, the intervention was significantly negatively associated with food knowledge in employed households compared with unemployed.
Ho et al. (2008)	This article described the results of a quasi-experimental pretest/posttest impact evaluation of a multi-component diabetes prevention program in four remote or semi-remote First Nations communities in Ontario. The store component of the prevention program promoted healthier alternatives to commonly consumed foods using shelf labels, posters, cooking demos and taste tests in local stores. Store managers were additionally asked to stock healthier items if they were not already available. The overall results indicate that knowledge and frequency of healthy food acquisition improved among intervention residents, but no significant differences were found in body mass index between groups.

Continued

Table 2. (Continued)

Author (year)	Main findings
Ho et al. (2006)	This study described the development of a multi-component diabetes prevention program for First Nations communities in Ontario. As part of the development of the program, direct observations of consumers' food purchases were conducted at stores to note eating and purchasing behaviours of community residents. While support for a healthy food promotion in stores component was mixed in different First Nations communities, residents' feedback was used to refine the healthy food promotion strategies in stores to ensure that they would be acceptable to community residents.
Critical commentaries	
Sadler and Gilliland (2015)	This critical commentary presents a theoretical position upon which to build empirical research on food environments research. The authors argued that retail food environment intervention research should focus on more than just structural limitations to accessing food. The proposed theoretical foundation built upon considerations of governance systems in retail-based interventions, structuration theory and behavioural economics, and viewed consumers as predictably irrational consumers. The article concluded that policy responses to food deserts should be that of libertarian paternalism, which encourages people to make healthy choices while not restraining them from making unhealthy choices. Interventions emphasizing empowerment and local food production were seen as more promising than governments leading social change, and suggested that policy action at the local level is a feasible starting point.
Bedore (2014)	This commentary used case-study methods and in-depth qualitative interviews to critically analyze a food desert in Kingston, ON, and its responses. The food desert is used as a phenomenon through which complexities and tensions around the idea of choice in a classed society can be understood. Declining retail food access was described as compounding people's struggles with low income and leading to negative emotional consequences and injustice. Class paternalism was seen as narrowing food options for economically marginalized groups. Interviews with 27 participants revealed that low-income participants preferred to shop at an affordable supermarket rather than rely on food charity. Current responses to food deserts were viewed as coming mainly from privileged people and places, and representing a form of cultural imperialism based on societal understandings of class. To promote the dignity of economically vulnerable people, the author argued, requires public discussion about food deserts as a divisive spatial politics of oppression.
Bedore (2012)	This case study took a historical, critical political economy lens to explore a food desert in Kingston, ON, as a product of capital formation and rescaling over time. The industrialized retail food system was seen as creating and perpetuating a spatial logic in which it is almost impossible for a major retailer to target inner cities or older urban areas. The food desert problem was traced back to retail food industry changes from a decentralized, small-scale, neighbourhood-embedded retail food sector to the scaled-up retail food industry that exists today.
Fieldhouse and Thompson (2012)	This commentary was based on a narrative review of food insecurity in First Nations communities. The authors drew on the literature and their experiences to describe the high prevalence of food insecurity and approaches to tackling food insecurity in First Nations communities. First Nations children and youth tend to prefer store-bought food over traditional foods, and store-bought foods are often unaffordable and of poor quality because of the extended supply routes to get to remote communities. The authors concluded that efforts to address food insecurity in northern communities will require programs and policies that aim to enhance geographic access to affordable, nutritious foods.
Minaker et al. (2011)	This article reviewed food environment characteristics, theories, conceptual models and assessment methods and aimed to present a theoretical basis for the selection of food environment assessment methods by public health planners and other practitioners. A case study of the Region of Waterloo was presented to show how food environments measures may be used for developing local policy to support healthy food environments. The authors described the Region of Waterloo's Regional Official Plan and suggested that applications to build new developments could include consideration of how a new development will support residents' access to safe, nutritious and affordable foods.
Wegener and Hanning (2010)	This commentary provided an overview of alternative food networks and argued that alternative retail food outlets, such as farmers' markets, online grocery stores and community-supported agricultural groups, are a growing source of food for Canadians. The authors undertook a literature review to provide an overview of concepts, measures and methods for assessing traditional retail food stores, and provided a rationale for including alternative retail food outlets in future food environments research to more comprehensively evaluate food environment exposures.

within provinces, two national studies examined retail food environments around schools,[37,38] and one study examined food environments in only a few neighbourhoods in Toronto, ON.[39] Most studies described food environments at the scale of administratively bounded units (e.g., census tracts) rather than person-specific buffers. Studies were diverse in terms of study populations, sample size, design and area-level measures, including those related to socio-economic status and demographic characteristics (Supplementary Table 2).

In the current review, studies examining "food deserts" were defined as those examining differences in geographic access to retailers often operationalized as "healthy food sources", such as grocery stores and fruit and vegetable markets, by area-level deprivation. Studies examining "food swamps" were defined as those that examined differences in geographic access to retailers that commonly offer minimally nutritious foods such as fast-food outlets and convenience stores, by area-level deprivation.[8] Of the 28 papers examining the socio-economic patterning of food environments, 13 papers explored the existence of food deserts, 4 explored the existence of food swamps, and 9 papers explored both food deserts and food swamps. Of the two papers that explored neither food deserts nor food swamps, one examined retail food environments around schools by size of city,[38] and one examined a retail food environment on the Six Nations reserve in southern Ontario.[40]

Of the 22 papers that explored the existence of food deserts, 16 (73%) found that more deprived areas had equal or higher geographic access to stores selling healthy foods compared with less deprived areas. Four (18%) found small pockets or a few neighbourhoods that met the definition of food deserts, and two (9%) found evidence for the existence of food deserts in London, ON,[41] and in Saskatoon, SK.[42] Of note, both studies that found evidence of food deserts concluded that geographic access to healthy food in deprived neighbourhoods had worsened over time.

Of the 13 studies that explored the existence of food swamps, 11 (85%) found higher geographic access to sources of unhealthy foods in more deprived areas than less deprived areas, whereas two (15%) found mixed results. Two studies examined access to "unhealthy" or "healthy" retail food outlets relative to access to all food outlets. In Montreal, QC, the percentage of all restaurants that were fast-food outlets was negatively associated with area-level poverty, and the relative density of fruit and vegetable stores (as a proportion of all food stores) was positively associated with area-level poverty.[43] In Toronto, Brampton, Mississauga and Hamilton,

ON, there were no significant associations between relative access to unhealthy food sources and area-level material deprivation.[44]

Other topics

Other Canadian articles relevant to retail food environments research can be broadly grouped as methodological contributions ($n = 6$), qualitative research ($n = 7$), retail food environment intervention research ($n = 8$) and commentary or critical analyses ($n = 6$). Table 2 provides an overview and description of the 27 "other" articles that were assessed. Methodological articles dealt exclusively with refining measures of food environment exposure rather than refining outcome measures in food environments research. The qualitative research to date has focused on how immigrants,[45,46] adolescents[47,48] and Indigenous peoples[20,21,49] navigate and experience retail food environments. The intervention research was diverse and employed a range of study designs, methods and relevant outcomes (see Table 2). Finally, themes addressed by critical commentaries included discussion of the theoretical bases for empirical food environments research,[50] a commentary on a food desert in Kingston, ON, from a critical political economy perspective,[51] and potential municipal policy and planning responses to food environments research.[52]

DISCUSSION

This scoping review provided an overview of the published Canadian retail food environments literature. The majority of the 88 studies assessed here examined either socio-economic patterning of retail food environments ($n = 28$) or associations between some aspect of the retail food environment and behavioural, anthropometric or health outcomes ($n = 33$). The remaining 27 studies were fairly evenly split between qualitative research, methodological contributions, commentaries or critical analyses, and intervention research.

Key findings

Six key findings emerged through this review. First, urban Canadian food environments are different from those in the US, where the food desert metaphor is appropriate, given the bulk of evidence suggesting that food deserts are prominent in US cities.[18,53] In urban Canada, the majority of studies have found that access to grocery stores and supermarkets in the more deprived areas is as good as or better than that of less deprived areas. On the other hand, this review found consistent evidence of food swamps in urban Canada, where more deprived areas have high geographic access to sources of minimally nutritious foods. That food swamps seem to be a more appropriate metaphor for urban Canada than food deserts has important policy and program implications. For example, "fixing" food swamps by enacting zoning bylaws that prohibit the opening of fast-food restaurants or convenience stores in a given neighbourhood may be far less politically palatable than "fixing" food deserts by promoting grocery stores or fresh food markets in deprived areas.

Second, in terms of scale, more than 70% of studies have examined retail food environments within cities, as opposed to within or across provinces and territories. This is an important limitation of the current Canadian literature, in particular because of the first law of geography, which reflects the phenomenon of spatial autocorrelation in its assertion that "... near things are more related than distant things." Therefore, food environment features within a city would be expected to show less variation than food environment features between cities, or across provinces or countries. This is problematic because true relationships between exposures and outcomes may be weak or non-existent if there is a lack of variability in the exposure variable. Therefore, even if there were a true relationship between food environments and dietary or health outcomes, the use of city-specific food environment data in Canadian studies would diminish the magnitude of the relationship. Moreover, the lack of rural food environments research in Canada (with a few notable exceptions[54,55]) is a major limitation, given that one in five Canadians live in rural areas[55] and that rural Canadians are at a health disadvantage compared with their urban counterparts[56–58] and have poorer diets, which may be in part explained by poor access to resources.[57] Future research should therefore explicitly consider rural retail food environments and should be conducted at a functional region (city-region or multiple municipalities of different sizes within an economic corridor) or provincial level, in addition to examining their associations with diet and anthropometric or health-related outcomes.

Third, and related to rural retail food environments, no published studies have examined objective features of retail food environments in indigenous communities. The qualitative evidence reviewed here showed that remote First Nations communities may indeed be considered food deserts[20,21] and that residents of the Six Nations reserve in Ontario perceive poorer access to fruits and vegetables on-reserve than off-reserve.[40] Future research should objectively assess features of the retail food environments in indigenous communities to determine the prevalence of food deserts, especially in more remote Canadian communities, in order to develop appropriate and comprehensive program and policy responses.

Fourth, the vast majority (91%) of articles examining relationships between food environments and outcomes have defined food environment exposures within specific geographic areas using measures of density, rather than proximity or other measures (e.g., consumer nutrition environment measures or residents' perceptions). This finding suggests that Canadian food environments researchers tend to conceptualize geographic access as density, although at least one study found that weight-related outcomes were more strongly associated with proximity measures than with density measures.[31] Only one study to date has examined associations between consumer nutrition environment measures and dietary and anthropometric outcomes. This study was a population-based, cross-sectional study of residents in three southern Ontario cities. It found that the relative affordability of healthy to less healthy options was associated with self-reported BMI and waist circumference in both men and women, but that other measures of the consumer nutrition environment were inconsistently associated with dietary and weight-related outcomes.[31] The lack of consideration of exposures within consumer nutrition environments found in Canadian research is consistent with previous systematic reviews of food environments research.[12,17,32] A lack of assessment of the consumer nutrition environment is problematic, because assigning "healthy" or "unhealthy" attributes to different types of food premises or businesses, as happens in most studies of community food

environments, has been done to date somewhat arbitrarily, given variation in administrative or industry data sources for premise categorization, and assumes that consumer experiences are invariant within outlet types.[17] Future research should endeavour to simultaneously examine community and consumer nutrition environment measures to comprehensively describe food environment exposures. Additional research using activity spaces[60–62] to define exposures and research examining residents' perceptions of their food environments would also be beneficial in refining retail food environment exposure measures.

Fifth, the most common outcomes of interest were those related to obesity. More than half (56%) of studies examining relationships between food environments and dietary, anthropometric or health-related outcomes used weight-related measures such as BMI or waist circumference. Of these 19 studies, 16 (84%) used self-reported measures of weight and/or height. Although the health risks associated with variations in self-reported BMI are comparable with those associated with variations in measured BMI,[63] using self-reported BMI is a limitation because respondents generally overestimate height and underestimate weight.[64,65] In terms of dietary outcomes, five studies examined minimally nutritious dietary behaviours (e.g., soft-drink consumption, fast food consumption), and six examined healthy dietary behaviours (e.g., vegetable and fruit consumption) or overall diet quality. Although the study authors typically did not include logic models that would specify hypothesized conceptual pathways by which food environment exposures might be associated with dietary outcomes, in all cases the measured exposure conceptually lined up with measured outcomes (e.g., exposure to fast-food outlets was measured alongside dietary intake at fast food outlets; exposure to all food outlet types was measured alongside comprehensive measures of diet quality). Of note, despite current discussions among public health practitioners and food-related NGOs of improving geographic access to healthy food as potentially helping to ameliorate food insecurity, only one published study examined supermarket proximity as a predictor of food insecurity and found no significant association.[34] Future research should clarify hypothesized mechanisms through which these associations might be mediated[65] and should consider exploring more proximal outcomes of interest (e.g., food purchasing) in addition to more distal outcomes (e.g., obesity).

Sixth, retail food environment intervention research is relatively new in Canada. Such interventions aim to support healthy dietary behaviours by improving the availability of affordable, nutritious food options in the community and/or by decreasing access to less nutritious options.[27] Retail food environment interventions typically have a strong health equity dimension,[59] because they are often set in places where spatial disparities in food access are likely to amplify the effects of inadequate household income.[18,66] The earliest description of a food retail environment intervention was published in 2006.[67] It described the development of a multi-component diabetes prevention program in a First Nations community in Ontario that included a store component aimed at increasing the availability and promotion of nutritious foods. The findings of this intervention's impacts were mixed: frequency of healthy food acquisition improved among intervention residents compared with control residents, but no significant differences were found in BMI between groups.[68] Retail food environment interventions have been diverse and have included a randomized controlled trial to determine the effect of toy premiums on children's fast food meal selection,[69] a mixed-methods study to assess the feasibility of a municipal menu labeling policy[70] and the Nutrition North Canada program, a federal subsidy to retailers to make fresh, nutritious foods more widely available in remote and semi-remote communities.[71] The most recent intervention study used store sales data to examine healthy and less healthy food purchases over a one-year period in Saskatoon.[72]

Intervention studies are needed in retail food environments research to advance the understanding of mechanisms through which food environments affect dietary outcomes and to facilitate the development of evidence-based, feasible and sustainable policies and programs to support Canadians' access to healthy, affordable foods. Future research should use food retailer sales data and potentially loyalty card data to objectively measure food purchasing at the store and consumer level respectively.[73] Sales and loyalty card data represent objective, theoretically proximal outcomes that may serve to elucidate mechanisms by which retail food environments ultimately influence dietary behaviours.

Strengths and limitations

The breadth and overarching objectives of this review are its major strength. Our systematic approach for identifying potentially relevant literature, including a systematic search of five electronic databases and use of two reviewers to screen and extract data from each paper, is also an important strength. However, several limitations should be noted. First, because of the objectives (i.e., to broadly describe research topics and findings, identify knowledge gaps and suggest future directions for research and practice), we did not apply quality filters, which is consistent with other scoping reviews.[74,75] Despite this, searching only the peer-reviewed literature served as a de facto quality filter.

CONCLUSIONS

Retail food environments research in Canada is a rapidly expanding field. Findings from the literature indicate the need for context-specific research to evaluate the impact of food swamps in urban areas and potential food deserts in northern and remote contexts. Balancing valid and consistent methods with context-appropriate assessment methods is an ongoing challenge. Explicit justification for method selection is required in future research. Long-term collaboration among food environments researchers would likely contribute to a systematic approach to building the evidence base across urban, rural and remote contexts, which would be useful given the current disparate methods and measures employed in Canadian food environments research.

REFERENCES

1. Garriguet D. Canadians' eating habits. *Health Rep* 2007;18(2):17–32. PMID: 17578013. Available at: http://www.statcan.gc.ca/pub/82-003-x/2006004/article/9609-eng.htm (Accessed April 4, 2016).
2. Garriguet D. Diet quality in Canada. *Health Rep* 2009;20(3):41–52. PMID: 19813438. Available at: http://www.statcan.gc.ca/pub/82-003-x/2009003/article/10914-eng.pdf (Accessed October 22, 2015).
3. Vandevijvere S, Monteiro C, Krebs-Smith SM, Lee A, Swinburn B, Kelly B, et al. Monitoring and benchmarking population diet quality globally: A step-wise approach. *Obes Rev* 2013;14(Suppl 1):135–49. PMID: 24074217. doi: 10.1111/obr.12082.

4. World Health Organization. Diet, Nutrition, and the Prevention of Chronic Diseases, 2003. Available at: http://www.who.int/dietphysicalactivity/publications/trs916/en/ (Accessed October 22, 2015).
5. Raine KD. Determinants of healthy eating in Canada: An overview and synthesis. *Can J Public Health* 2005;96(Suppl 3):S8–14. PMID: 16042158. doi: 10.17269/cjph.96.1499.
6. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: Policy and environmental approaches. *Annu Rev Public Health* 2008;29:253–72. PMID: 18031223. doi: 10.1146/annurev.publhealth.29.020907.090926.
7. 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:e95–106. PMID: 20604870. doi: 10.1111/j.1467-789X.2010.00769.x.
8. Health Canada. Measuring the Food Environment in Canada, 2013. Available at: http://www.hc-sc.gc.ca/fn-an/nutrition/pol/som-ex-sum-environ-eng.php (Accessed October 22, 2015).
9. US Department of Health and Human Services. Healthy Food Financing Initiative, 2015. Available at: http://www.acf.hhs.gov/programs/ocs/programs/community-economic-development/healthy-food-financing (Accessed October 22, 2015).
10. Kleinert S, Horton R. Rethinking and reframing obesity. *Lancet* 2015;385(9985):2326–28. PMID: 25703115. doi: 10.1016/S0140-6736(15)60163-5.
11. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Public Health* 2014;14(1):522. PMID: 24884443. doi: 10.1186/1471-2458-14-522.
12. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18:1172–87. PMID: 22717379. doi: 10.1016/j.healthplace.2012.05.006.
13. van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, et al. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. *Health Educ Res* 2007;22(2):203–26. PMID: 16861362. doi: 10.1093/her/cyl069.
14. Kamphuis CBM, Giskes K, de Bruijn GJ, Wendel-Vos W, Brug J, van Lenthe FJ. Environmental determinants of fruit and vegetable consumption among adults: A systematic review. *Br J Nutr* 2006;96(4):620–35. PMID: 17010219. doi: 10.1079/BJN20061896.
15. Kirkpatrick SI, Reedy J, Butler EN, Dodd KW, Subar AF, Thompson FE, et al. Dietary assessment in food environment research: A systematic review. *Am J Prev Med* 2014;46(1):94–102. PMID: 24355678. doi: 10.1016/j.amepre.2013.08.015.
16. Black JL, Macinko J. Neighborhoods and obesity. *Nutr Rev* 2008;66(1):2–20. PMID: 18254880. doi: 10.1111/j.1753-4887.2007.00001.x.
17. Cobb LK, Appel LJ, Franco M, Jones-Smith JC, Nur A, Anderson CAM. The relationship of the local food environment with obesity: A systematic review of methods, study quality, and results. *Obesity* 2015;23(7):1331–44. PMID: 26096983. doi: 10.1002/oby.21118.
18. Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: A review of food deserts literature. *Health Place* 2010;16(5):876–84. PMID: 20462784. doi: 10.1016/j.healthplace.2010.04.013.
19. Black J. Local food environments outside of the United States – a look to the north: Examining food environments in Canada. In: Morland KB (Ed.), *Local Food Environments: Food Access in America*. Boca Raton, FL: CRC Press Taylor and Francis Group, 2014; 231–61.
20. Skinner K, Hanning RM, Desjardins E, Tsuji LJS. Giving voice to food insecurity in a remote Indigenous community in subarctic Ontario, Canada: Traditional ways, ways to cope, ways forward. *BMC Public Health* 2013;13(1):427. PMID: 23639143. doi: 10.1186/1471-2458-13-427.
21. DyckFehderau D, Holt NL, Ball GD, Willows ND. Feasibility study of asset mapping with children: Identifying how the community environment shapes activity and food choices in Alexander First Nation. *Rural Remote Health* 2013;13(2):2289. PMID: 23534835.
22. Public Health Agency of Canada. *Curbing Childhood Obesity: A Federal, Provincial and Territorial Framework for Action to Promote Healthy Weights*. Ottawa, ON: Public Health Agency of Canada, 2010. Available at: http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/framework-cadre/index-eng.php (Accessed June 18, 2015).
23. Mah C, Minaker L, Cook B. *Policy Options for Healthier Food Environments in City-Regions: A Discussion Paper*. Vancouver, BC: National Collaborating Centre for Environmental Health (NCCEH), 2015.
24. Health Canada. Working with Grocers to Support Healthy Eating, 2013. Available at: http://www.hc-sc.gc.ca/fn-an/nutrition/pol/som-ex-sumgrocers-epiciers-eng.php (Accessed October 23, 2015).
25. Public Health Nutritionists of Saskatchewan. The Role of the Dietitian in the Built Environment, 2015. Available at: http://www.fhhr.ca/Documents/TheRoleoftheDietitianintheBuiltEnvironmentPHNSWG2015FINAL.pdf (Accessed October 2, 2015).
26. Food Matters Manitoba. Let's Grow our Local Food Economy, 2015. Available at: http://www.foodmattersmanitoba.ca/2014/09/lets-grow-localfood-economy/ (Accessed October 10, 2015).
27. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *Am J Health Promot* 2005;19(5):330–33. PMID: 15895534. doi: 10.4278/0890-1171-19.5.330.
28. Olstad DL, Raine KD, McCargar LJ. Adopting and implementing nutrition guidelines in recreational facilities: Public and private sector roles. A multiple case study. *BMC Public Health* 2012;12(1):376. PMID: 22632384. doi: 10.1186/1471-2458-12-376.
29. Olstad DL, Raine KD. Profit versus public health: The need to improve the food environment in recreational facilities. *Can J Public Health* 2013;104(2):e167–69. PMID: 23618211. doi: 10.17269/cjph.104.3647.
30. Pabayo R, Spence JC, Cutumisu N, Casey L, Storey K. Sociodemographic, behavioural and environmental correlates of sweetened beverage consumption among pre-school children. *Public Health Nutr* 2012;15(8):1338–46. PMID: 22269184. doi: 10.1017/S1368980011003557.
31. Minaker LM, Raine KD, Wild TC, Nykiforuk CIJ, Thompson ME, Frank LD. Objective food environments and health outcomes. *Am J Prev Med* 2013;45(3):289–96. PMID: 23953355. doi: 10.1016/j.amepre.2013.05.008.
32. Kestens Y, Lebel A, Chaix B, Clary C, Daniel M, Pampalon R, et al. Association between activity space exposure to food establishments and individual risk of overweight. *PLoS One* 2012;7(8):e41418. PMID: 22936974. doi: 10.1371/journal.pone.0041418.
33. Lebel L, Krittasudthacheewa C, Salamanca A, Sriyasak P. Lifestyles and consumption in cities and the links with health and well-being: The case of obesity. *Curr Opin Environ Sustain* 2012;4(4):405–13. doi: 10.1016/j.cosust.2012.09.005.
34. Kirkpatrick SI, Tarasuk V. Assessing the relevance of neighbourhood characteristics to the household food security of low-income Toronto families. *Public Health Nutr* 2010;13(7):1139–48. PMID: 20196916. doi: 10.1017/S1368980010000339.
35. He M, Tucker P, Gilliland J, Irwin JD, Larsen K, Hess P. The influence of local food environments on adolescents' food purchasing behaviors. *Int J Environ Res Public Health* 2012;9(4):1458–71. PMID: 22690205. doi: 10.3390/ijerph9041458.
36. Chum A, O'Campo P. Cross-sectional associations between residential environmental exposures and cardiovascular diseases. *BMC Public Health* 2015;15(1):438. PMID: 25924669. doi: 10.1186/s12889-015-1788-0.
37. Seliske LM, Pickett W, Boyce WF, Janssen I. Association between the food retail environment surrounding schools and overweight in Canadian youth. *Public Health Nutr* 2009;12(9):1384–91. PMID: 19087383. doi: 10.1017/S1368980008004084.
38. Browning HF, Laxer RE, Janssen I. Food and eating environments: In Canadian schools. *Can J Diet Pract Res* 2013;74(4):160–66. PMID: 24472163. doi: 10.3148/74.4.2013.160.
39. Behjat A, Koc M, Ostry A. The importance of food retail stores in identifying food deserts in urban settings. *WIT Trans Ecol Environ* 2013;170:89–98. doi: 10.2495/FENV130091.
40. Joseph P, Davis AD, Miller R, Hill K, McCarthy H, Banerjee A, et al. Contextual determinants of health behaviours in an aboriginal community in Canada: Pilot project. *BMC Public Health* 2012;12(1):952. PMID: 23134669. doi: 10.1186/1471-2458-12-952.
41. Larsen K, Gilliland J. Mapping the evolution of 'food deserts' in a Canadian city: Supermarket accessibility in London, Ontario, 1961–2005. *Int J Health Geogr* 2008;7:16. PMID: 18423005. doi: 10.1186/1476-072X-7-16.
42. Peters EJ, McCreary TA. Poor neighbourhoods and the changing geography of food retailing in Saskatoon, Saskatchewan, 1984–2004. *Can J Urban Res* 2008;17(1):78–106. doi: 10.1016/j.apgeog.2011.01.010.
43. Mercille G, Richard L, Gauvin L, Kestens Y, Payette H, Daniel M. Comparison of two indices of availability of fruits/vegetable and fast food outlets. *J Urban Health* 2013;90(2):240–45. PMID: 22736278. doi: 10.1007/s11524-012-9722-6.
44. Polsky JY, Moineddin R, Glazier RH, Dunn JR, Booth GL. Foodscapes of southern Ontario: Neighbourhood deprivation and access to healthy and unhealthy food retail. *Can J Public Health* 2014;105(5):e369–75. PMID: 25365272. doi: 10.17269/cjph.105.4541.
45. Mannion CA, Raffin-Bouchal S, Henshaw CJ. Navigating a strange and complex environment: Experiences of Sudanese refugee women using a new nutrition resource. *Int J Women's Health* 2014;6(1):411–22. PMID: 24790470. doi: 10.2147/IJWH.S56256.
46. Vahabi M, Damba C. Perceived barriers in accessing food among recent Latin American immigrants in Toronto. *Int J Equity Health* 2013;12(1):1. PMID: 23286318. doi: 10.1186/1475-9276-12-1.
47. McPhail D, Chapman GE, Beagan BL. "Too much of that stuff can't be good": Canadian teens, morality, and fast food consumption. *Soc Sci Med* 2011;73(2):301–7. PMID: 21689876. doi: 10.1016/j.socscimed.2011.05.022.
48. McPhail D, Chapman GE, Beagan BL. The rural and the rotund? A critical interpretation of food deserts and rural adolescent obesity in the Canadian context. *Health Place* 2013;22:132–39. PMID: 23694820. doi: 10.1016/j.healthplace.2013.03.009.
49. Pal S, Haman F, Robidoux MA. The costs of local food procurement in two northern Indigenous communities in Canada. *Food Foodways* 2013;21(2):132–52. doi: 10.1080/07409710.2013.792193.

50. Sadler RC, Gilliland JA, Arku G. Theoretical issues in the 'food desert' debate and ways forward. *GeoJournal* 2015:1–13. doi: 10.1007/s10708-015-9634-6.
51. Bedore M. Food desertification: Situating choice and class relations within an urban political economy of declining food access. *Stud Soc Just* 2014; 8(2):207–28.
52. Minaker L, Fisher P, Raine KD, Frank LD. Measuring the food environment: From theory to planning practice. *J Agric Food Syst Community Dev* 2011; 2(1):65–82. doi: 10.5304/jafscd.2011.021.021.
53. Sadler RC, Gilliland JA, Arku G. An application of the edge effect in measuring accessibility to multiple food retailer types in southwestern Ontario, Canada. *Int J Health Geogr* 2011;10:34. PMID: 21575162. doi: 10.1186/1476-072X-10-34.
54. Hollands S, Campbell MK, Gilliland J, Sarma S. Association between neighbourhood fast-food and full-service restaurant density and body mass index: A cross-sectional study of Canadian adults. *Can J Public Health* 2014; 105(3):e172–78. PMID: 25165835. doi: 10.17269/cjph.105.4287.
55. Statistics Canada. Population, Urban and Rural, by Province and Territory (Canada), 2011. Available at: http://www.statcan.gc.ca/tables-tableaux/sumsom/l01/cst01/demo62a-eng.htm (Accessed July 28, 2015).
56. DesMeules M, Pong R, Lagace C, Heng D, Manuel D, Pitblado R, et al. *How Healthy are Rural Canadians? An Assessment of Their Health Status and Health Determinants*. Ottawa, ON: Canadian Institute for Health Information, 2006; ISBN 13: 978-1-55392-881-2 (PDF).
57. Lavergne MR, Kephart G. Examining variations in health within rural Canada. *Rural Remote Health* 2012;12(1):1848. PMID: 22384808.
58. Pampalon R, Hamel D, Gamache P. Health inequalities in urban and rural Canada: Comparing inequalities in survival according to an individual and area-based deprivation index. *Health Place* 2010;16(2):416–20. PMID: 20022551. doi: 10.1016/j.healthplace.2009.11.012.
59. Gustafson A, Hankins S, Jilcott S. Measures of the consumer food store environment: A systematic review of the evidence 2000–2011. *J Community Health* 2012;37(4):897–911. PMID: 22160660. doi: 10.1007/s10900-011-9524-x.
60. Kestens Y, Lebel A, Daniel M, Theriault M, Pampalon R. Using experienced activity spaces to measure foodscape exposure. *Health Place* 2010;16:1094–103. PMID: 20667762. doi: 10.1016/j.healthplace.2010.06.016.
61. Lebel A, Kestens Y, Pampalon R, Theriault M, Daniel M, Subramanian SV. Local context influence, activity space, and foodscape exposure in two Canadian metropolitan settings: Is daily mobility exposure associated with overweight? *J Obes* 2012;2012:912645;1–9. PMID: 22254135. doi: 10.1155/2012/912645.
62. Stommel M, Schoenborn CA. Accuracy and usefulness of BMI measures based on self-reported weight and height: Findings from the NHANES & NHIS 2001–2006. *BMC Public Health* 2009;9:421. PMID: 19922675. doi: 10.1186/1471-2458-9-421.
63. Shields M, Gorber B, Tremblay MS. Estimates of obesity based on self-report versus direct measures. *Health Rep* 2008;19:61–76. PMID: 18642520.
64. Gorber SC, Tremblay M, Moher D, Gorber B. A comparison of direct vs. self-report measures for assessing height, weight and body mass index: A systematic review. *Obes Rev* 2007;8(4):307–26. PMID: 17578381. doi: 10.1111/j.1467-789X.2007.00347.x.
65. Cummins S. Neighbourhood food environment and diet: Time for improved conceptual models? *Prev Med* 2007;44(3):196–97. PMID: 17222896. doi: 10.1016/j.ypmed.2006.11.018.
66. Mah CL, Timmings C. Equity in public health ethics: The case of menu labelling policy at the local level. *Public Health Ethics* 2015;8(1):85–89. doi: 10.1093/phe/phu011.
67. Ho LS, Gittelsohn J, Harris SB, Ford E. Development of an integrated diabetes prevention program with First Nations in Canada. *Health Promot Int* 2006; 21(2):88–97. PMID: 16407394. doi: 10.1093/heapro/dak003.
68. Ho LS, Gittelsohn J, Rimal R, Treuth MS, Sharma S, Rosecrans A, Harris SB. An integrated multi-institutional diabetes prevention program improves knowledge and healthy food acquisition in northwestern Ontario First Nations. *Health Educ Behav* 2008;35(4):561–73. PMID: 18456866. doi: 10.1177/1090198108315367.
69. Hobin EP, Hammond DG, Daniel S, Hanning RM, Manske SR. The Happy Meal® Effect: The impact of toy premiums on healthy eating among children in Ontario, Canada. *Can J Public Health* 2012;103(4):244–48. PMID: 23618634.
70. Mah CL, Vanderlinden L, Mamatis D, Ansara DL, Levy J, Swimmer L. Ready for policy? Stakeholder attitudes toward menu labelling in Toronto, Canada. *Can J Public Health* 2013;104(3):e229–34. PMID: 23823887. doi: 10.17269/cjph.104.3708.
71. Galloway T. Is the Nutrition North Canada retail subsidy program meeting the goal of making nutritious and perishable food more accessible and affordable in the north? *Can J Public Health* 2014;105(5):e395–97. PMID: 25365276. doi: 10.17269/cjph.105.4624.
72. Fuller D, Engler-Stringer R, Muhajarine N. Examining food purchasing patterns from sales data at a full-service grocery store intervention in a former food desert. *Prev Med Rep* 2015;2:164–69. PMID: 26844066. doi: 10.1016/j.pmedr.2015.02.012.
73. Glanz K, Bader MDM, Iyer S. Retail grocery store marketing strategies and obesity: An integrative review. *Am J Prev Med* 2012;42(5):503–12. PMID: 22516491. doi: 10.1016/j.amepre.2012.01.013.
74. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. *Int J Soc Res Methodol: Theory Pract* 2005;8(1):19–32. doi: 10.1080/1364557032000119616.
75. Levac D, Colquhoun H, O'Brien KK. Scoping studies: Advancing the methodology. *Implement Sci* 2010;5(1):69. PMID: 20854677. doi: 10.1186/1748-5908-5-69.

RÉSUMÉ

OBJECTIFS : Le domaine de la recherche sur les environnements alimentaires au détail est relativement nouveau au Canada. Dans notre étude de champ, nous donnons un aperçu de la recherche sur les environnements alimentaires au détail menée avant juillet 2015 au Canada. En particulier, nous décrivons les objectifs et les principales constatations de la recherche, nous en cernons les lacunes et nous suggérons des pistes de recherche futures.

MÉTHODE : Nous avons interrogé les bases de données PubMed, Web of Science, Scopus, PsychInfo et ERIC en juillet 2015 pour recenser les enquêtes canadiennes publiées qui traitent des points de vente d'aliments au détail (magasins d'alimentation, restaurants). Nous avons inclus les études parues en anglais qui présentaient des données qualitatives ou quantitatives sur tout aspect de l'environnement alimentaire au détail, ainsi que les documents conceptuels et les commentaires.

SYNTHÈSE : Quatre-vingt-huit études ont été incluses dans notre revue, ce qui indique que le domaine de la recherche sur les environnements alimentaires au détail se développe rapidement au Canada. Un seul article avait été publié avant 2005, mais 66 l'ont été entre 2010 et 2015. La recherche canadienne sur les environnements alimentaires évalue généralement soit la structuration socioéconomique des environnements alimentaires ($n = 28$), soit les associations entre les environnements alimentaires au détail et le régime alimentaire, les données anthropométriques ou les résultats sanitaires ($n = 33$). Les autres articles présentent de la recherche méthodologique, des études qualitatives, de la recherche d'intervention et des commentaires critiques ($n = 27$). Les principales lacunes dans la littérature actuelle sont le manque d'uniformité des indicateurs choisis dans les études et le manque d'études longitudinales et d'études d'intervention.

CONCLUSION : Les environnements alimentaires au détail sont un sujet qui intéresse de plus en plus la recherche et l'élaboration des politiques et des programmes au Canada. Des méthodes uniformes (le cas échéant), des études longitudinales, de la recherche d'intervention et des partenariats étroits entre les chercheurs et les acteurs privilégiés feraient grandement progresser le domaine de la recherche sur les environnements alimentaires au détail au Canada.

MOTS CLÉS : nourriture; environnement; inégalités; Canada; revue de la littérature

Using GPS and activity tracking to reveal the influence of adolescents' food environment exposure on junk food purchasing

Richard C. Sadler, PhD,[1] Andrew F. Clark, PhD,[2] Piotr Wilk, PhD,[3] Colleen O'Connor, PhD,[4] Jason A. Gilliland, PhD[5]

ABSTRACT

OBJECTIVES: This study examines the influence of adolescents' exposure to unhealthy food outlets on junk food purchasing during trips between home and school, with particular attention to how exposure and purchasing differ according to child's biological sex, mode of transportation, and direction to or from school.

METHODS: Between 2010 and 2013, students ($n = 654$) aged 9–13 years from 25 schools in London and Middlesex County, ON, completed a socio-demographic survey and an activity diary (to identify food purchases), and were observed via a global positioning system for 2 weeks (to track routes for trips to/from school). Spatial data on routes and purchase data were integrated with a validated food outlet database in a geographic information system, and exposure was measured as the minutes a child spent within 50 m of an unhealthy food outlet (i.e., fast food restaurants, variety stores). For trips involving junk food exposure ($n = 4588$), multilevel logistic regression was used to assess the relationship between exposure and purchasing.

RESULTS: Multilevel analyses indicated that adolescents' duration of exposure to unhealthy food outlets between home and school had a significant effect on the likelihood of junk food purchasing. This relationship remained significant when the data were stratified by sex (female/male), trip direction (to/from school) and travel mode (active/car), with the exception of adolescents who travelled by bus.

CONCLUSION: Policies and programs that mitigate the concentration of unhealthy food outlets close to schools are critical for encouraging healthy eating behaviours among children and reducing diet-related health issues such as obesity.

KEY WORDS: Built environment; food environment; GPS; food purchase; diet; child; adolescent

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS14–eS20
doi: 10.17269/CJPH.107.5346

Some of the most critical public health issues facing Canadians (e.g., obesity, heart disease, stroke, hypertension and type 2 diabetes) are linked to poor nutrition.[1] Among other variables, poor dietary habits have contributed to adverse health outcomes among Canadian adolescents: nearly one third are overweight or obese.[2] Obesity and other diet-related health issues arise not only from individual-level factors (e.g., genetics, lifestyle) but also from the characteristics of our local environments that discourage healthy diets, such as the presence of unhealthy food outlets.[3–6] Neighbourhood food environments can have a particularly strong influence on children, including adolescents, who tend to be more restricted geographically than adults and who are therefore more captive to their local built environments, including food outlets, recreational spaces and transportation infrastructure.[7,8] Understanding the local food environment is therefore important to encouraging healthy lifestyles among adolescents.[9]

Despite increasing acknowledgements of the importance of the built environment for health, it remains poorly conceptualized in much public health work. Researchers at the forefront of the field have advocated the combination of GPS(global positioning system)-derived activity spaces with activity/food diaries to better link junk food exposure and purchasing behaviours.[10–12] In this paper, we evaluate the relationship between junk food exposure and purchasing behaviour among adolescents during the school day, while controlling for sex, mode of transportation, and direction of the trip between home and school.

Addressing bias in geospatial proxies

Sadler and Gilliland[10] showed how geospatial proxies rather than direct measurements continue to be used to evaluate exposure to junk food. Most proxies have included calculating the density of junk food outlets in a child's home or school neighbourhood, or

Author Affiliations

1. Department of Family Medicine, Division of Public Health, Michigan State University, East Lansing, MI
2. Department of Geography, University of Western Ontario, London, ON
3. Department of Epidemiology & Biostatistics, Department of Paediatrics, University of Western Ontario, London, ON
4. Division of Food & Nutrition Sciences, Brescia University College, London, ON
5. Department of Geography, Department of Paediatrics, School of Health Studies, University of Western Ontario, London, ON

Correspondence: Jason A. Gilliland, PhD, Department of Geography, Department of Paediatrics, School of Health Studies, University of Western Ontario, 1151 Richmond St., London, ON N6A 5C2, Tel: 519-661-2111, ext. 81239, E-mail: jgillila@uwo.ca

Acknowledgements: The STEAM (Spatial Temporal Environment and Activity Monitoring) study was jointly funded by the Canadian Institutes of Health Research and the Heart and Stroke Foundation of Canada, with seed funding from the Social Sciences and Humanities Research Council of Canada. Additional support was provided by the Children's Health Research Institute and the Children's Health Foundation. We thank the students, parents, teachers, principals and research boards from the Thames Valley District School Board, the London District Catholic School Board, Conseil scolaire catholique Providence and the Conseil scolaire Viamonde. We would also like to acknowledge the dozens of research assistants from the Human Environments Analysis Laboratory who helped with the STEAM project.

Conflict of Interest: None to declare.

both.[3–5,13,14] Such density estimates are typically calculated within a buffered walkable zone (typically between 400 and 1600 m and measured along the street network or "as the crow flies") around home and/or school, or within the boundaries of a more arbitrary administrative unit, such as the census tract or census dissemination area where the home or school is located. Each method is susceptible to the modifiable areal unit problem, because any observed association may change depending on which scale of areal unit is employed.[15] Williams et al.[16] have cautioned against the use of such metrics because "predominant exposure measures may not account for what individual children actually experience" (p. 359).

Because of the lack of certainty in measurement, the population-level modelling approach common to most studies has been critiqued for creating biases in classification. For instance, user-defined activity spaces have been characterized as subjective constructions of travel surveys and food store listings.[17] While the use of activity spaces overcomes the limitations of grounding exposure to one location, researchers have advocated for more detailed individual-level neighbourhood assessments.[10,14–16]

Objectively measured aspects of the built environment, such as GPS tracking of activity spaces, offers an advance in the level of certainty in approximating a child's food environment. GPS tracking is more accurate for quantifying activity spaces than estimations by parents or participant self-report.[18] In one case, Harrison et al.[19] showed that GPS trips accounted for 50% more food outlets on children's trips home from school when compared with assumed trips.

New work emphasizes the need to focus "on combining GIS [geographic information systems]-based objective measurement of the community food environment with self-report measures" (p. 13).[20] Others refer to this as a need for "ego-centred definitions of areas that approximate individuals' local activity spaces" (p. 227).[21] A recent observational study using self-report measures found that children who ride home from school in private automobiles eat more snacks and candy than those who walk.[22] As that study did not use GPS tracking to delineate and characterize the food environment through which children travelled, important questions remain about the role of exposure.

The objective of this study is to explore the nature of the relationship between junk food purchasing (JFP) and the level of exposure to junk food outlets (JFOs). We achieved this objective by assessing the magnitude of this relationship and considered three trip-level control variables: 1) mode of transportation (active, bus and car); 2) trip direction (to school and from school); and 3) child's biological sex (females and males).

METHODS

Data collection

Data were collected as part of the Spatial Temporal Environment and Activity Monitoring (STEAM) Project (steamproject.ca). The STEAM Project compiled demographic, behavioural and GPS tracking data on 932 adolescents aged 9–13 years from communities in southwestern Ontario. The central aim of STEAM is to explore and assess how the physical (built and natural) environment influences adolescents' activity patterns and food consumption habits. This study was conducted with approval from the University of Western Ontario's Non-Medical Research Ethics Board (REB#: 17918S).

Data were collected over four years (2010–2013), each child being observed for one week in the spring and one week in the fall. The current study uses data from 511 adolescents from 25 elementary schools in Middlesex County and the City of London (Middlesex-London), which are characterized by a broad range of built forms and social environments. Adolescents completed socio-demographic questionnaires and daily activity diaries each week, answering questions about physical activity, eating habits and social/familial engagements. Adolescents indicated for each day whether they had purchased something on their way to or from school and the location of that purchase.

GPS tracks for every child were collected every second between the child leaving for school and the child returning home. Data derived from these GPS tracks included the mode of transportation (e.g., walk, bike, bus, car), time of day, and a key field to link with child-specific individual-level characteristics.

Every JFO in the region was extracted from the Middlesex-London public health inspector's food outlet database and geocoded (using principles of accuracy as discussed in Healy and Gilliland[23]) in a GIS (ArcGIS 10.1, Environmental Systems Research Institute, Redlands, CA). Given average road widths and typical viewsheds within our community, 50 m buffers were calculated around every unhealthy food source to help measure exposure.[10,19] These buffers were combined in GIS with GPS data on trips to give a measure of the number of minutes each adolescent was exposed to junk food sites on each trip to and from school.

The final data used in this study combined the individual GPS trips and modelled exposure values for each trip with data from the activity diaries, which indicated any JFP along the trip to and/or from school. These combined data provide the ability to analyze the relationship between exposure and JFP on a trip-by-trip basis. The study uses the trips to and from school because adolescents indicate that they have the most autonomy during these times.[24] This final set of trips for adolescents exposed to junk food were used for the final analysis, as a trip without exposure provided no opportunity to purchase junk food.

Analysis methods

The dependent variable, JFP, is a binary variable indicating whether junk food was purchased or not on the trip. It is calculated for each trip to and from school for each adolescent on the basis of the activity diary entries. Junk food was considered unhealthy food items purchased from fast food or variety stores, pizza places and ice cream shops.

The key independent variable, exposure to JFOs, was defined as the number of minutes during which a child was exposed (i.e., within 50 m) to fast food, variety stores, pizza places or ice cream shops (ranges from 0 sec to 350 min). This variable was truncated at 17 min (1020 sec) to account for significant outliers of exposure.

Three control variables were hypothesized to influence the relationship between exposure and food purchasing: biological sex, mode of transportation, and direction of the trip. Sex was defined as male and female. Mode of transportation was defined for each trip, including active modes (bike, walk, scooter or skateboard), car, and bus (school bus or city transit). The direction of the trip was either to or from school.

This study uses multilevel logistic regression, a commonly used technique with a binary outcome variable that takes into account clustering within the data. Individual trips are not independent but nested within adolescents; data on individual trips from a given adolescent are expected to be more alike than data collected from another adolescent. The study first assessed the overall effect of JFO exposure on JFP. The strength of this relationship was then examined separately for each category of one of the three control variables. Since this was an exploratory analysis, no multivariate models or models with interaction effects were tested. Both the linear and the quadratic effects were evaluated; none of the quadratic terms, however, were significant at the $p = 0.05$ level. To ease interpretability of the effects, the predicted probabilities of JFP were computed from across a range of exposure values (from "up to 1 min" to "up to 17 min") and plotted separately for each category of the three control variables. Predicted probabilities were computed from multilevel logistic regression models using both the intercepts and corresponding regression coefficients.

Child-level variances in JFP were also estimated by specifying the intercepts in all multilevel regression models as random. The amount of variation in JFP across adolescents was assessed by the intra-class correlation coefficient (ICC) and median odds ratio (MOR). The ICC was calculated by dividing the cluster-level variance by the total variance, representing the proportion of variance attributed to differences among adolescents. To calculate the ICC for the binary variable, the trip-level (level one) variance was fixed to the variance of the standard logistic distribution.[25] The MOR converts the cluster-level variance to an odds ratio scale and, as a consequence, it can be compared directly with odds ratios for fixed effects.[25] A large MOR implies large variation across adolescents, whereas a value of 1 suggests no such variation. The multilevel models are computed using Mplus.[26]

RESULTS

Descriptive statistics

In total, we observed 7,499 individual trips from 654 adolescents in Middlesex-London with both GPS and food purchasing data from recall diaries; 4,588 of these trips, from 511 children, involved exposure to junk food and were therefore retained for analysis. Of these 4,588 trips, 224 (4.9%) involved JFP. The average number of observed trips per child was 9, ranging from 1 to 20, and the prevalence of JFP among adolescents ranged from 0.0% to 100.0%. Additional characteristics included: more females (58.7%) than males (41.3%); more valid trips from (51.6%) than to (48.4%) school; and a modal split of 39.0% by bus, 30.8% by active modes and 30.2% by car.

Factors associated with junk food purchasing

Overall Effect

The results from the multilevel logistic regression analysis reported in Table 1 indicate that as exposure (measured in minutes) increased, the odds that junk food was purchased on that trip increased significantly. The OR for JFP associated with a 1-min increase in exposure to JFOs was 1.174 (95% CI [confidence interval] 1.14–1.21). The trip-level results from a multilevel model should be interpreted as ORs for within-cluster comparisons; they compare two trips observed in the same child. Figure 1a indicates that the probability of JFP increased from approximately 1.7% for trips with exposure of less than 1 min to 15.8% for trips with exposure of between 16 and 17 min. Finally, JFP across adolescents varied significantly, corresponding to an ICC of 0.499 and an MOR of 5.613. Thus, about 50% of the variance in the likelihood of JFP was due to differences between adolescents, and the MOR of 5.613 suggests a substantial difference between two trips with the same level of exposure but made by different, randomly chosen adolescents.

Mode of Transportation

Stratification of the focal relationship by the mode of transportation indicated that the relationship between exposure to JFOs and JFP was statistically significant and positive for data involving trips made by active modes of transportation and for trips made by car, but not significant for trips made by bus. The ORs for JFP associated with a 1-min increase in exposure for active and car travel were 1.13 (95% CI 1.06–1.20) and 1.22 (95% CI 1.16–1.28) respectively. Figure 1b indicates that the rate of increase in the predicted probabilities of JFP was much steeper for trips made by car than for trips made by active modes of transportation, increasing from 2.7 times more likely at 5 min to 4.4 times more likely at 15 min. Finally, the variation in JFP across adolescents was lowest for trips made by car (ICC = 0.459; MOR = 4.914) and the highest for active trips (ICC = 0.610; MOR = 8.705), the trips made by bus falling in the middle (ICC = 0.541; MOR = 6.546).

Trip Type

Stratification by route to or from school indicated that the relationship between JFO exposure and JFP was statistically significant and positive for data involving trips made to and from school. These effects translate into ORs of 1.22 (95% CI 1.12–1.33) and 1.12 (95% CI 1.08–1.16) respectively. Figure 1c shows that, although the effect of exposure was slightly more pronounced for trips to school, trips from school were much more likely to be associated with JFP than trips to school at all levels of exposure. Because the odds of JFP varied by the amount of time spent exposed on a trip to or from school, we cannot give one value for the magnitude of this difference. We can, however, estimate that the average ratio between the two was 4.19, ranging from 6.56 at 1 min to 1.81 at 16 min. In terms of the cross-cluster variance, the variation in JFP was more pronounced in trips to school (ICC = 0.513; MOR = 5.907) than trips from school (ICC = 0.445; MOR = 4.707).

Biological Sex

The results from the multilevel logistic regression models exploring the role of biological sex indicate that, for females, the OR for JFP associated with a 1-min increase in exposure was 1.19 (95% CI 1.15–1.24). For males, the corresponding OR was 1.12 (95% CI 1.06–1.19). Figure 1d shows that trips made by females had a higher likelihood of being linked to JFP at all levels of exposure than trips made by males, but the gap between the two widened with the increased level of exposure, from 2.5 times more likely at 5 min to 3.0 times more likely at 15 min. Finally, the variation in JFP was higher for trips made by males (ICC = 0.583; MOR = 7.734) than for trips made by females (ICC = 0.439; MOR = 4.617).

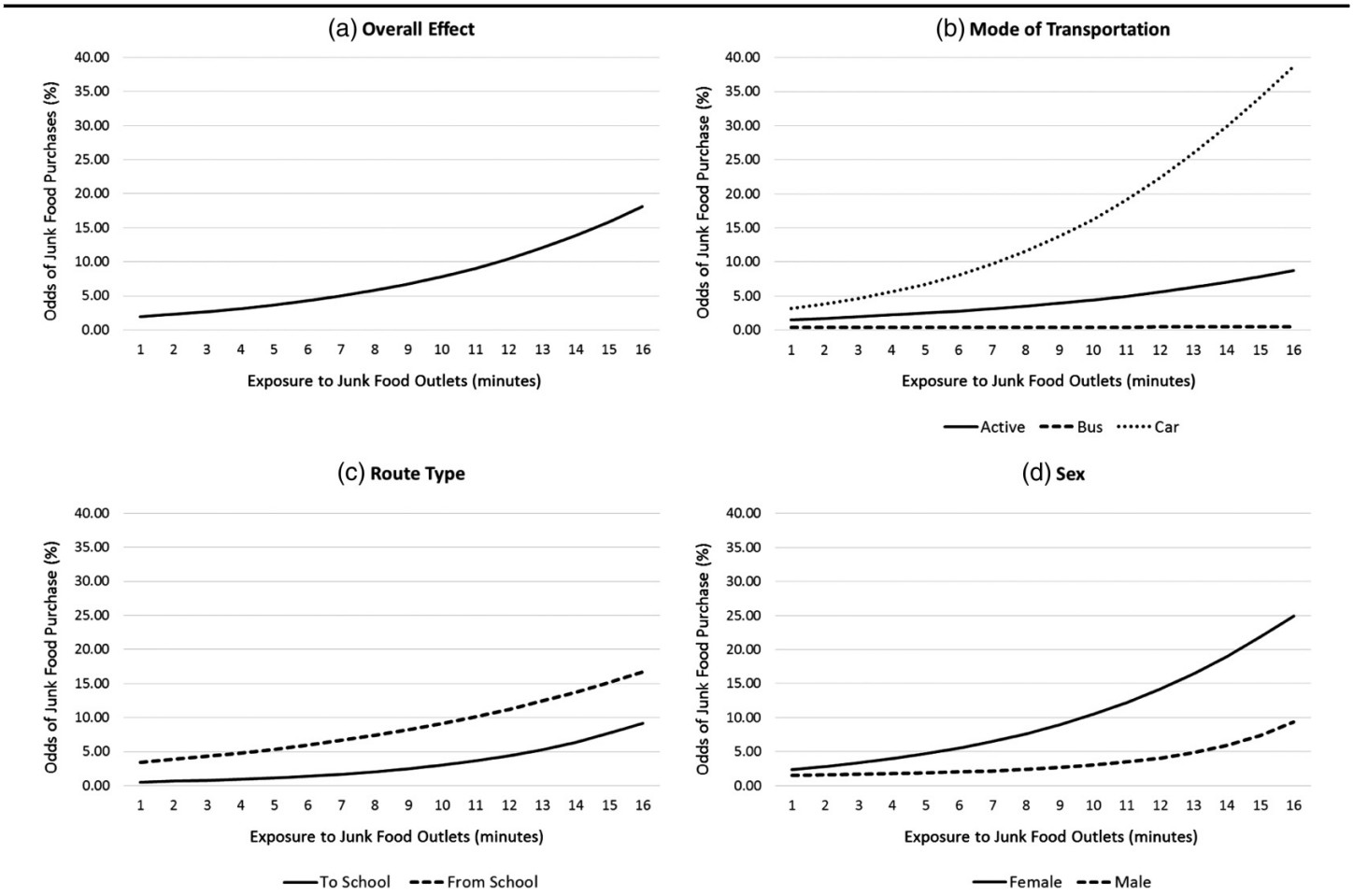

Figure 1. Effects of exposure to junk food outlets on junk food purchasing by a) overall effect; b) mode of transportation; c) trip type; and d) sex

DISCUSSION

In this study of adolescents aged 9–13 years in Middlesex-London, ON, nearly 1 in 20 trips (4.9%) made to and from school involved the purchase of unhealthy junk food. Furthermore, a significant positive relationship existed between adolescents' duration of exposure to unhealthy food outlets (i.e., fast food restaurants and variety stores) between home and school and the likelihood of JFP. This finding corroborates a previous study of adolescents in the same geographic area, which suggested that the availability or density of JFOs in a child's home or school neighbourhood increases the likelihood of junk food purchasing.[3]

While previous research has established a relationship between the presence of JFOs and purchasing/consumption,[3,5,7] such findings are inconsistent.[27] This inconsistency may be a result of using areal unit measures as proxies for exposure, which are unable to directly connect the presence of JFOs to the actual routes that adolescents take to and from school. This study has advanced a novel method to connect the GPS-derived routes of adolescents' individual trips between home and school to their junk food exposure. This is particularly important because an individual's trips and activities rarely coincide with the arbitrary spatial boundaries used in previous research (e.g., buffers, census tracts or postal codes).[3–5,13,14] Our research, therefore significantly improves upon the accuracy of daily JFO exposure among children/adolescents en route to/from school. By accurately measuring exposure to JFOs, we are able to fully understand how a child's individual and trip characteristics may alter the relationship between exposure and purchases.

Although this study found a significant relationship between exposure and purchasing, the results show considerable unexplained variance due to differences among adolescents. Exploring these differences by stratifying the data by sex, direction of trip (to or from school), and mode of travel revealed that the relationship remained significant for all categories of stratification, with the exception of adolescents who travel by bus. This lack of a relationship is due to school district policy, which prohibits children from exiting a school bus along the route to/from school before their designated stop. Any purchases would therefore be conducted only while traveling between a bus stop and home.

Conversely, not only was the relationship between exposure to JFOs and JFP positive and statistically significant for trips made by automobile, but the rate of increase in the predicted probabilities of JFP was also much steeper for trips made by automobile than for trips made by active modes (i.e., walking or biking). This finding is an important contribution to the academic literature and useful for

Table 1. Results from multilevel logistic regression models for the effects of exposure to junk food on junk food purchasing

Model		Log-odds	SE	Wald	*p*	Odds	Confidence interval	ICC	MOR
Overall effect	Intercept	−4.071	0.200	20.323	0.000	0.017			
(*n* = 4588)	Exposure (β)	0.160	0.016	9.822	0.000	1.174	1.14–1.21		
	Variance (τ)	3.271	0.710	4.610	0.000			0.499	5.613
By mode of transportation									
Active	Intercept	−4.280	0.441	9.708	0.000	0.014			
(*n* = 1414)	Exposure (β)	0.121	0.031	3.912	0.000	1.129	1.06–1.20		
	Variance (τ)	5.146	1.787	2.880	0.004			0.610	8.705
Bus	Intercept	−5.660	0.683	8.284	0.000	0.003			
(*n* = 1790)	Exposure (β)	0.019	0.051	0.370	0.711	1.019	0.92–1.13		
	Variance (τ)	3.880	1.920	2.021	0.043			0.541	6.546
Car	Intercept	−3.612	0.319	11.322	0.000	0.027			
(*n* = 1384)	Exposure (β)	0.197	0.026	7.607	0.000	1.218	1.16–1.28		
	Variance (τ)	2.786	1.087	2.564	0.010			0.459	4.914
By trip type									
To school	Intercept	−5.442	0.695	7.828	0.000	0.004			
(*n* = 2221)	Exposure (β)	0.197	0.043	4.619	0.000	1.218	1.12–1.33		
	Variance (τ)	3.467	2.071	1.674	0.094			0.513	5.907
From school	Intercept	−3.449	0.208	16.591	0.000	0.032			
(*n* = 2367)	Exposure (β)	0.115	0.018	6.421	0.000	1.122	1.08–1.16		
	Variance (τ)	2.637	0.658	4.007	0.000			0.445	4.707
By sex									
Female	Intercept	−3.886	0.231	16.788	0.000	0.021			
(*n* = 2806)	Exposure (β)	0.174	0.019	8.951	0.000	1.190	1.15–1.24		
	Variance (τ)	2.572	0.744	3.459	0.001			0.439	4.617
Male	Intercept	−4.388	0.375	11.686	0.000	0.012			
(*n* = 1782)	Exposure (β)	0.117	0.030	3.864	0.000	1.124	1.06–1.19		
	Variance (τ)	4.599	1.537	2.993	0.003			0.583	7.734

SE, standard error; ICC, intra-class correlation coefficient; MOR, median odds ratio.

the development of interventions, as it indicates that the influence of exposure on adolescents' JFP is actually greater when adolescents are driven to/from school under adult supervision than when they walk or bike. This may be a result of time-crunched parents buying food for their adolescents "on the go" and parents bending to the will of the child requesting junk food.[28] While exposure also significantly influences JFP among walkers, this should not discourage parents or public health promoters from advocating that adolescents walk to school, especially because active travel has well-known physical and mental health benefits and helps the child develop independence and a sense of environmental competence.[29]

Consistent with previous research on the built environment and adolescents' health-related behaviours,[29,30] this study revealed different patterns of behaviour along the journey to school in the morning versus the journey home from school in the afternoon. Although the effect of exposure was significant for trips in both directions, the odds of JFP by adolescents were much higher on the journey home from school versus to school, and the odds narrowed the longer a child travelled. This finding is likely related to the adolescent having more flexible time on the way home after school compared with the morning, when he or she has to reach school for a set time; it could also be due to daily eating patterns and adolescents just being hungrier after a long school day.

Analysis revealed that females were more strongly influenced by exposure to JFOs than males, being between 1.6 and 3.5 times more likely to make a JFP. Trips made by females had a higher likelihood of being linked to JFP at all levels of exposure than trips made by males. The gap in the likelihood of JFP between trips by females and males widened with the increased level of exposure. This finding is consistent with a previous study of adolescents in London, ON, which found that females were 1.5 times more likely than males to have self-purchased (without parents) fast food at least once per week.[3] It is unclear why the females in our study were more likely to purchase junk food and were more influenced by exposure. Females may have greater access to their own spending money, as it is common in Canadian culture for adolescent girls to start earning money earlier through babysitting.[31]

Limitations

Although this study offers a significant advance by using objective methods of observing adolescents' actual routes between home and school to assess direct JFO exposure, some limitations exist. Researchers have cautioned that even GPS data can have limitations, as they track only where the child has travelled over the course of data collection and may not encompass the totality of their potential exposure.[19] Chaix et al.[12] argue that biases related to selective daily mobility may prohibit accurate assessment of environmental effects. To limit the potential burden on research subjects, most studies using GPS tracking limit data collection to short periods (typically one week); it can be argued that one week of tracking spatial behaviours is not enough time to assess how potential environmental exposures may affect chronic diseases (e.g., obesity, type 2 diabetes, cancer). Nevertheless, it can be argued that GPS tracking can be an ideal tool for assessing how exposure to environmental features such as JFOs influences the likelihood of making a JFP (often an impulse activity).

CONCLUSION

This is one of the first studies to empirically establish a relationship between objective, GPS-derived measurement of direct JFO exposure and adolescents' JFP. While causal relations cannot be inferred and the data are not necessarily generalizable to other age groups or geographic settings, the study highlights important implications for municipal planners, school board officials and other decision-makers involved in the regulation, development

and management of adolescents' environments. In particular, municipalities should embed specific bylaws and policies restricting the concentration of JFOs close to schools, as passed in London, UK.[32] School board officials should also consider potential JFO exposure when making decisions on the siting of new schools and the closing of existing neighbourhood schools, which typically results in longer average commutes for students and greater exposure to JFOs. Furthermore, public health agencies at all levels (i.e., municipal, provincial and federal) should work together, in concert with municipal economic development organizations (e.g., business improvement areas) and private sector stakeholders on the supply side of the food system (e.g., food producers, restaurant owner associations, retailers) to introduce effective economic incentives to encourage greater availability, visibility and knowledge of healthier food options in local food stores and restaurants.

In addition to highlighting the need to reduce junk food exposure in neighbourhood food environments, we also reiterate what other studies have shown about the importance of parents as role models for their adolescents when it comes to healthy eating.[33] The findings indicate that junk food exposure has the greatest impact on JFP when adolescents are being driven in a car (i.e., being accompanied by an adult). This finding points to the need for further education to improve food literacy regarding overconsumption of generally unhealthy fast food. Nevertheless, public health practitioners and researchers should not single out adolescents as inherently poor decision-makers; we cannot forget how common junk food consumption is across North American society. Like their adult counterparts, adolescents report eating junk food because of the convenience and taste.[33] Furthermore, "to give up eating what teens call 'junk food' would be to give up much more than the food itself. This speaks to the importance of changing social norms around healthful eating." (p. S42)[34] Thus, we need to continue to make it easier and more attractive to eat healthily; this is an area where food "apps" for smartphones have proven to be effective at behaviour change.[35] Given the immediate and long-term health issues associated with poor dietary habits among adolescents, it is imperative that more innovative research be conducted on how to ameliorate the negative impacts of junk food exposure in adolescents' environments, particularly strategies and interventions that promote lifelong healthy behaviours.

REFERENCES

1. Yusuf S, Hawken S, Ounpuu S, et al. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: A case-control study. *Lancet* 2005;366:1640–1649. PMID: 16271645. doi: doi:10.1016/S0140-6736(05)67663-5.
2. Statistics Canada. Overweight and obese youth (self-reported), 2014. Statistics Canada Health Fact Sheets, 2015; 82–625, http://www.statcan.gc.ca/pub/82-625-x/2015001/article/14186-eng.htm.
3. He M, Tucker P, Gilliland J, Irwin JD, Larsen K, Hess P. The influence of local food environments on adolescents' food purchasing behaviors. *Int J Environ Res Public Health* 2012;9(4): 1458–1471. PMID: 22690205. doi: 10.3390/ijerph9041458.
4. He M, Tucker P, Irwin JD, Gilliland J, Larsen K, Hess P. Obesogenic neighbourhoods: The impact of neighbourhood restaurants and convenience stores on adolescents' food consumption behaviours. *Public Health Nutr* 2012;15(12): 2331–2339. PMID: 22390896. doi: 10.1017/S1368980012000584.
5. Gilliland JA, Rangel CY, Healy MA, Tucker P, Loebach JE, Hess PM, et al. Linking childhood obesity to the built environment: A multi-level analysis of home and school neighbourhood factors associated with body mass index. *Can J Public Health* 2012;103(9): eS15–eS21. PMID: 23618083. doi: 10.17269/cjph.103.3283.
6. Gilliland J. (2010). The built environment and obesity: trimming waistlines through neighborhood design. *In*: Bunting T, Filion P, Walker R, eds. *Canadian Cities in Transition*. Oxford, UK: Oxford University Press, pp. 391–410.
7. Bowman SA, Gortmaker SL, Ebbeling CB, Pereira MA, Ludwig DS. Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Pediatrics* 2004;113(1): 112–118. doi: 10.1542/peds.113.1.112.
8. Loebach J, Gilliland J. Child-led tours to uncover children's perceptions and use of neighborhood environments. *Children Youth Environ* 2010;20(1): 52–90. doi: 10.7721/chilyoutenvi.20.1.0052.
9. Sallis JF, Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. *Fut Children* 2006;16(1): 89–108. doi: 10.1353/foc.2006.0009.
10. Sadler RC, Gilliland JA. Comparing children's GPS tracks with geospatial proxies for exposure to junk food. *Spatial Spatio-Temp Epidemiol* 2015;14:55–61.
11. Shearer C, Rainham D, Blanchard C, Dummer T, Lyons R, Kirk S. Measuring food availability and accessibility among adolescents: Moving beyond the neighbourhood boundary. *Social Sci Med* 2015;133(May): 322–330. doi: 10.1016/j.socscimed.2014.11.019.
12. Chaix B, Meline J, Duncan S, Merrien C, Karusisi N, Perchoux C, et al. GPS tracking in neighborhood and health studies: A step forward for environmental exposure assessment, a step backward for causal inference? *Health Place* 2013;21: 46–51. PMID: 23425661. doi: 10.1016/j.healthplace.2013.01.003.
13. Morland K, Diez-Roux AV, Wing S. Supermarkets, other food stores, and obesity: The Atherosclerosis Risk in Communities Study. *Am J Prev Med* 2006;30(4): 333–339. PMID: 16530621. doi: 10.1016/j.amepre.2005.11.003.
14. Kestens Y, Daniel M. Social inequalities in food exposure around schools in an urban area. *Am J Prev Med* 2010;39(1): 33–40. PMID: 20537844. doi: 10.1016/j.amepre.2010.03.014.
15. Lovasi S, Grady S, Rundle A. Steps forward: Review and recommendations for research on walkability, physical activity and cardiovascular health. *Public Health Rev* 2012;33(2): 484–506. PMID: 25237210.
16. Williams J, Scarborough P, Matthews A, Cowburn G, Foster C, Roberts N, et al. A systematic review of the influence of the retail food environment around schools on obesity-related outcomes. *Obes Rev* 2014;15(5): 359–374. PMID: 24417984. doi: 10.1111/obr.12142.
17. Kestens Y, Lebel A, Chaix B, Clary C, Daniel M, Pampalon R, et al. Association between activity space exposure to food establishments and individual risk of overweight. *PloS one* 2012;7(8): e414–18. PMID: 22936974. doi: 10.1371/journal.pone.0041418.
18. Boruff BJ, Nathan A, Nijënstein S. Using GPS technology to (re)-examine operational definitions of 'neighbourhood' in place-based health research. *Int J Health Geogr* 2012;11(1): 22. PMID: 22738807. doi: 10.1186/1476-072X-11-22.
19. Harrison F, Burgoine T, Corder K, van Sluijs EM, Jones A. How well do modelled trips to school record the environments children are exposed to? A cross-sectional comparison of GIS-modelled and GPS-measured trips to school. *Int J Health Geogr* 2014;13(5). PMID: 24529075. doi: 10.1186/1476-072X-13-5.
20. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Public Health* 2014;14(1): 522. PMID: 24884443. doi: 10.1186/1471-2458-14-522.
21. Leal C, Chaix B. The influence of geographic life environments on cardiometabolic risk factors: A systematic review, a methodological assessment and a research agenda. *Obes Rev* 2011;12(3): 217–230. PMID: 20202135. doi: 10.1111/j.1467-789X.2010.00726.x.
22. Madsen KA, Cotterman C, Thompson HR, Rissman Y, Rosen NJ, Ritchie LD. Passive commuting and dietary intake in fourth and fifth grade students. *Am J Prev Med* 2015;48(3): 292–299. PMID: 25547928. doi: 10.1016/j.amepre.2014.09.033.
23. Healy MA, Gilliland JA. Quantifying the magnitude of environmental exposure misclassification when using imprecise address proxies in public health research. *Spat Spatiotemporal Epidemiol* 2012;3(1): 55–67. PMID: 22469491. doi: 10.1016/j.sste.2012.02.006.
24. Loebach J, Gilliland J. Free range kids? Using GPS-derived activity spaces to examine children's independent neighborhood activity and mobility. *Environ Behav* 2014; 1–33. doi: 10.1177/0013916514543177.
25. Larsen K, Merlo J. Appropriate assessment of neighborhood effects on individual health: Integrating random and fixed effects in multilevel logistic regression. *Am J Epidemiol* 2005;161(1): 81–88. PMID: 15615918. doi: 10.1093/aje/kwi017.
26. Muthen LK, Muthen BO. Mplus User's Guide [computer program]. Los Angeles, CA: Muthen and Muthen, 2015.
27. Van Hulst A, Barnett TA, Gauvin L, Daniel M, Kestens Y, Bird M, et al. Associations between children's diets and features of their residential and school neighbourhood food environments. *Can J Public Health* 2012;103(9): eS48–eS54. PMID: 23618089.

28. Jabs J, Devine CM. Time scarcity and food choices: An overview. *Appetite* 2006;47(2): 196–204. PMID: 16698116. doi: 10.1016/j.appet.2006.02.014.
29. Larsen K, Gilliland J, Hess P. Route based analysis to capture the environmental influences on a child's mode of travel between home and school. *Annals of the Association of American Geographers* 2012;102(6): 1348–1365. doi: 10.1080/00045608.2011.627059.
30. Larsen K, Gilliland J, Hess PM, Tucker P, Irwin J, He M. The influence of the physical environment and sociodemographic characteristics on children's mode of travel to and from school. *Am J Public Health* 2009;99(3): 520–526. PMID: 19106422. doi:10.2105/AJPH.2008.135319.
31. Breslin FC, Koehoorn M, Cole DC. Employment patterns and work injury experience among Canadian 12 to 14 year olds. *Can J Public Health* 2008; 201–205. PMID: 18615942. doi: 10.17269/cjph.99.1630.
32. Fraser LK, Edwards KL, Cade J, Clarke GP. The geography of fast food outlets: A review. *Int J Environ Res Public Health* 2010;7(5): 2290–2308. PMID: 20623025. doi:10.3390/ijerph7052290.
33. Neumark-Sztainer D, Story M, Perry C, Casey MA. Factors influencing food choices of adolescents: Findings from focus-group discussions with adolescents. *J Am Dietetic Assoc* 1999;99(8): 929–937. doi: 10.1016/S0002-8223(99)00222-9.
34. Story M, Neumark-Sztainer D, French S. Individual and environmental influences on adolescent eating behaviors. *J Am Dietetic Assoc* 2002;102(3): S40–S51. doi: 10.1016/S0002-8223(02)90421-9.
35. Gilliland J, Sadler R, Clark A, O'Connor C, Milczarek M, Doherty S. Using a smartphone application to promote healthy dietary behaviours and local food consumption. *BioMed Res Int*, 2015. doi: 10.1155/2015/841368.

RÉSUMÉ

OBJECTIFS : Examiner l'influence de l'exposition des adolescents aux points de vente d'aliments malsains sur leurs achats d'aliments vides durant le trajet entre l'école et la maison, et en particulier à la façon dont l'exposition et les achats diffèrent selon le sexe biologique de l'enfant, le moyen de transport et le sens du trajet.

MÉTHODE : Entre 2010 et 2013, des élèves ($n = 654$) de 9–13 ans fréquentant 25 écoles du comté de London-Middlesex, ON, ont rempli un questionnaire sociodémographique et un journal de leurs activités (pour repérer leurs achats d'aliments), et ont été observés pendant deux semaines par un système mondial de localisation (pour suivre leurs trajets entre l'école et la maison). Les données spatiales sur les itinéraires et les données d'achat ont été intégrées à une base de données validée de points de vente d'aliments dans un système d'information géographique; l'exposition a été mesurée selon le nombre de minutes qu'un enfant passait à moins de 50 m d'un point de vente d'aliments malsains (p. ex., restaurants rapides, magasins à prix uniques). Pour les trajets où les enfants étaient exposés à des aliments vides ($n = 4588$), nous avons procédé par régression logistique multiniveau pour évaluer la relation entre l'exposition et l'achat.

RÉSULTATS : Les analyses multiniveaux ont montré que la durée d'exposition des adolescents aux points de vente d'aliments malsains sur le chemin de l'école avait un effet significatif sur leur probabilité d'achat d'aliments vides. Cette relation est demeurée significative lorsque les données ont été stratifiées selon le sexe (fille/garçon), le sens du trajet (vers l'école/vers la maison) et le moyen de transport (transport actif/automobile), sauf pour les adolescents se déplaçant en autobus.

CONCLUSION : Les politiques et les programmes qui atténuent la concentration des points de vente d'aliments malsains près des écoles sont essentiels pour encourager les comportements alimentaires sains chez les enfants et pour réduire les problèmes de santé liés à l'alimentation, comme l'obésité.

MOTS CLÉS : milieu bâti; environnement alimentaire; systèmes d'information géographique; achat d'aliments; régime alimentaire; enfant; adolescent

Identifying rural food deserts: Methodological considerations for food environment interventions

Alexandre Lebel, PhD,[1,2] David Noreau, MSc,[1,3] Lucie Tremblay, RDN, MSc,[4] Céline Oberlé, MSc,[1] Maurie Girard-Gadreau, MSc,[1] Mathieu Duguay, MSc,[1] Jason P. Block, MD, PhD[5]

ABSTRACT

OBJECTIVES: Food insecurity in an important public health issue and affects 13% of Canadian households. It is associated with poor accessibility to fresh, diverse and affordable food products. However, measurement of the food environment is challenging in rural settings since the proximity of food supply sources is unevenly distributed. The objective of this study was to develop a methodology to identify food deserts in rural environments.

METHODS: In-store evaluations of 25 food products were performed for all food stores located in four contiguous rural counties in Quebec. The quality of food products was estimated using four indices: freshness, affordability, diversity and the relative availability. Road network distance between all residences to the closest food store with a favourable score on the four dimensions was mapped to identify residential clusters located in deprived communities without reasonable access to a "good" food source. The result was compared with the food desert parameters proposed by the US Department of Agriculture (USDA), as well as with the perceptions of a group of regional stakeholders.

RESULTS: When food quality was considered, food deserts appeared more prevalent than when only the USDA definition was used. Objective measurements of the food environment matched stakeholders' perceptions.

CONCLUSION: Food stores' characteristics are different in rural areas and require an in-store estimation to identify potential rural food deserts. The objective measurements of the food environment combined with the field knowledge of stakeholders may help to shape stronger arguments to gain the support of decision-makers to develop relevant interventions.

KEY WORDS: Social environment; geography; food supply; food insecurity

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS21–eS26
doi: 10.17269/CJPH.107.5353

Adequate nutrition is fundamental from infancy until adult life and is among the most important determinants of health.[1–3] Healthy dietary choices are associated with a higher life expectancy; unhealthy choices are associated with substantial comorbidities, including obesity, diabetes and other chronic diseases.[4,5] While individual dietary behaviours remain important,[6] there is an increasing interest in ecological approaches to improving nutrition, including access to healthy foods.[7,8] Promotional interventions for healthy eating are essential, but it is widely recognized that such interventions are more efficient when healthy choices are facilitated by enhanced accessibility to a variety of nutritious foods at a reasonable price.[9] If such accessibility is unevenly distributed among regions or between demographic subgroups, health determinant disparities may emerge,[10] including food insecurity.[11] Food insecurity occurs when all members of a household do not have reliable access to food in sufficient quantity and quality to maintain an active and healthy lifestyle.[12]

In 2012, 13% of Canadian households experienced food insecurity,[5] which is similar to the 14.5% observed in the US.[4] In 2012, all the 10 counties in the Health Region of Chaudière-Appalaches (HR-CA), a mainly rural administrative region in the province of Quebec with approximately 400,000 people, perceived food insecurity as a priority area for policy action.[13] According to regional HR-CA stakeholders, most production of fresh food is oriented to the market outside the region. In order to develop context-specific interventions, the Regional Public Health Authority (RPHA-CA) planned to characterize the food supply offered and its accessibility in the Authority's Action Plan 2013–2018.[14]

Various methods to measure accessibility to the food environment have been developed during the last decade. The use of geographic information systems (GIS) as a tool for

Author Affiliations

1. Graduate School of Land Management and Regional Planning, Laval University, Québec, QC
2. Evaluation Platform on Obesity Prevention, Quebec's Heart and Lung Institute, Laval University, Québec, QC
3. Ministère des Affaires municipales et de l'Occupation du territoire, Québec, QC
4. Regional Public Health Authority, Chaudière-Appalaches, Ste-Marie de Beauce, QC
5. Obesity Prevention Program, Department of Population Medicine, Harvard Medical School, Harvard Pilgrim Health Care Institute, Boston, MA, USA

Correspondence: Alexandre Lebel, PhD, Graduate School of Land Management and Regional Planning, Laval University, Pavillon Félix-Antoine-Savard, Office 1616, 2325, allée des Bibliothèques, Québec, QC G1V 0A6, Tel: 418-656-7685, E-mail: alexandre.lebel@esad.ulaval.ca

Acknowledgements: This research was partly funded by the Fonds de recherche du Québec-Santé, the Graduate School of Land management and Regional Planning of the Laval University, the Evaluation Platform on Obesity Prevention of the Quebec's Heart and Lung Institute, and the Regional Public Health Authority, Chaudière-Appalaches. The authors would like to acknowledge members of the Regional Food Security Committee of Chaudière-Appalaches for sharing their knowledge.

Conflict of Interest: None to declare.

spatial analysis is one approach.[15] It involves mapping food establishments across a region, measuring spatial access to these facilities,[16] and determining the association with individual dietary and other health behaviours.[15] The popularity of GIS in public health studies has generated a great number of food access measures and methods. In some cases, differing methods of characterizing food access could provide different results and associations. Some studies have focused on a specific food source, such as fast food restaurants or convenience stores, others aimed to describe and compare accessibility between neighbourhoods or regions. A review of these studies has demonstrated evidence for disparities in food access, income and race[17,18] and has shown an impressive heterogeneity in measurements,[19] which are not always comparable. Findings from other high-income countries have been sparse and equivocal.[20] The most common measurements rely on either density of food sources per square/area or physical proximity in road distance network.[21] These studies have been particularly useful in identifying problematic areas and have been closely linked to the notion of food deserts.[22] Food deserts are typically defined as "poor urban areas, where residents cannot buy affordable, healthy food".[23,24]

The majority of studies aiming to measure the food environment focus on higher density urban environments, using measurements that are perhaps unsuitable for less dense and more scarcely populated regions.[25,26] The concept of a food desert is contested regarding rural environments since it is expected that rural dwellers always have access to motorized transport and that they maximize shopping efficiency by making large-volume shopping trips.[27] Yet, low-income or elderly rural residents may not have access to safe and reliable transportation, which may lead to low shopping frequency.[28] In effect, rural households with fewer resources may be constrained, the long distances and less frequent trips to their primary food store reducing the regularity of healthy food availability at home. Aside from the issue of physical distance between individuals and resources, this situation makes the food desert phenomenon similar to that for low-income urban residents, i.e., healthy food is difficult to reach and is often more expensive.[29] However, the measurement of the food environment remains challenging in rural settings, since both population and food supply sources are unevenly distributed in these territories. Few studies address this problem and may be responsible for mischaracterizing food deserts.[30] For example, according to desk top information, the US Department of Agriculture (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".[31] Such a definition may limit the identification of rural food deserts because of three important shortcomings: it does not consider the relative geographic distribution between households and food supply sources; it only considers large food sources that are often nonexistent in rural communities; and it overlooks the quality of what is offered within food sources. With the increasing proportion of low-income and elderly people in rural areas, the access to fresh, diverse and affordable food products becomes a critical issue, and more precise measurements are needed to identify potential food deserts in rural areas.[10,30]

The objective of this study was to build a methodology to describe the food environment in a rural area. A specific description of the food environment is more likely to identify potential food deserts and may provide an opportunity for stakeholders to develop intersectoral interventions and policies to address the current food insecurity problem[32] currently perceived in the HR-CA.

METHODS

We developed objective ecologic measurements to assess the regional food environment using a mixed methodology approach, grounded in the closely linked concepts of food security and food deserts. Food security rests on four pillars: food availability, access, utilization and stability.[11] The food desert concept has been typically operationalized in three ways: problems with food accessibility, problems with food affordability and problems with food availability.[33] Food utilization and stability have typically been the domain of individuals and are not considered to be ecologic measurements. Accessibility describes whether an individual has physical access to food retailers selling healthy items. Affordability relates to the cost of food within these retailers. Availability indicates the relative diversity of food choices available in the food retail economy of a particular neighborhood.

We constructed ecologic measures of the food environment in three steps: 1) modelling the ecumene, a wide concept essentially referring to the area inhabited by human society;[34] 2) assessing food store quality; and 3) identifying potential food deserts. Geographic information was validated directly in the field. Inter-rater statistics were computed for in-store observations. Final results were compared with the food desert parameters proposed by the USDA, as well as with the perceptions of a group of regional stakeholders involved in the Regional Food Security Committee.

Modelling the ecumene

A major limitation for the identification of food deserts in rural environments is the need to take into account the enormous variation of the relative geographic distribution between people and resources. In effect, the proximity of food supply sources is disproportionately distributed between households in rural settings, where some people live relatively close to a wide range of food sources and others may have access to only a single store with limited produce, such as a convenience store or a gas station, within 10 or 20 km. In this study, the ecumene was assessed by computing the road network of each household to food establishments in all communities. Communities were defined as municipalities, subsections of municipalities or groups of municipalities in which individuals share common needs and activities. A group of regional stakeholders designated these communities as such while considering attachment or belonging to a community that may influence individuals' travel behaviour.[35] The deprivation level of the communities was assessed using the regional weighted deprivation index provided by the Quebec National Public Health Institute using the Canadian census 2006. This index is widely used in Canada and was computed from the communities' mean income, proportion of people without a high school diploma and unemployment rate, and was divided into quintiles.[36] A topologic road network database was created using DMTI CanMap Streetfiles 2013 and a GIS (ArcGIS, 10.1).

The Quebec Ministry of Municipal Affairs, Regions and Land Occupancy (MAMROT) provided the municipal property assessment roll of 2010 as well as the civic address and the function of every listed property. We gathered information on all buildings categorized as "food retail": supermarkets, convenience stores, large general stores (e.g., Walmart) and even gas stations, which often provide a large variety of food products in rural municipalities. All food outlets were mapped and visited to confirm their existence and location. All roads where no food outlets were reported were also visited in order to locate outlets missing from the MAMROT database. Missing outlets ($n = 30$) were removed from the database, and those that were not reported ($n = 43$) were added, thus providing a complete and exhaustive list of 153 food outlets. Six places refused the assessment and were not considered. This validation indicated that the MAMROT data had a positive predictive value of 0.74, which means that it delivered accurate information for 74% of registered food stores three years after its publication in 2010, and a sensitivity of 0.80, which means that 20% of reported food stores in the original data were not observed in the field in 2014.

Assessment of food store quality

In-store evaluations were performed to acquire information on the food affordability and availability. For all visited stores, we categorized 25 food products present in the National Nutritious Food Basket (2008) and distributed among the four groups of Canada's Food Guide (vegetables and fruit 4, meat and alternatives 10, grain products 6 and milk and alternatives 5) according to availability, freshness and price. The information was used to construct four synthetic indexes: affordability, freshness, diversity and relative availability.

Affordability: The observed price of each food product was subtracted from the regional mean price of the same product. We categorized food as above or below the regional mean.

Freshness: For the vegetables and fruit, a simple qualitative assessment determined whether the product was fresh or not. For products with an expiration date, we considered the product to be fresh if the product had not yet "expired". A store was considered to be selling fresh food if all products were reported to be fresh.

Diversity: The diversity index was built using an entropy-based formula similar to the land-use mix index.[37] It synthesised the importance and availability of each of the four categories of food as shown in Equation 1, where p_i is the proportion of the type of product in one food category and n is the number of food categories ($n = 4$). The denominator $\ln_n$ allows for the calculation of an index bounded between 0 and 1, where 0 qualifies as a store selling a single food product category (no diversity) and 1 indicates a store that has a great number of products (high diversity). The 25% of food stores having the highest scores (fourth quartile) were considered as selling a high diversity of food products.

$$-((\Sigma_n p_i * \ln\, p_i)/\ln_n) \quad (1)$$

Relative availability: As suggested by Pouliot and Hamelin,[38] the shelf space provided for healthy (vegetables and fruit) and unhealthy (sodas and chips) foods was estimated using step count. The ratio of the estimated shelf space for each type allowed for the identification of stores offering more shelf space for healthy than unhealthy products.

Food products quality assessment validation: Using two teams of two observers, we conducted this assessment in two regional counties from October to December of 2013 and another two in October to early December 2014. The observers had been previously trained to look for the right produce and to avoid outliers or inaccurate observations, such as weekly sales and different volumes of product. Inter-rater agreement (Kappa statistics) was computed for all the reported information in a subset of 20 food stores. Most Kappa statistics were above 0.90 (mean 0.92), indicating a very high concordance among observers. However, the freshness of whole wheat bread scored a moderate concordance with a coefficient of 0.57. This indicator was not considered reliable and was removed from the analyses.

Identification of potential food deserts

Food stores that qualified as affordable and selling fresh, diverse and high-quality food products were selected in the GIS and labeled as "high store". A road network distance was calculated between each residential building to the closest high store. Residences located above 16 km to a high store[31] and in most

Table 1. Regional characteristics to identify potential food deserts for the ecumene model and US Department of Agriculture (USDA) criteria

Ecumene model	Robert-Cliche		Etchemins		Beauce-Sartigan		Appalaches		Region	
	n	%	*n*	%	*n*	%	*n*	%	Total	%
Population	19,288	14.8%	17,245	13.2%	50,962	39.0%	43,120	33.0%	130,615	100%
Number of residences	6500	14.3%	6850	15.1%	16,727	36.8%	15,323	33.8%	45,400	34.8%
Located in a deprived comunity	1898	29.2%	4711	68.8%	5021	30.0%	3661	23.9%	15,291	11.7%
Located beyond 16 km of a high store*	181	2.8%	2770	40.4%	3188	19.1%	725	4.7%	6864	5.3%
Located in a potential food desert	24	0.4%	2211	32.3%	2339	14.0%	541	3.5%	5115	3.9%
Mean distance to closest high store*	5.4 km		14.8 km		7.2 km		5.3 km		7.4 km	
Median distance to closest high store*	3.2 km		14.4 km		2.2 km		2.3 km		3.5 km	
USDA criteria	*n*	%	*n*	%	*n*	%	*n*	%	Total	%
Population in derived census tract	0	0.0%	3370	31.9%	2462	23.3%	4720	44.7%	10,552	8.1%
Population beyond 16 km supermarket	110	3.9%	196	6.9%	745	26.2%	1797	63.1%	2848	2.2%
Population in potential food desert	0	0.0%	0	0.0%	0	0.0%	686	100%	686	0.5%

* Affordable and selling fresh, diverse and high-quality food products.

deprived quintile communities were identified as potential food deserts.

Comparison with USDA method and stakeholders' perceptions

We used the USDA method to define potential food deserts.[31] The methodology was applied by keeping only retailers identified as "supermarkets". The results were then compared to highlight the differences in the exposed population. All results were presented to the Regional Food Security Committee of Chaudière-Appalaches and collaborators in March 2015. This interdisciplinary committee comprises 17 professionals working in the field of education, public health, agriculture, food banks and other non-government organizations (NGOs) and includes as many other collaborators from various institutions (for a total *n* of close to 40). We obtained their perceptions regarding this representation of the food environment and inquired whether the information matched their knowledge of the region.

RESULTS

All regions have extensive numbers of food establishments; few residences have no access within 16 km. When in-store food affordability, freshness, diversity, quality and relative availability are incorporated, the proportion of residences with poor accessibility varied from 2.8% to 40.4% among regions. When residences located in deprived communities only were considered, accessibility varied from 0.4% to 32.3% among regions (Table 1). The Etchemin region may be particularly vulnerable since the mean distance to reach a high store was 14.8 km; over 68% of the population live in a deprived community. The difference between the mean and the median distance to a high store indicates the importance of the variation within and among regions, and highlights the heterogeneity of local contexts of food environment.

Using the USDA criteria to define rural food deserts led to substantially altered results. For example, Table 1 shows that 5,115 households were living in a potential food desert distributed among all four regions, whereas using USDA criteria this dropped to 686 households located in only one region.

Mapping provided more precision regarding the location of residential clusters located in a deprived community and living further than 16 km from a high store (Figure 1). The map also reveals vulnerable communities that are materially deprived but where accessibility to a good food source relies on only one store.

The results of the food environment description were presented to the Regional Food Security Committee of Chaudière-Appalaches (March 20, 2015). Many stakeholders recognized what they generally observed in the communities but were impressed by how many households were located in a potential food desert and by the variety of contexts in which potential food deserts were identified. The presentation inspired many alternative interventions, such as developing a cooperative businesses network, mobile food suppliers or enhancing in-store diversity. Nevertheless, it was clear to the Committee that the structure of the ecumene makes the development of cost-effective solutions challenging, that none of these alternatives would entirely address the perceived food insecurity problem and that intersectoral cooperation among regional stakeholders (e.g., producers, suppliers, NGOs) would be needed. An objective description of

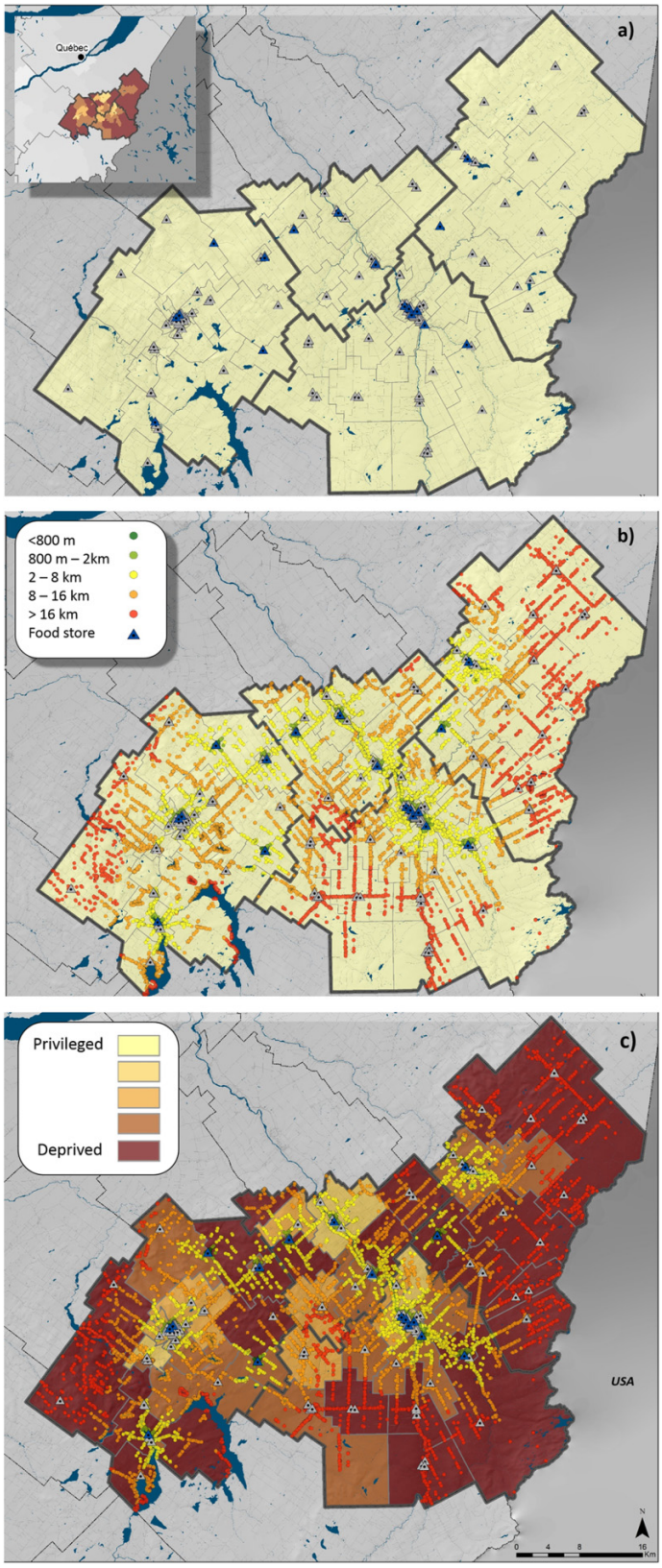

Figure 1. Potential food deserts in four regional counties in Chaudière-Appalaches, Quebec; a) identification of "high stores" (affordable and selling fresh, diverse and high-quality food products); b) residence proximity to high stores; c) deprivation level of communities and potential food deserts

the food environment was seen as a valuable complementary tool and as a first essential step in building the case for decision-makers to develop adapted interventions for the region.

DISCUSSION

Knowledge of the food environment is a critical dimension to address when considering the food insecurity problem in the population.[39] Because it is particularly challenging to describe the food environment in a rural setting, this study proposes a more precise methodology to identify potential food deserts and has revealed an impressive variety of local contexts. Regional stakeholders in HR-CA recognized this objective measurement as a better complementary tool to their knowledge of the situation than what is usually used and as better contributing to robust arguments directed at decision-makers for facilitating interventions. Regional stakeholders understand the complexity of the food market dynamics and are not looking for a single and easy solution for all vulnerable areas. Although many proposed interventions are known to them, analyzing the food environment by considering the ecumene more closely strengthens the need for intersectoral interventions. Identifying the most vulnerable areas (potential food deserts) may also help to prioritize some areas for intervention or point to the presence of support for initiatives in those areas.

The ecumene model provides a more precise assessment of the food environment and allows the identification of a variety of local contexts, since accessibility to food sources is not constrained by census tract boundaries, as for the USDA criteria. Another benefit of the proposed methodology is its flexibility, as it could easily be transferred to study any rural food environment. Yet food items and thresholds chosen for building each indicator were based on relative measurements specifically in HR-CA and were defined with the help of regional public health authority professionals, including a nutritionist. Consequently, any measurement or threshold proposed in this study should not be considered as an absolute indicator of food-store quality and should be adapted to the area under investigation. Although four synthetic indices (affordability, freshness, diversity and relative availability) are directly associated with the notion of food insecurity, we further recommend validating the thresholds used to identify a good food source with the knowledge of regional stakeholders.

The main limitation of this methodology is that it requires field observation and many data validation procedures. Although these procedures are demanding, our experience has shown that the alternative of using exclusively desk information may be not only less reliable but also misleading for decision-making for at least two reasons: 1) a significant number of errors were found in administrative databases; 2) several nontraditional food sources, such as gas stations, are often the only reachable source of healthy food and must be considered.

Assessment of the food environment in rural areas is methodologically challenging. Nevertheless, in order to provide a relevant complementary tool to stakeholders, we recommend considering field observations and the relative distribution of people and resources (the ecumene) as a necessity, not an option.

REFERENCES

1. Mozaffarian D, Ludwig DS. The 2015 US dietary guidelines: Lifting the ban on total dietary fat. *JAMA* 2015;313(24):2421–22. PMID: 26103023. doi: 10.1001/jama.2015.5941.
2. Kiefte-de Jong JC, de Vries JH, Bleeker SE, Jaddoe VW, Hofman A, Raat H, et al. Socio-demographic and lifestyle determinants of 'Western-like' and 'Health conscious' dietary patterns in toddlers. *Br J Nutr* 2013;109(1):137–47. PMID: 22475342. doi: 10.1017/S0007114512000682.
3. USDA, D.G.A.C. Scientific Report of the 2015 *Dietary Guidelines Advisory Committee*. Washington, DC: USDA and US Department of Health and Human Services, 2015.
4. Coleman-Jensen A, Rabbitt MP, Gregory C, Singh A. *Household Food Security in the United States in 2014, 194*. Washington, DC: US Department of Agriculture, Economic Research Service, 2015.
5. Tarasuk V, Mitchell A, Dachner N. *Household Food Insecurity in Canada, 2012*. Toronto, ON: Research to Identify Policy Options to Reduce Food Insecurity (PROOF), 2014.
6. Egger G, Swinburn B. An "ecological" approach to the obesity pandemic. *Br Med J* 1997;315(7106):477–80. PMID: 9284671. doi: 10.1136/bmj.315.7106.477.
7. Townsend N, Foster C. Developing and applying a socio-ecological model to the promotion of healthy eating in the school. *Public Health Nutr* 2013;16(6):1101–8. PMID: 22014870. doi: 10.1017/S1368980011002655.
8. Golden SD, Earp JAL. Social ecological approaches to individuals and their contexts: Twenty years of Health Education & Behavior health promotion interventions. *Health Educ Behav* 2012;39(3):364–72. PMID: 22267868. doi: 10.1177/1090198111418634.
9. Giskes K, Kamphuis CB, van Lenthe FJ, Kremers S, Droomers M, Brug J. A systematic review of associations between environmental factors, energy and fat intakes among adults: Is there evidence for environments that encourage obesogenic dietary intakes? *Public Health Nutr* 2007;10(10):1005–17. PMID: 17381942. doi: 10.1017/S1368980007665525.
10. McEntee J, Agyeman J. Towards the development of a GIS method for identifying rural food deserts: Geographic access in Vermont, USA. *Appl Geogr* 2010;30(1):165–76. doi: 10.1016/j.apgeog.2009.05.004.
11. Barrett CB. Measuring food insecurity. *Science* 2010;327(5967):825–28. PMID: 20150491. doi: 10.1126/science.1182768.
12. Radimer K, Olson C. Understanding hunger and developing indicators to assess it in women and children. *J Nutr Educ* 1992;24(1):36S–44S. doi: 10.1016/S0022-3182(12)80137-3.
13. HR-CA. *L'identification des déserts alimentaires en milieu rural*. Direction de santé publique de Chaudière-Appalaches, Sainte_Marie de Beauce, 2015; 10.
14. HR-CA. *Plan d'action régional en sécurité alimentaire de Chaudière-Appalaches 2013–2018*. In: D.d.s. publique (Ed.): Gouvernement du Québec, 2013; 15.
15. Charreire H, Casey R, Salze P, Simon C, Chaix B, Banos A, et al. Measuring the food environment using geographical information systems: A methodological review. *Public Health Nutr* 2010;13(11):1773–85. PMID: 20409354. doi: 10.1017/S1368980010000753.
16. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *Am J Health Promot* 2005;19(5):330–33. PMID: 15895534. doi: 10.4278/0890-1171-19.5.330.
17. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18(5):1172–87. PMID: 22717379. doi: 10.1016/j.healthplace.2012.05.006.
18. Walker RE, Keane CR, Burke JG. Disparities and access to healthy food in the United States: A review of food deserts literature. *Health Place* 2010;16(5):876–84. PMID: 20462784. doi: 10.1016/j.healthplace.2010.04.013.
19. Lytle LA. Measuring the food environment: State of the science. *Am J Prev Med* 2009;36(4):S134–44. PMID: 19285204. doi: 10.1016/j.amepre.2009.01.018.
20. Beaulac J, Kristjansson E, Cummins S. Peer reviewed: A systematic review of food deserts, 1966–2007. *Prev Chronic Dis* 2009;6(3):A105. PMID: 19527577.
21. Apparicio P, Abdelmajid M, Riva M, Shearmur R. Comparing alternative approaches to measuring the geographical accessibility of urban health services: Distance types and aggregation-error issues. *Int J Health Geogr* 2008;7(1):7. PMID: 18282284. doi: 10.1186/1476-072X-7-7.
22. Morland KB. *Local Food Environments: Food Access in America*. xxiv, 323, 8 pages de planches non numérotées.
23. Cummins S, Macintyre S. A systematic study of an urban foodscape: The price and availability of food in greater Glasgow. *Urban Stud* 2002;39(11):2115–30. doi: 10.1080/0042098022000011399.
24. Ver Ploeg M, Breneman V, Dutko P, Williams R, Snyder S, Dicken C, Kaufman P. Access to affordable and nutritious food: Updated estimates of distance to supermarkets using 2010 data, ERR-143. Washington, DC: U.S. Department of Agriculture, Economic Research Service, November 2012.
25. Bitler M, Haider SJ. An economic view of food deserts in the United States. *J Policy Anal Manage* 2011;30(1):153–76. doi: 10.1002/pam.20550.
26. Smith C, Morton LW. Rural food deserts: Low-income perspectives on food access in Minnesota and Iowa. *J Nutr Educ Behav* 2009;41(3):176–87. PMID: 19411051. doi: 10.1016/j.jneb.2008.06.008.
27. Hartley D, Anderson N, Fox K, Lenardson J. How does the rural food environment affect rural childhood obesity? *Child Obes* 2011;7(6):450–61.
28. Lucan SC, Gustafson A, Jilcott Pitts SB. The concept of "rural food deserts" is still meaningful. *Child Obes* 2012;8(5):484–85. PMID: 23061503. doi: 10.1089/chi.2012.0063.

29. Black J. Local food environments outside of the United States—a look to the north: Examining food environments in Canada. In: Morland KB (Ed.), *Local Food Environments: Food Access in America*. Boca Raton, FL: Taylor and Francis Group, 2015; 231–69.
30. Sadler RC, Gilliland JA, Arku G. An application of the edge effect in measuring accessibility to multiple food retailer types in Southwestern Ontario, Canada. *Int J Health Geogr* 2011;10:34. PMID: 21575162. doi: 10.1186/1476-072X-10-34.
31. USDA, E. *Food Access Research Atlas*, 2012.
32. Mader E, Busse H. Hungry in the heartland: Using community food systems as a strategy to reduce rural food deserts. *J Hunger Environ Nutr* 2011;6(1):45–53. doi: 10.1080/19320248.2011.549377.
33. Cummins S. *Food Deserts*. The Wiley Blackwell Encyclopedia of Health, Illness, Behavior, and Society, 2014.
34. Berque A. *Écoumène: introduction à l'étude des milieux humains*. Paris: Belin, 2000; 271.
35. Liu QA, Ryan V, Aurbach H, Besser T. The influence of local church participation on rural community attachment. *Rural Sociol* 1998;63(3):432.
36. Pampalon R, Raymond G. A deprivation index for health and welfare planning in Quebec. *Chronic Dis Can* 2000;21(3):104–13. PMID: 11082346.
37. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med* 2004;27(2):87–96. PMID: 15261894. doi: 10.1016/j.amepre.2004.04.011.
38. Pouliot N, Hamelin A-M. Disparities in fruit and vegetable supply: A potential health concern in the greater Quebec City area. *Public Health Nutr* 2009; 12(11):2051–59. PMID: 19344543. doi: 10.1017/S1368980009005369.
39. Buck-McFadyen EV. Rural food insecurity: When cooking skills, homegrown food, and perseverance aren't enough to feed a family. *Can J Public Health* 2015;106(3):e140–46. PMID: 26125240. doi: 10.17269/cjph.106.4837.

RÉSUMÉ

OBJECTIFS : L'insécurité alimentaire est une problématique de santé publique qui atteint près de 13 % des ménages canadiens. Elle est associée à une faible accessibilité à des produits alimentaires frais, diversifiés et abordables. Cependant, la mesure de l'environnement alimentaire demeure un défi important en milieu rural puisque les sources d'approvisionnement alimentaire sont distribuées de façon inégale sur le territoire. L'objectif de cette étude était de développer une méthodologie pour identifier les déserts alimentaires potentiels en milieu rural.

MÉTHODES : L'évaluation de 25 produits alimentaires a été réalisée pour tous les magasins d'alimentation de quatre municipalités régionales de comté rurales québécoises. La qualité des produits alimentaires fut estimée par quatre indices : la fraîcheur, l'abordabilité, la diversité et la disponibilité relative. La distance réticulaire entre toutes les résidences et le magasin d'alimentation le plus proche ayant un indice favorable pour les quatre indices fut cartographiée pour localiser les regroupements de résidences localisés dans une communauté défavorisée n'ayant pas un accès à une « bonne » source d'approvisionnement alimentaire. Le résultat fut comparé aux paramètres d'identification d'un désert alimentaire proposés par le USDA, ainsi qu'à la perception d'un groupe d'acteurs régionaux.

RÉSULTATS : Lorsque la qualité de l'alimentation était considérée, la présence de déserts alimentaires potentiels était beaucoup plus importante qu'avec la définition proposée par le USDA. La mesure objective de l'environnement alimentaire concordait avec la perception des acteurs régionaux.

CONCLUSION : Les caractéristiques des magasins d'alimentation sont différentes en milieu rural et nécessitent une évaluation directe pour identifier les déserts alimentaires potentiels. Les mesures objectives de l'environnement alimentaire conjuguées avec les connaissances des acteurs régionaux pourraient contribuer à développer des arguments plus solides pour obtenir le support des décideurs afin d'élaborer des interventions adaptées au milieu.

MOTS CLÉS : environnement social; géographie; approvisionnement alimentaire; insécurité alimentaire

Relative and absolute availability of fast-food restaurants in relation to the development of diabetes: A population-based cohort study

Jane Y. Polsky, MSc,[1,2] Rahim Moineddin, PhD,[3,4] Richard H. Glazier, MD,[1–4] James R. Dunn, PhD,[4,5] Gillian L. Booth, MD[2,4]

ABSTRACT

OBJECTIVES: To determine whether residents living in areas with a high proportion of fast-food restaurants (FFR) relative to all restaurants are more likely to develop diabetes and whether the risk varies according to the volume of FFR.

METHODS: The study cohort consisted of adult respondents (20–84 years) to the Canadian Community Health Survey (cycles 2005, 2007/2008, 2009/2010) who resided within walking distance (720 m) of at least one restaurant in Toronto, Brampton, Mississauga or Hamilton, ON. The development of diabetes was established by linking participants to the Ontario Diabetes Database. Cox proportional hazards models were used to estimate hazard ratios (HRs) of incident diabetes associated with relative and absolute measures of restaurant availability.

RESULTS: During a median follow-up of 5 years, 347 of 7,079 participants (4.6%) developed diabetes. Among younger adults (20–65 years, $n = 5{,}806$), a greater proportion of fast-food relative to all restaurants was significantly associated with incident diabetes after adjustment for a range of individual and area-level covariates, but only in areas with high volumes of fast-food retailers (3+ outlets) (HR = 1.79, 95% confidence interval: 1.03–3.12, across the interquartile range). Adjusting for body mass index rendered this association non-significant. No significant associations were observed in areas with low volumes of FFR or among older adults (65–84 years, $n = 1{,}273$). Absolute availability (number) of fast-food and other restaurants was generally unrelated to incident diabetes.

CONCLUSION: Areas with the double burden of a high volume of FFR and few dining alternatives may represent an adverse environment for the development of diabetes.

KEY WORDS: Diabetes mellitus; fast food; restaurants; body mass index; cohort studies

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS27–eS33
doi: 10.17269/CJPH.107.5312

Diabetes has emerged as one of the most serious public health challenges of the 21st century because of the heavy burden it imposes on individuals, families and the health care system.[1,2] In Canada, rates of diabetes have risen dramatically over the past two decades,[3] with an estimated 3.4 million Canadians (9.3%) currently living with diabetes and another 1.6 million expected to develop the condition by 2025.[4] Overweight and obesity are important drivers of the diabetes epidemic in the population, particularly in developed nations like Canada.[2] Physical inactivity, sedentary living and the Western diet play a key role as risk factors for overweight and obesity, and through their independent effects on diabetes risk.[2]

Canadians frequently consume meals away from home, many of which are purchased at fast-food restaurants (FFR).[5] Fast food tends to be energy dense and of poor nutritional quality,[6] making it a convenient target for public policies promoting healthier eating. Prospective studies have linked regular consumption of fast food to the risk of obesity, insulin resistance and type 2 diabetes.[7,8] However, studies exploring the relationship between local exposure to FFR and obesity have yielded mixed results.[9] For example, a recent national study observed a positive association between mean body mass index (BMI) and a greater number of chain FFR within large administrative areas, and a negative association for other restaurant types.[10] Other studies using smaller geographic levels (e.g., the number of FFR within walking distance of residential areas) found no association or results in the opposite direction.[11–13] Measures of FFR exposure also vary widely across studies (e.g., absolute numbers or density of outlets, proximity to outlets), and most studies on the topic are cross-sectional, which limits any conclusions about causality.[9]

Author Affiliations

1. Dalla Lana School of Public Health, University of Toronto, Toronto, ON
2. Centre for Research on Inner City Health, Keenan Research Centre, Li Ka Shing Knowledge Institute of St. Michael's Hospital, Toronto, ON
3. Department of Family and Community Medicine, University of Toronto, Toronto, ON
4. Institute for Clinical Evaluative Sciences, Toronto, ON
5. Department of Health, Aging and Society, McMaster University, Hamilton, ON

Correspondence: Jane Y. Polsky, Centre for Research on Inner City Health, Keenan Research Centre, Li Ka Shing Knowledge Institute of St. Michael's Hospital, 30 Bond Street, Toronto, ON M5B 1W8, Tel: 416-864-6060, ext. 77486, E-mail: jane.polsky@mail.utoronto.ca

Acknowledgements: This study was supported by the Institute for Clinical Evaluative Sciences (ICES), which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). The opinions, results and conclusions reported in this paper are those of the authors and are independent of the funding sources. No endorsement by ICES or the Ontario MOHLTC is intended or should be inferred. During the tenure of this study, J. Polsky was supported by the Canadian Institutes of Health Research Doctoral Research Award. R. Glazier was supported as a clinician scientist in the Department of Family and Community Medicine at St. Michael's Hospital and at the University of Toronto. The authors sincerely thank Jonathan Weyman for creating all GIS-based measures for this work.
Conflict of Interest: None to declare.

Moreover, there is a dearth of data exploring *direct* links between the retail food environment and the development of other diet-related outcomes, like diabetes.

A growing number of recent reports indicate that *relative* measures, such as the ratio or proportion of various types of food retail outlets, may be more useful than absolute measures for understanding associations with dietary behaviours and related health outcomes, because they better reflect the balance of available resources.[11,12,14] A recent study from Ontario found a strong relationship between the concentration of fast-food relative to other types of restaurants and obesity in areas with high volumes of fast-food retailers.[11] In light of these findings, the primary aim of this study was to assess whether this exposure accelerates the risk of diabetes. More specifically, we tested whether the percentage of all local restaurants that offer fast food is associated with the development of diabetes, and whether this association varies according to the volume of FFR. Our secondary aim was to assess whether BMI mediates any such associations. Last, we also assessed whether the number of FFR and other types of restaurant alone is associated with incident diabetes. This study represents one of the first investigations into the impact of the local restaurant environment on the risk of developing diabetes and the first study using Canadian data.

METHODS

Study cohort

Participant data for this retrospective cohort study came from Ontario respondents to three cycles of the Canadian Community Health Survey (CCHS)[15] who agreed to have their data linked with their personal health information (Share Files 2005, 2007/2008 and 2009/2010). We selected adult participants aged 20 to 84 years residing in urban, residential areas of four cities in southern Ontario: Toronto, Brampton, Mississauga and Hamilton. Eligible participants were those who were free of diabetes on the day of survey participation (according to their inclusion in the Ontario Diabetes Database (ODD) or self-report in the CCHS) and eligible for provincial health coverage for a minimum of 1 year at baseline. The final study cohort consisted of 7,079 participants who resided within walking distance of at least one restaurant.

Diabetes incidence

Cohort participants were followed forward in time from the date of CCHS interview until March 31, 2013. Incident diabetes was ascertained by linking individuals to the ODD, a validated and cumulative population-based registry of all patients with diabetes based on physician service claims and hospital discharge records since 1991.[16] The ODD's selection criteria have been demonstrated to have 86% sensitivity and 97% specificity in identifying patients with confirmed diabetes.[16] While the ODD does not differentiate between type 1 and 2 diabetes, the majority of people (90%–95%) with diabetes have type 2 diabetes.[17]

Restaurant environment

Data on restaurant locations were purchased from a commercial database (Dun & Bradstreet, Canada), which contained the geocoded locations of all restaurants in the study area in January 2008. After selecting the initial list of all eating establishments using North American Industry Classification System codes, we then conducted extensive cleaning of extracted records and additional reclassifying efforts consistent with a protocol adopted in previous studies.[18] We defined FFR as locally owned or chain limited-service restaurants (establishments without table service where patrons pay before receiving their meal) serving full meals. All remaining restaurants were classified as either full-service (establishments where patrons order and are served while seated, and pay after eating) or other restaurants (all other eating places such as cafes, coffee shops or snack-type outlets).

Restaurant exposure was derived for small residential parcels of land known as dissemination blocks (DBs) defined by Statistics Canada and assigned to individuals on the basis of their residential postal code (average of 2.4 study participants per block). For each participant, restaurant exposure was calculated as a buffer zone around the geometric centroid of the DB using network analysis tools in ArcGIS 9.3 software (ESRI, Redlands, CA). Although a wide range of buffer distances has been used in previous research, the majority of studies use buffer zones ranging from 500 to 1000 m to represent a neighbourhood environment accessible by walking.[19,20] In this study, we calculated the number of restaurants within a ~10-min walking distance (720 m) of DB centroids, based on an estimated speed of 1.2 m/sec and using an existing street network. This number represents the *absolute* availability of each restaurant type within a 10-min walk. *Relative* availability of FFR was calculated as the percentage of FFR relative to all restaurants within each buffer (absolute number of FFR/absolute number of total restaurants × 100%).

Baseline covariates

Baseline information on socio-demographic characteristics, smoking status and BMI of cohort participants was derived from the CCHS and is listed in Table 1. Household income adequacy was measured in quintiles and is a relative measure of participants' household income relative to all other Ontario respondents, adjusted for household and community size. Participants with missing values for household income were included in a separate category. BMI (kg/m^2) values were derived from self-reported height and weight data and were corrected for bias resulting from self-report using a validated error correction factor.[21]

Because of previously reported associations between the local retail food environment, area socio-economic composition, walkability and diabetes,[22–25] our analyses included composite indices of material deprivation and walkability at slightly larger geographic units than DBs – dissemination areas (small census areas with an average population of 400–700 people). Area material deprivation was measured using the Ontario Marginalization Index, a theoretically informed and empirically derived composite index of Canadian marginalization[26] previously shown to relate to the distribution of retail food outlets across this study's area.[23] Area walkability was assessed using a validated walkability index recently linked to levels of obesity and diabetes in Toronto.[22,24]

Statistical analysis

All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC) and applied standard sampling weights provided by Statistics Canada in order to maintain population representativeness. The SURVEY Cox proportional hazard

Table 1. Baseline characteristics of cohort participants (n = 7079)

Characteristic	Mean ± SD or *n* (%)
Age in years	43.4 ± 16.8
20–39	1244 (22.4)
30–64	4562 (65.9)
65–84	1273 (11.7)
Female	3881 (52.4)
Male	3198 (47.6)
Married/cohabiting	3461 (57.5)
Divorced/separated/widowed	1424 (12.9)
Single	2187 (29.6)
White	4911 (58.8)
Non-White	2139 (41.2)
Non-immigrant	3938 (47.7)
Immigrant	3126 (52.3)
High school or less	1968 (27.2)
Some post-secondary	2693 (38.1)
University or higher	2390 (34.7)
1 Lowest household income adequacy	1810 (23.8)
2 Medium-low	1446 (19.6)
3 Middle	1138 (14.8)
4 Medium-high	1105 (14.6)
5 Highest household income adequacy	1029 (13.6)
Missing	551 (13.6)
Toronto	4355 (72.7)
Brampton/Mississauga	1504 (19.1)
Hamilton	1220 (8.2)
Current smoker	1580 (21.8)
Former smoker	2630 (32.4)
Never smoked	2856 (45.8)
Survey cycle 2005	2170 (29.3)
Survey cycle 2007–2008	2622 (37.3)
Survey cycle 2009–2010	2287 (33.5)
Body mass index, kg/m^2	26.2 ± 4.9

Note: Frequencies presented in the table are unweighted counts, and percentages are weighted using survey sampling weights.

regression procedure was used to estimate hazard ratios (HRs) and associated 95% confidence intervals (CIs) for incident diabetes. Cohort participants were followed from the date of CCHS interview until diabetes diagnosis, death or end of study period (March 31, 2013), whichever occurred first. Each restaurant exposure measure was modeled separately, and all models accounted for the clustering of participants within DBs using the CLUSTER statement.

The main analyses comprised three models that examined the effect of relative restaurant availability on incident diabetes: Model 1 is an unadjusted model. Model 2 adjusted for all the individual-level socio-demographic baseline covariates shown in Table 1, as well as area-level material deprivation and walkability. Leisure-time physical activity and alcohol intake were also considered as possible confounders; however, adjustment for these variables did not change the final results, and they were therefore omitted for parsimony. Model 3 added a term for BMI in order to examine whether BMI may mediate the association between restaurant exposure and risk of diabetes.

In order to allow for greater comparability of effect sizes across variables with different distributions, each restaurant measure was rescaled by its interquartile range (IQR, difference between the 25th and 75th percentiles of each variable's distribution). Each HR unit thus represents the effect of one IQR increase of restaurant availability on the risk of incident diabetes. These IQRs corresponded to increases of 2 FFR, 4 full-service restaurants, 2 other restaurants, 8 total restaurants and 42.1% in the percentage of all restaurants that were FFR.

Because of a previously reported joint effect of relative and absolute FFR exposure on excess body weight,[11] we also assessed effect modification of relative FFR availability by the absolute number of FFR using interaction terms and stratified analyses. Analyses stratified by lower and higher volume of FFR were limited to 5,506 participants with 1 or more FFR within walking distance, because the relative number of FFR does not vary (i.e., can only equal 0%) when the absolute number of FFR = 0 but can have a value of up to 100% when the absolute number of FFR ≥1. Furthermore, because the effect of BMI on diabetes incidence is less pronounced among older adults[27] and because older Canadians tend to consume healthier diets and less fast food than younger adults,[5] we chose to stratify all analyses by age group (20–64 and 65–84 years).

Finally, we also tested the sensitivity of associations within a larger distance accessible by motorized transport by generating all analyses using larger, 3-km buffers (N = 10,135 participants). The study protocol was approved by the University of Toronto and Sunnybrook Health Sciences Centre research ethics boards.

RESULTS

Baseline characteristics of cohort participants are presented in Table 1. The majority of participants were adults of working age (<65 years, 88.3%) and resided in Toronto (72.7%). The average BMI placed participants in the overweight range (26.2 kg/m^2). During a median follow-up of 5 years (IQR 3.6–7.3 years), 347 participants developed diabetes (crude incidence of 4.6% or 9.1 per 10,000 person years).

In the overall sample, there was no significant association between the relative number of FFR (as the percentage of all restaurants within walking distance) and diabetes incidence (Table 2). However, because we identified a significant interaction between the relative share and the absolute number (i.e., volume) of FFR in relation to diabetes incidence, we generated analyses stratified by lower and higher volume of FFR. In areas with a high volume of FFR (3+ outlets), a greater relative share of FFR was related to higher risk of diabetes (HR = 1.76; 95% CI: 1.14–2.72, across the IQR) in the unadjusted analysis. However, this association was rendered non-significant after adjustment for individual and area-level covariates.

When analyses were further stratified by age, the heightened risk of diabetes related to a greater relative number of FFR persisted among younger adults aged 20–64 residing in areas with a high volumes of FFR (Table 2). In this group, a one IQR (42%) increase in the percentage of all restaurants that were FFR was related to a 79% higher risk of diabetes, after adjustment for covariates (Model 2; HR = 1.79; 95% CI: 1.03–3.12). Adjustment for BMI as a potential mediator attenuated this association by over 20%, rendering it non-significant (Model 3; HR = 1.40; 95% CI: 0.70–2.80, across the IQR). In contrast, the relative number of FFR was not significantly related to diabetes incidence among older adults or those of any age living in areas with low volumes of FFR.

Table 2. Relative number of fast-food restaurants (FFR) in relation to diabetes incidence in all areas and stratified by absolute number (volume) of FFR and age*

Relative number (%) of FFR	All areas			Low volume of FFR (1–2 outlets)‖			High volume of FFR (3+ outlets)‖		
	HR	(95% CI)	*p* value	HR	(95% CI)	*p* value	HR	(95% CI)	*p* value
All participants		*n* = 7079			*n* = 2837			*n* = 2669	
Model 1, unadjusted†	1.17	(0.91, 1.49)	0.218	1.11	(0.79, 1.55)	0.549	1.76	(1.14, 2.72)	0.011
Model 2, adjusted†	1.17	(0.89, 1.54)	0.264	1.16	(0.78, 1.72)	0.467	1.39	(0.82, 2.34)	0.222
Model 3, BMI as mediator§	1.10	(0.81, 1.48)	0.549	1.11	(0.72, 1.70)	0.648	1.27	(0.78, 2.06)	0.335
Age 20–64		*n* = 5806			*n* = 2330			*n* = 2219	
Model 1, unadjusted†	1.27	(0.96, 1.68)	0.096	1.29	(0.87, 1.90)	0.201	2.12	(1.29, 3.46)	0.003
Model 2, adjusted†	1.24	(0.89, 1.75)	0.205	1.32	(0.82, 2.12)	0.257	1.79	(1.03, 3.12)	0.039
Model 3, BMI as mediator§	1.12	(0.76, 1.65)	0.562	1.20	(0.69, 2.07)	0.517	1.40	(0.70, 2.80)	0.336
Age 65+		*n* = 1273			*n* = 507			*n* = 450	
Model 1, unadjusted†	0.83	(0.58, 1.20)	0.329	0.61	(0.32, 1.16)	0.131	0.62	(0.23, 1.71)	0.353
Model 2, adjusted†	0.96	(0.67, 1.38)	0.835	0.70	(0.40, 1.24)	0.222	0.56	(0.20, 1.59)	0.272
Model 3, BMI as mediator§	1.04	(0.72, 1.49)	0.843	0.76	(0.45, 1.30)	0.320	0.85	(0.35, 2.10)	0.725

HR = hazard ratio; 95% CI = 95% confidence interval; BMI = body mass index.
* Relative number of FFR was defined as the percentage of FFR relative to total restaurants within a 10-min walk of participants' residential areas. Results presented in the table are from separate Cox Proportional Hazard models. HRs represent the risk of incident diabetes estimated for 1 interquartile range increase in FFR proportion (42.1%).
† Model 1 is an unadjusted model.
‡ Model 2 is adjusted for age, sex, ethnoracial group, immigration status, education level, household income adequacy, smoking status, city of residence, area deprivation, area walkability and survey cycle.
§ Model 3 is adjusted for covariates in Model 2 and BMI, as a potential mediator.
‖ Stratified analyses by absolute number (volume) of FFR were restricted to 5506 participants.

Associations between absolute numbers of FFR and other restaurant types within walking distance are presented in Figure 1. Among younger adults, an increase of 4 full-service restaurants was related to a 9% lower risk of diabetes (HR = 0.91; 95% CI: 0.83–1.00). Associations for other restaurant types were similarly in the inverse direction, although failing to reach statistical significance. No significant associations were found for older adults aged 65–84, with all HRs near the null value.

The results of sensitivity analyses using the larger 3-km buffers yielded qualitatively similar results to the main analyses (data not shown).

DISCUSSION

This study represents one of the first investigations into the direct impact of the local retail food environment on incident diabetes and the first Canadian study of its kind. Using a population-based, urban cohort, we showed that exposure to a greater proportion of FFR relative to all restaurants within walking distance of participants' residential areas accelerated the risk of developing diabetes, but only among younger adults living in areas with high volumes of FFR (3+ outlets). In this subgroup, a ~40% increase in the percentage of all restaurants that were fast food was related to a 79% higher risk of developing diabetes, with adjustment for individual-level socio-economic covariates, area deprivation and walkability. Further adjustment for BMI attenuated this association. These findings suggest that the most adverse restaurant environment in relation to incident diabetes is one in which a high volume of FFR is poorly balanced by other types of dining options, and that this association may be mediated by higher body weight.

While the novel nature of these findings does not allow for direct comparisons with previous reports, our findings are consistent with the results of one recent study from Ontario, which demonstrated substantially elevated levels of obesity – a leading risk factor for diabetes – among adults residing in areas with both a high volume of FFR and low proportion of non-FFR.[11] Recent studies from Montreal and the US using similar measures of FFR availability have linked a higher relative concentration of FFR to lower quality diets and higher weight status among local residents.[12,28,29] Given experimental evidence demonstrating that the variety of available food options has a strong influence on food choices and the amount of food consumed,[30] it is possible that local exposure to the combination of a high volume and high share of FFR may similarly affect how individuals anchor their food purchasing decisions given the slate of available options, with less healthy options potentially competing with and "crowding out" healthier options.[31] Recurrent exposure to this type of restaurant environment may also contribute toward normalizing fast food, thereby influencing individuals' propensity for its consumption both within and outside residential settings. Additionally, given recent evidence that certain individuals (e.g., those who are highly reward sensitive) may be more susceptible to unhealthy environmental cues (including higher proportion of FFR near their home),[32] it is possible that exposure to a high volume of FFR that is poorly balanced by non-FFR may serve as an additional unique cue for vulnerable individuals to crave and consume fast food; this merits further investigation.

This study failed to observe significant associations between incident diabetes and the absolute number (volume) of FFR and other restaurants, with the exception of a significant negative association for full-service restaurants among younger adults. These findings contrast with those of the only previously published investigation of diabetes risk related to FFR exposure, which observed an elevated risk of prevalent diabetes among adults living within walking distance of a greater number of FFR.[33] However, when excess weight is considered, our results are in line with several Canadian and US reports observing lower weight status among residents of areas with a greater volume of FFR, other restaurants and food retail in general.[11–13] Such findings reflect the common coexistence of higher volumes of food retail in areas that

	HR	(95% CI)	*p*-value
Fast-food restaurants			
All participants	0.95	(0.87, 1.04)	0.269
Aged 20-64	0.96	(0.86, 1.07)	0.413
Aged 65+	0.94	(0.79, 1.12)	0.499
Full-service restaurants			
All participants	0.93	(0.86, 1.01)	0.070
Aged 20-64	0.91	(0.83, 1.00)	0.039
Aged 65+	1.02	(0.92, 1.12)	0.749
Other restaurants			
All participants	0.96	(0.91, 1.02)	0.172
Aged 20-64	0.95	(0.89, 1.02)	0.163
Aged 65+	1.01	(0.92, 1.11)	0.843
Total restaurants			
All participants	0.92	(0.84, 1.01)	0.080
Aged 20-64	0.90	(0.81, 1.01)	0.064
Aged 65+	1.00	(0.87, 1.16)	0.965

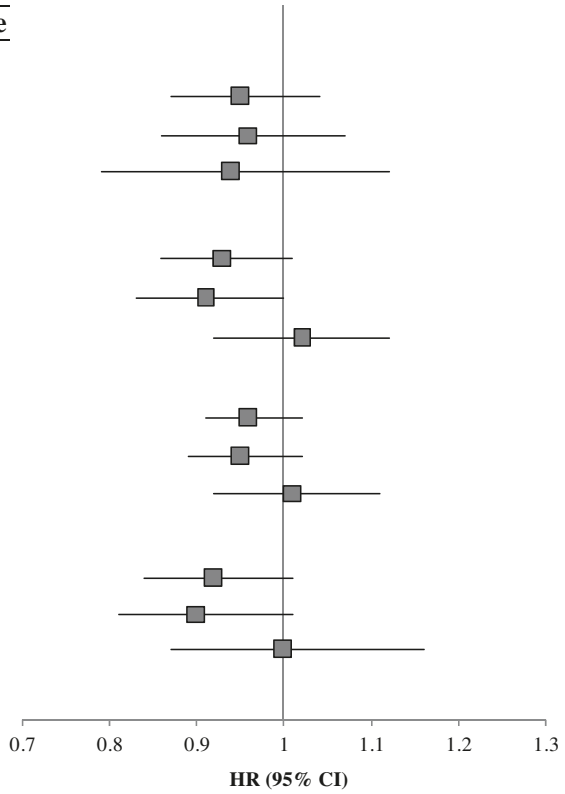

Figure 1. Absolute numbers of restaurants in relation to diabetes incidence*. HR = hazard ratio; 95% CI = 95% confidence interval. * Results of separate Cox proportional hazard models. HRs represent the risk of incident diabetes estimated for 1 interquartile range increase in the following absolute numbers of restaurants: 2 for fast-food restaurants; 4 for full-service restaurants; 1 for other restaurants; 8 for total restaurants. All models adjust for the following covariates: age, sex, ethnoracial group, immigration status, education level, household income adequacy, smoking status, city of residence, area deprivation, area walkability and survey cycle.

are more walkable (i.e., areas with a high diversity of land uses and many walkable destinations), a feature that has been repeatedly linked to higher rates of physical activity and lower rates of obesity and diabetes.[22,24] Thus, our adjustment for area walkability was intended to account for features of urban form that track with greater availability of restaurants, and represents an important improvement over previous studies on the topic.

The lack of associations seen among older adults (aged 65–84) in our study for both relative and absolute availability of FFR is consistent with our initial hypothesis that older adults may be less susceptible to any adverse effects of the retail food environment on diabetes risk. However, our sample of older adults was small, and so these results should be interpreted with caution. Other limitations of this analysis include a relatively short follow-up period (median of 5 years), which resulted in a small number of events. The transition from pre-diabetes states to diabetes spans many years, and so future studies with longer follow-up periods and those incorporating cumulative measures of food retail exposure are warranted. As with all observational research and despite our extensive control for individual- and area-level covariates, we cannot rule out the possibility that residual confounding by unmeasured or mismeasured characteristics may account for some of the observed results. Furthermore, our classification of restaurants into three broad categories may have introduced some degree of misclassification, and data on individuals' consumption of restaurant foods or detailed information on dietary intake were not available. This study focused on restaurant availability near the home and lacked data on restaurant exposure in other important settings of daily life (e.g., near the workplace), which may also influence diet and body weight.[12,34] Finally, the generalizability of our results is limited to urban or suburban areas with access to restaurants within walking distance.

CONCLUSION

This study documented an important interaction between the relative share and the volume of FFR in relation to incident diabetes, indicating that proximity to a high volume of FFR (3+ outlets) matters only if they are the predominant type of restaurant in the area. This association was limited to younger adults (<65 years), a group experiencing the most rapid rise in diabetes incidence,[3] likely a result of increasing levels of overweight and obesity. These findings are important as Canadian and US policy-makers increasingly target the local retail food environment with policies to restrict the number of FFR in certain areas as a means of promoting healthier food choices and reducing rates of obesity and associated health outcomes.[25,35] Findings from this

study suggest that policies merely targeting the volume of FFR or other retail food outlets may have limited effectiveness without a concurrent consideration of the overall balance of outlets within the local retail food landscape. Future studies should aim to replicate these findings in other settings, and additional evidence from longitudinal investigations and natural experiments to help define the optimal balance between outlets serving more and less healthful foods would be valuable for the design of effective health-promoting policies and interventions.

REFERENCES

1. Canadian Diabetes Association (CDA). An Economic Tsunami: The Cost of Diabetes in Canada, 2009. Available at: http://www.diabetes.ca/CDA/media/documents/publications-and-newsletters/advocacy-reports/economic-tsunami-cost-of-diabetes-in-canada-english.pdf (Accessed April 19, 2016).
2. Hu FB. Globalization of diabetes: The role of diet, lifestyle, and genes. *Diabetes Care* 2011;34(6):1249–57. PMID: 21617109. doi: 10.2337/dc11-0442.
3. Lipscombe LL, Hux JE. Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995–2005: A population-based study. *Lancet* 2007;369(9563):750–56. PMID: 17336651. doi: 10.1016/S0140-6736(07)60361-4.
4. Canadian Diabetes Association (CDA). Diabetes in Canada. Key Statistics. 2015. Available at: https://www.diabetes.ca/getmedia/513a0f6c-b1c9-4e56-a77c-6a492bf7350f/diabetes-charter-backgrounder-national-english.pdf.aspx (Accessed September 21, 2015).
5. Garriguet D. Canadians' eating habits. *Health Rep* 2007;18(2):17–32. PMID: 17578013.
6. Prentice AM, Jebb SA. Fast foods, energy density and obesity: A possible mechanistic link. *Obes Rev* 2003;4(4):187–94. PMID: 14649369. doi: 10.1046/j.1467-789X.2003.00117.x.
7. Krishnan S, Coogan PF, Boggs DA, Rosenberg L, Palmer JR. Consumption of restaurant foods and incidence of type 2 diabetes in African American women. *Am J Clin Nutr* 2010;91(2):465–71. PMID: 20016014. doi: 10.3945/ajcn.2009.28682.
8. Duffey KJ, Gordon-Larsen P, Steffen LM, Jacobs Jr DR, Popkin BM. Regular consumption from fast food establishments relative to other restaurants is differentially associated with metabolic outcomes in young adults. *J Nutr* 2009;139(11):2113–18. PMID: 19776183. doi: 10.3945/jn.109.109520.
9. Fleischhacker SE, Evenson KR, Rodriguez DA, Ammerman AS. A systematic review of fast food access studies. *Obes Rev* 2011;12(5):e460–71. PMID: 20149118. doi: 10.1111/j.1467-789X.2010.00715.x.
10. Hollands S, Campbell MK, Gilliland J, Sarma S. Association between neighbourhood fast-food and full-service restaurant density and body mass index: A cross-sectional study of Canadian adults. *Can J Public Health* 2014;105(3):e172–78. PMID: 25165835.
11. Polsky JY, Moineddin R, Dunn JR, Glazier RH, Booth GL. Absolute and relative densities of fast-food versus other restaurants in relation to weight status: Does restaurant mix matter?*Prev Med* 2016;82:28–34. PMID: 26582211. doi: 10.1016/j.ypmed.2015.11.008.
12. Kestens Y, Lebel A, Chaix B, Clary C, Daniel M, Pampalon R, et al. Association between activity space exposure to food establishments and individual risk of overweight. *PLoS One* 2012;7(8):e41418. PMID: 22936974. doi: 10.1371/journal.pone.0041418.
13. Zick C, Smith K, Fan J, Brown B, Yamada I, Kowaleski-Jones L. Running to the store? The relationship between neighborhood environments and the risk of obesity. *Soc Sci Med* 2009;69(10):1493–500. PMID: 19766372. doi: 10.1016/j.socscimed.2009.08.032.
14. Clary CM, Ramos Y, Shareck M, Kestens Y. Should we use absolute or relative measures when assessing foodscape exposure in relation to fruit and vegetable intake? Evidence from a wide-scale Canadian study. *Prev Med* 2015;71:83–87. PMID: 25481095. doi: 10.1016/j.ypmed.2014.11.023.
15. Beland Y. Canadian community health survey – Methodological overview. *Health Rep* 2002;13(3):9–14. PMID: 12743956.
16. Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario: Determination of prevalence and incidence using a validated administrative data algorithm. *Diabetes Care* 2002;25(3):512–16. PMID: 11874939. doi: 10.2337/diacare.25.3.512.
17. World Health Organization (WHO). Diabetes. Fact Sheet no. 312, 2015. Available at: http://www.who.int/mediacentre/factsheets/fs312/en/ (Accessed January 25, 2016).
18. Ohri-Vachaspati P, Martinez D, Yedidia MJ, Petlick N. Improving data accuracy of commercial food outlet databases. *Am J Health Promot* 2011;26(2):116–22. PMID: 22040393. doi: 10.4278/ajhp.100120-QUAN-21.
19. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Public Health* 2014;14(1):522. PMID: 24884443. doi: 10.1186/1471-2458-14-522.
20. Cobb LK, Appel LJ, Franco M, Jones-Smith JC, Nur A, Anderson CAM. The relationship of the local food environment with obesity: A systematic review of methods, study quality, and results. *Obesity* 2015;23(7):1331–44. PMID: 26096983. doi: 10.1002/oby.21118.
21. Connor Gorber S, Shields M, Tremblay MS, McDowell I. The feasibility of establishing correction factors to adjust self-reported estimates of obesity. *Health Rep* 2008;19(3):71–82. PMID: 18847148.
22. Glazier RH, Creatore MI, Weyman JT, Fazli G, Matheson FI, Gozdyra P, et al. Density, destinations or both? A comparison of measures of walkability in relation to transportation behaviors, obesity and diabetes in Toronto, Canada. *PLoS One* 2014;9(1):e85295. PMID: 24454837. doi: 10.1371/journal.pone.0085295.
23. Polsky JY, Moineddin R, Glazier RH, Dunn JR, Booth GL. Foodscapes of southern Ontario: Neighbourhood deprivation and access to healthy and unhealthy food retail. *Can J Public Health* 2014;105(5):e369–75. PMID: 25365272.
24. Booth GL, Creatore MI, Moineddin R, Gozdyra P, Weyman JT, Matheson FI, et al. Unwalkable neighborhoods, poverty, and the risk of diabetes among recent immigrants to Canada compared with long-term residents. *Diabetes Care* 2013;36(2):302–8. PMID: 22988302. doi: 10.2337/dc12-0777.
25. Health Canada. *Measuring the Food Environment in Canada*. Ottawa: Health Canada, 2013. Available at: http://www.hc-sc.gc.ca/fn-an/nutrition/pol/som-ex-sum-environ-eng.php (Accessed September 22, 2015).
26. Matheson FI, Dunn JR, Smith KLW, Moineddin R, Glazier RH. Development of the Canadian marginalization index: A new tool for the study of inequality. *Can J Public Health* 2012;103(Suppl 2):S12–16. PMID: 23618065.
27. Narayan KMV, Boyle JP, Thompson TJ, Gregg EW, Williamson DF. Effect of BMI on lifetime risk for diabetes in the U.S. *Diabetes Care* 2007;30(6):1562–66. PMID: 17372155. doi: 10.2337/dc06-2544.
28. Mercille G, Richard L, Gauvin L, Kestens Y, Shatenstein B, Daniel M, et al. Associations between residential food environment and dietary patterns in urban-dwelling older adults: Results from the VoisiNuAge study. *Public Health Nutr* 2012;15(11):2026–39. PMID: 22789436. doi: 10.1017/S136898001200273X.
29. Mehta NK, Chang VW. Weight status and restaurant availability a multilevel analysis. *Am J Prev Med* 2008;34(2):127–33. PMID: 18201642. doi: 10.1016/j.amepre.2007.09.031.
30. Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annu Rev Nutr* 2004;24:455–79. PMID: 15189128. doi: 10.1146/annurev.nutr.24.012003.132140.
31. Yeh MC, Matsumori B, Obenchain J, Viladrich A, Das D, Navder K. Validity of a competing food choice construct regarding fruit and vegetable consumption among urban college freshmen. *J Nutr Educ Behav* 2010;42(5):321–27. PMID: 20655281. doi: 10.1016/j.jneb.2009.08.004.
32. Paquet C, Dubé L, Gauvin L, Kestens Y, Daniel M. Sense of mastery and metabolic risk: Moderating role of the local fast-food environment. *Psychosom Med* 2010;72(3):324–31. PMID: 20100887. doi: 10.1097/PSY.0b013e3181cdf439.
33. Bodicoat DH, Carter P, Comber A, Edwardson C, Gray LJ, Hill S, et al. Is the number of fast-food outlets in the neighbourhood related to screen-detected type 2 diabetes mellitus and associated risk factors? *Public Health Nutr* 2015;18(9):1698–705. PMID: 25358618. doi: 10.1017/S1368980014002316.
34. Burgoine T, Forouhi NG, Griffin SJ, Wareham NJ, Monsivais P. Associations between exposure to takeaway food outlets, takeaway food consumption, and body weight in Cambridgeshire, UK: Population based, cross sectional study. *Br Med J* 2014;348:g1464. PMID: 24625460. doi: 10.1136/bmj.g1464.
35. Sturm R, Hattori A. Diet and obesity in Los Angeles county 2007–2012: Is there a measurable effect of the 2008 "fast-food ban?" *Soc Sci Med* 2015;133:205–11. PMID: 25779774. doi: 10.1016/j.socscimed.2015.03.004.

RÉSUMÉ

OBJECTIFS : Déterminer si les résidents de secteurs comptant une proportion élevée de restaurants rapides (RR) par rapport à l'ensemble des restaurants sont plus susceptibles de contracter le diabète et si le risque varie selon le volume de RR.

MÉTHODE : Cette étude de cohorte comprenait les répondants adultes (20–84 ans) de l'Enquête sur la santé dans les collectivités canadiennes (cycles 2005, 2007–2008, 2009–2010) résidant à distance de marche (720 m) d'au moins un restaurant à Toronto, Brampton, Mississauga ou Hamilton (Ontario). Nous avons établi la survenue du diabète en reliant les participants à la base de données sur le diabète de l'Ontario. Nous avons utilisé des modèles à risques proportionnels de Cox pour estimer les coefficients de danger (QD) du diabète incident associés aux indicateurs relatifs et absolus de disponibilité des restaurants.

RÉSULTATS : Au cours d'un suivi médian de 5 ans, 347 des 7,079 participants (4.9 %) ont contracté le diabète. Chez les adultes les plus jeunes (20–65 ans, *n* = 5,806), une proportion plus élevée de restaurants rapides par rapport à l'ensemble des restaurants présentait une corrélation significative avec le diabète incident compte tenu d'une gamme de covariables individuelles et par secteur, mais seulement dans les secteurs ayant des volumes élevés de restaurants rapides (3 ou plus) (QD = 1.79, intervalle de confiance de 95 % : 1.03–3.12, dans tout l'écart interquartile). Si l'on tient compte de l'indice de masse corporelle, cette association devient non significative. Aucune association significative n'a été observée dans les secteurs ayant de faibles volumes de RR, ni chez les personnes âgées (65–84 ans, *n* = 1,273). La disponibilité absolue (le nombre) des restaurants rapides et des autres restaurants était en général sans rapport avec le diabète incident.

CONCLUSION : Les secteurs ayant un volume élevé de RR, mal équilibré par rapport aux autres types de restaurants, peuvent représenter un milieu défavorable pour ce qui est de la survenue du diabète.

MOTS CLÉS : diabète sucré; aliments de restauration rapide; restaurants; indice de masse corporelle; études de cohortes

The food environment and diet quality of urban-dwelling older women and men: Assessing the moderating role of diet knowledge

Geneviève Mercille, PhD,[1] Lucie Richard, PhD,[2,3] Lise Gauvin, PhD,[1,4,5] Yan Kestens, PhD,[1,4] Bryna Shatenstein, PhD,[6,7] Mark Daniel, PhD,[8,9] Hélène Payette, PhD[10,11]

ABSTRACT

OBJECTIVES: The relationships between local food environments and dietary patterns are important for older adults and could be different in men and women. We examined associations between exposure to neighbourhood food sources and food consumption and the moderating role of diet knowledge separately among older women and men living in Montreal in 2003–2005 ($n = 722$).

METHODS: The proportion of fast-food outlets relative to all restaurants (%FFO) and the proportion of healthy food stores relative to all stores (%HFS) were estimated for 500 m buffers around participants' homes. Two dietary patterns, designated "Western" and "prudent", reflecting lower- and higher-quality diets respectively, were identified from food frequency questionnaire data. The unique and interactive effects of diet knowledge and food-source exposure on diet scores were tested with separate linear regression models for women and men.

RESULTS: For men, greater %FFO exposure was related to lower prudent diet scores ($\beta = -0.18$, $p = 0.02$), but no effect of %HFS exposure was observed and no interactions were statistically significant. For women, an inverse relationship between %FFO and prudent diet scores was strongest among those with low diet knowledge ($\beta = -0.22$, $p < 0.01$). No other associations were statistically significant.

CONCLUSION: Older men's diet patterns may reflect unhealthy cues associated with fast-food outlets. Among women, diet knowledge potentiated both negative and positive relationships with the food environment. In the absence of consistent main effects of the food environment on diet scores, subgroup analysis is a promising avenue for research.

KEY WORDS: Diet; older adults; urban population; food supply; effect modifier

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS34–eS41
doi: 10.17269/CJPH.107.5309

Nutrition plays a major role in successful aging and in the prevention and management of chronic diseases.[1] However, national surveys highlight concerns regarding inadequate intakes of several foods and nutrients among independent older adults.[2] With advancing age and the onset of chronic diseases, concerns about health and healthy eating increase. Women are more active seekers of nutrition information in their desire to take responsibility for their health,[3] whereas men pay less attention to their food choices.[4] Diet knowledge differs by sex among seniors[5] and is an independent determinant of food choices.[6]

Although nutrition knowledge does not necessarily translate into healthier diets, it is a prerequisite for the selection of healthy foods in a competitive food environment where healthy and unhealthy food options co-exist.[7] Few studies have investigated the influence of food environment among older adults,[8,9] despite the importance of residential neighbourhood influence posited by ecological models of aging.[10]

Among younger adults, evidence suggests that better access to supermarkets and the availability of healthy foods as measured in grocery stores are associated with more healthy food choices in the US, but this relationship is not observed consistently elsewhere.[11] Inconsistent findings might be linked to incomplete measures of exposure to the food environment, as many studies have often examined only a single dimension. Absolute measures (e.g., density of specific food outlets, distance to food stores) do not account for

Author Affiliations

1. Centre de Recherche du Centre Hospitalier de l'Université de Montréal (CRCHUM), Montréal, QC
2. Institut de recherche en santé publique de l'Université de Montréal (IRSPUM), Montréal, QC
3. Faculté des sciences infirmières, Université de Montréal, Montréal, QC
4. Département de médecine sociale et préventive, École de santé publique, Université de Montréal, Montréal, QC
5. Centre de recherche Léa-Roback sur les inégalités sociales de santé de Montréal, Montréal, QC
6. Département de nutrition, Université de Montréal, Montréal, QC
7. Centre de recherche, Institut universitaire de gériatrie de Montréal, Centre intégré universitaire de santé et de services sociaux (CIUSSS) du Centre-Sud-de-l'Île-de-Montréal, Montréal, QC
8. Centre for Population Health Research, University of South Australia, Adelaide, Australia
9. Department of Medicine, St. Vincent's Hospital, The University of Melbourne, Melbourne, Australia
10. Département des sciences de la santé communautaire, Faculté de médecine et des sciences de la santé, Université de Sherbrooke, Sherbrooke, QC
11. Centre de recherche sur le vieillissement, CIUSSS de l'Estrie-Centre hospitalier universitaire de Sherbrooke, Sherbrooke, QC

Correspondence: Geneviève Mercille, PhD, CRCHUM, Tour St-Antoine, 850, St-Denis – S02-336, Montréal, QC H2X 0A9, Tel: 514-890-8000, ext. 31450, E-mail: genevieve.mercille.1@umontreal.ca

Acknowledgements: This work was supported by the Canadian Institutes of Health Research (grant MOP-173669 to the VoisiNuAge study and MOP-62842 to the NuAge Study, and grant MFE-226542 to GM) and the Fonds de la recherche en santé du Québec (grant #16207 to LR and #20328 to YK). LG held a CIHR/CRPO (Canadian Institutes of Health Research/Centre de recherche en prévention de l'obésité) Applied Public Health Chair on Neighbourhoods, Lifestyle, and Healthy Body Weight. GM was also supported by the Strategic Training Program in Transdisciplinary Research on Public Health Interventions: Promotion, Prevention and Public Policy (4P), a partnership of CIHR and the Québec Population Health Research Network. YK holds a CIHR Applied Public Health Chair on Urban Interventions and Population Health. The results presented in this paper are solely the responsibility of the authors and do not necessarily represent the view of the funders.
Conflict of Interest: None to declare.

the complexity of exposure to diverse food sources. Furthermore, because "healthy" and "unhealthy" sources are often spatially correlated in urban areas, relative measures of exposure may be more adapted to tease out effects.[12] A small but growing number of studies have used such metrics to estimate associations with diet-related outcomes.[8,12,13]

Inconsistent findings might also be linked to variations in the dose–response relationship. Ecological models have long recognized dynamic and complex interactions between individuals and their environments.[10] An increasing body of evidence shows a sex-differential impact of the food environment on diet across age groups and socio-economic status.[14–16] Few studies have explored psychological or psychosocial moderators of diet.[15,17]

The current study examined associations between local food-source availability and dietary patterns, and tested the moderating role of diet knowledge within an urban, population-based sample of generally healthy and cognitively intact group of older adults living independently. It sought also to determine how these associations are present in men and women after adjustments for health status and social support, two factors known for their joint influence on both diet and access to neighbourhood food sources.[1]

METHODS

Context

The current cross-sectional study is part of the VoisiNuAge study, which integrates person-level data from the Longitudinal Study on Nutrition and Successful Aging (NuAge) cohort, described in detail elsewhere,[18] and area-level data from a geographic information system[19] to address questions on associations between neighbourhood environments and health among seniors. NuAge is a 5-year longitudinal study (2003–2008) of 1,793 community-dwelling men and women aged 67–84 years, drawn from an age- and sex-stratified random sample of the Québec Medicare database for the regions of Montreal, Laval and Sherbrooke. Participants were in good general health, and cognitively and functionally intact at recruitment. Data were collected by trained research assistants at the research centre where recruitment took place. All participants signed an informed consent form approved by the ethics committees of the University Institutes of Geriatrics of Sherbrooke and Montréal. The study area was Montréal and Laval islands (populations of 1.8 million and 343,000 inhabitants respectively in 2001). The current study reports on data gathered on 848 participants at baseline (T1) between December 2003 and April 2005. A road-network buffer of 500 m was computed around each participant's residential address and used to extract area exposures.

Measures

Diet

Usual diet over the previous 12 months was assessed by a validated 78-item food frequency questionnaire[20] and further reduced to 37 foods or food groups on the basis of similarity of type of food and nutrient characteristics. Dietary patterns were obtained from a categorical principal components analysis of food groups (see Mercille et al.[8] for a comprehensive description). Standardized scores from a two-uncorrelated factor solution representing "Western" and "prudent" diet patterns were used as continuous outcome variables. Higher scores on the Western pattern indicate greater consumption of processed meats, potatoes, red meat, sweets and refined grains. Higher scores on the prudent pattern represent individuals with healthier food behaviours, higher consumption of fruits, vegetables, fish and yogurt, and lower consumption of refined grains and sweetened beverages.[21]

Residential Food Environment Exposure

Densities of food stores and restaurants within a 500 m road network buffer of participants' homes were calculated using a commercial inventory of businesses and services (Tamec Inc., Zipcom database 2005, Montréal), validated through field verification.[22] Records were identified through the Standard Industrial Classification Code and the product name, corresponding to the classification system found in the yellow pages directory. Densities were capped at the average plus 3.29 SD to remove extreme outliers and reduce skewness.[23] Two relative availability measures were computed for each participant: 1) the percentage of chain and independent fast-food restaurants out of the total number of restaurants (%FFO) and 2) the percentage of stores selling healthy foods (grocery stores, supermarkets, fruit and vegetable stores, farmers' markets, specialty food stores) of all food stores, including convenience stores (%HFS, healthy food stores). Although grocery stores and supermarkets sell both healthy and unhealthy food, they were classified as healthy because of their importance regarding the purchase of healthy foods in the retail environment.

Diet Knowledge

The NuAge questionnaire included questions drawn from the American Dietetic Association nationwide consumer opinion survey, conducted periodically since 1991 among a representative sample of the US adult population (including older adults).[24] Diet knowledge measures were obtained from nine questions on knowledge of the health benefits of the following foods or nutrients: soy-based products, low-fat foods, omega-3 fatty acids, green tea, folic acid, lycopene, antioxidants, red wine and berries. For each item, self-reported stated knowledge ranged from 1 (no knowledge) to 5 (yes, a lot). Internal consistency was 0.82. Principal components analysis ($n = 842$ participants with complete data) confirmed the unidimensionality of the scale (total variance explained = 0.42). Given that the scale reflected a single dimension, the component loadings were applied as weights to the sum of responses to the set of questions. Sex-stratified tertiles of diet knowledge scores were then used for analyses.

Participant Characteristics

Participants provided information on their age, sex, marital status, place of birth, educational level and annual family income. *Health and functional status* was assessed using the SF-36 Physical Component Summary and Social Functioning subscale,[25] the Geriatric Depression Scale (GDS)[26] and the System for Measuring Functional Autonomy scale (SMAF Scale).[27] *Social environment* variables were the number of participants' adult children living in the neighbourhood and a binary variable identifying presence or absence of social support. The social support variable was calculated from the Social Resources Scale of the Older Americans

Table 1. Characteristics of participants by sex

Characteristic	Women ($n = 381$)		Men ($n = 341$)		p value*
	%	Mean (SD)	%	Mean (SD)	
Dietary patterns†					
Western pattern score (range: −2.24; 3.00)		−0.230 (0.86)		0.207 (1.01)	<0.001
Prudent pattern score (range: −2.87; 2.57)		0.157 (0.96)		−0.160 (0.95)	<0.001
Residential food environment					
Proportion of healthy food stores (%)		55.3 (14.8)		53.2 (14.8)	0.06
Proportion of fast-food outlets (%)		20.3 (10.3)		21.7 (10.8)	0.08
Diet knowledge scores					
Low level of knowledge	33.1	11.2 (2.1)	31.4	9.8 (1.8)	
Intermediate level of knowledge	33.3	16.4 (1.3)	35.2	14.2 (1.2)	
High level of knowledge	33.6	22.3 (2.7)	33.4	20.2 (3.2)	<0.001
Socio-demographic characteristics and health					
Age, years		75.0 (4.2)		74.8 (4.0)	0.48
Country of birth					
Canada	83.2		76.2		
Elsewhere	16.8		23.8		0.02
Marital status					
Single	15.7		7.9		
Widowed	34.9		9.7		
Divorced/separated	8.7		7.9		
Married/common law	40.7		74.5		<0.001
Education					
2–11 years	44.6		35.5		
12–13 years	21.5		17.3		
14 years or more	33.9		47.2		0.001
Family income					
<Low income cut-off‡	16.8		11.1		
>Low income cut-off	64.6		80.6		
Income not reported§	18.6		8.2		<0.001
SF-36 Physical Component (0–100)		48.4 (8.4)		52.1 (6.5)	<0.001
Depression (GDS) (0–30)		5.3 (4.6)		4.1 (3.6)	<0.001
Functional status (SMAF) (0–87)		3.2 (2.8)		3.8 (3.4)	0.01
SF-36 Social Functioning (0–100)		88.6 (18.4)		92.2 (14.4)	0.003
Social environment					
Children living nearby					
0	41.2		29.6		
1	26.8		26.7		
2 or more	32.0		43.7		0.001
Social support					
Presence of support	74.0		85.0		
Little or no support	26.0		15.0		<0.001
Residential neighbourhood					
% of residents below low income cut-off		24.2 (12.1)		23.0 (11.8)	0.20
% of residents speaking neither French nor English		25.6 (15.2)		24.7 (15.0)	0.41
% of residents with university degree		27.4 (16.1)		25.3 (15.3)	0.07

* p value for differences between men's and women's distributions of variables using χ^2 tests for proportions and t-tests or analysis of variance for means.
† Factor scores for dietary patterns represent standardized variables (with mean 0 and standard deviation of 1). Healthier diets are characterized by lower scores on the Western diet pattern (less consumption of red and processed meats, potatoes, sweets and refined grains) and higher scores on the prudent diet pattern (higher consumption of fruits, vegetables, fish and yoghurt and low consumption of refined grains and sweetened beverages).
‡ Statistics Canada. Low income cut-offs 1994–2003 and low income measures 1992–2001. Income research paper series. Ottawa, ON: Statistics Canada, 2004.
§ 105 participants did not report household income but were included in the analyses.

Resources and Services,[28] assessing support from a spouse, a family member or friend in the following situations: 1) availability of help in case of illness, disability or problem, 2) someone who could take care of the respondent as long as necessary, 3) for a short period of time or 4) from time to time. Finally, to account for the socio-demographic characteristics of the residential environment, three *residential neighbourhood* variables were computed using 2001 Census data (www12.statcan.ca/english/census01/home/index.cfm): 1) the proportion of residents in households below the low income cut-off, 2) the proportion of people with a university degree and 3) the proportion of households speaking neither Canadian official language. Area-weighted averages were calculated in which buffers included more than one census tract. All of the above variables were used as covariates in statistical analyses.

Analysis

Descriptive and bivariate analyses were performed. Examination of bivariate relationships among all variables was performed to assess collinearity. Main and moderating effects of diet knowledge and food-source exposure on diet pattern scores were tested using separate linear regression models accounting for covariates for women and men. Continuous covariates were mean centred by sex to reduce multicollinearity between predictors and to facilitate the creation of the graphs necessary for interpretation of significant interactions. Variables for statistical models were entered as follows: 1) predictor variables (i.e., %HFS or %FFO, and diet knowledge) to test for main effects; 2) two-way products of the predictors (%HFS or %FFO*diet knowledge tertiles) to test for interactions. Interactions were identified by significant increments in R^2 in models when two-way products were entered. Finally,

Table 2. Sex differences on parameter estimates for main and moderating effects of neighbourhood food source exposure and diet knowledge on prudent diet score*, adjusted for covariates† ($n = 722$)

Women ($n = 381$)	β	**(95% CI)**	p	β	**(95% CI)**	p	β	**(95% CI)**	p
		Model 1 (Main)			**Model 2 Knowledge*HFS**			**Model 3 Knowledge*FFO**	
Intercept		(0.05, 0.66)	0.03		(0.06, 0.68)	0.02		(0.10, 0.71)	0.01
Proportion of healthy food stores (%HFS)	−0.07	(−1.44, 0.48)	0.33	−0.22	(−2.66, −0.17)	0.03	−0.07	(−1.40, 0.51)	0.36
Proportion of fast-food outlets (%FFO)	−0.11	(−2.32, 0.25)	0.11	−0.10	(−2.22, 0.34)	0.15	0.12	(−0.86, 3.14)	0.26
Low knowledge	−0.25	(−0.75, −0.26)	<0.001	−0.25	(−0.75, −0.26)	<0.001	−0.26	(−0.77, −0.29)	<0.001
Intermediate knowledge	−0.08	(−0.40, 0.07)	0.16	−0.09	(−0.41, 0.05)	0.12	−0.10	(−0.44, 0.02)	0.08
High knowledge (ref)	1.00			1.00			1.00		
%HFS*low knowledge				0.13	(−0.09, 3.21)	0.06			
%HFS*intermediate knowledge				0.16	(0.10, 3.11)	0.04			
%HFS*high knowledge (ref)				1.00			1.00		
%FFO*low knowledge							−0.22	(−5.79, −1.15)	<0.01
%FFO*intermediate knowledge							−0.16	(−4.61, −0.05)	0.05
%FFO*high knowledge (ref)							1.00		
ΔR^2 for adding interaction					0.013	0.08		0.017	0.03
R^2 (R^2 adjusted)		0.17 (0.11)			0.18 (0.12)			0.19 (0.13)	
Men ($n = 341$)		**Model 4 (Main)**			**Model 5 Knowledge*HFS**			**Model 6 Knowledge*FFO**	
Intercept		(0.00, 0.60)	0.05		(−0.01, 0.59)	0.05		(0.02, 0.62)	0.04
Proportion of healthy food stores (%HFS)	−0.04	(−1.30, 0.80)	0.64	0.01	(−1.38, 1.46)	0.96	−0.04	(−1.30, 0.80)	0.64
Proportion of fast-food outlets (%FFO)	−0.18	(−2.90, −0.27)	0.02	−0.17	(−2.84, −0.20)	0.02	−0.04	(−2.42, 1.71)	0.74
Low knowledge	−0.27	(−0.82, −0.29)	<0.001	−0.27	(−0.82, −0.29)	<0.001	−0.28	(−0.84, −0.31)	<0.001
Intermediate knowledge	−0.11	(−0.47, 0.02)	0.07	−0.11	(−0.47, 0.03)	0.08	−0.12	(−0.49, 0.00)	0.05
High knowledge (ref)	1.00			1.00			1.00		
%HFS*low knowledge				−0.09	(−2.61, 0.75)	0.28			
%HFS*intermediate knowledge				0.00	(−1.67, 1.75)	0.96			
%HFS*high knowledge (ref)				1.00					
%FFO*low knowledge							−0.10	(−4.14, 0.83)	0.19
%FFO*intermediate knowledge							−0.12	(−3.93, 0.69)	0.17
%FFO*high knowledge (ref)							1.00		
ΔR^2 for adding interaction					0.007	0.28		0.007	0.28
R^2 (R^2 adjusted)		0.13 (0.06)			0.13 (0.06)			0.13 (0.06)	

* Factor scores for dietary patterns represent standardized variables (with mean of 0 and standard deviation of 1). Healthier diets are characterized by higher scores on prudent diet pattern (higher consumption of fruits, vegetables, fish and yoghurt and low consumption of refined grains and sweetened beverages).

† Models adjusted for socio-demographic characteristics (sex, age, country of birth, marital status, education, family income), health characteristics (SF36 Physical Component Summary, depression, functional status, SF36 Social Functioning), social environment (support, children living nearby) and residential environment variables (% residents below the low income cut-off, % residents speaking neither French nor English, % residents with university degree).

models were adjusted by adding the remaining variables. Multicollinearity was evaluated by calculating variance inflation factors (VIF) on final models assessing main effects on diet scores. All VIFs were below 2.5, indicating limited multicollinearity. Only significant interactions were illustrated, by plotting diet scores from the regressions equation at ±1 SD of the average food source exposure for each level of knowledge. The influence of outliers was examined by removing extreme values, with the use of a $p < 0.001$ criterion for Mahalanobis distance or leverage values >2 p/n (where p is the number of regression parameters) and with Cook distance above average plus three SD in further analyses.[23] As analyses done with and without outliers yielded different findings, the results are reported only for analyses conducted with outliers removed. Statistical significance was set at $p < 0.05$. PASW software (PASW Statistics 18.0; SPSS Inc., Chicago, IL) was used for statistical analyses. Spatial autocorrelations in the residuals were assessed with Moran's Index, using ArcGIS 9.3.1 (ESRI Inc., Redlands, CA).

RESULTS

Of 848 initial participants, 100 were excluded, 71 because of insufficient or implausible dietary information and 29 because of missing data on covariates, leaving 748 participants (392 women and 356 men) for analysis. Removal of outliers (11 women [2.8%] and 15 men [4.2%]) left 722 participants in the final sample (381 women and 341 men). Female outliers had a higher Western diet score (mean 0.96 vs. −0.23; $p = 0.03$) and a higher GDS score (mean 8.3 vs. 5.3; $p = 0.04$), and were less likely to be married (none compared with 41%; $p = 0.004$) than female non-outliers. Male outliers had higher GDS scores (mean 8.6 vs. 4.1; $p = 0.004$), were more likely to live in low-income households (33% vs. 11%; $p = 0.02$) and less likely to be married (40% vs. 75%; $p = 0.006$).

Descriptive statistics are shown in Table 1. Male and female respondents were similar on age and residential characteristics, but important between-sex differences are apparent in Table 1. Women had significantly healthier dietary patterns and higher scores on diet knowledge than men. For men, being more often married and having children living nearby might be related to better social support. Overall health status was good: Physical Component Summary scores were consistent with the SF-36 Canadian normative data,[29] and high Social Functioning scores indicated few limitations in social activities due to health. GDS and SMAF scores were very low, indicating few depressive symptoms or disabilities, and statistically significant differences between sexes were not clinically significant.[26,27]

The results of the multivariate linear regressions are reported for both diet scores separately for men and women. Table 2 presents the results for the prudent diet scores and Table 3 for the Western diet scores. Models 1 and 4 show main effects for women and men respectively. Models 2 and 5 show interactions between %HFS and knowledge, whereas Models 3 and 6 show interactions with %FFO.

Table 3. Sex differences on parameter estimates for main and moderating effects of neighbourhood food sources exposure and diet knowledge on Western diet score*, adjusted for covariates† ($n = 722$)

Women ($n = 381$)	β	**(95% CI)**	***p***	β	**(95% CI)**	***p***	β	**(95% CI)**	***p***
		Model 1 (Main)			**Model 2 Knowledge*HFS**			**Model 3 Knowledge*FFO**	
Intercept		(−0.63, −0.07)	0.01		(−0.60, −0.05)	0.02		(−0.62, −0.06)	0.02
Proportion of healthy food stores (%HFS)	−0.12	(−1.16, 0.16)	0.11	−0.16	(−2.05, 0.18)	0.10	−0.14	(−1.66, 0.08)	0.07
Proportion of fast-food outlets (%FFO)	−0.01	(−1.29, 1.03)	0.83	−0.01	(−1.20, 1.09)	0.92	−0.03	(−2.04, 1.59)	0.81
Low knowledge	0.13	(0.01, 0.45)	0.04	0.12	(0.00, 0.44)	0.05	0.13	(0.02, 0.45)	0.03
Intermediate knowledge	0.03	(−0.16, 0.26)	0.63	0.02	(−0.16, 0.25)	0.69	0.04	(−0.14, 0.28)	0.51
High knowledge (ref)	1.00			1.00			1.00		
%HFS*low knowledge				−0.10	(−2.63, 0.32)	0.13			
%HFS*intermediate knowledge				0.14	(−0.04, 2.65)	0.06			
%HFS*high knowledge (ref)				1.00					
%FFO*low knowledge							0.10	(−0.72, 3.49)	0.20
%FFO*intermediate knowledge							−0.08	(−3.08, 1.06)	0.34
%FFO*high knowledge (ref)							1.00		
ΔR^2 for adding interaction					0.017	0.03		0.009	0.18
R^2 (R^2 adjusted)		0.14 (0.09)			0.17 (0.11)			0.16 (0.10)	
Men ($n = 341$)		**Model 4 (Main)**			**Model 5 Knowledge*HFS**			**Model 6 Knowledge*FFO**	
Intercept		(−0.07, 0.54)	0.13		(−0.12, 0.50)	0.22		(−0.09, 0.52)	0.18
Proportion of healthy food stores (%HFS)	0.06	(−0.66, 1.51)	0.44	0.01	(−1.41, 1.52)	0.94	0.06	(−0.67, 1.50)	0.45
Proportion of fast-food outlets (%FFO)	−0.02	(−1.53, 1.18)	0.80	−0.02	(−1.59, 1.13)	0.74	−0.08	(−2.86, 1.39)	0.50
Low knowledge	0.05	(−0.17, 0.38)	0.44	0.05	(−0.17, 0.38)	0.45	0.05	(−0.15, 0.40)	0.37
Intermediate knowledge	0.04	(−0.16, 0.35)	0.47	0.04	(−0.17, 0.34)	0.50	0.04	(−0.16, 0.35)	0.47
High knowledge (ref)	1.00			1.00			1.00		
%HFS*low knowledge				0.09	(−0.75, 2.73)	0.26			
%HFS*intermediate knowledge				0.01	(−1.61, 1.92)	0.86			
%HFS*high knowledge (ref)				1.00					
%FFO*low knowledge							−0.02	(−2.97, 2.15)	0.76
%FFO*intermediate knowledge							0.10	(−0.86, 3.90)	0.21
%FFO*high knowledge (ref)							1.00		
ΔR^2 for adding interaction					0.007	0.30		0.013	0.10
R^2 (R^2 adjusted)		0.18 (0.12)			0.18 (0.12)			0.18 (0.12)	

* Factor scores for dietary patterns represent standardized variables (with mean of 0 and SD of 1). Healthier diets are characterized by lower scores on the Western diet pattern (less consumption of red and processed meats, potatoes, sweets and refined grains).

† Models adjusted for socio-demographic characteristics (sex, age, country of birth, marital status, education, family income), health characteristics (SF36 Physical Component Summary, GDS, SMAF, SF36 Social Functioning), social environment (social support, children living nearby) and residential environment (% residents below the low income cut-off, % residents speaking neither French nor English, % residents with university degree).

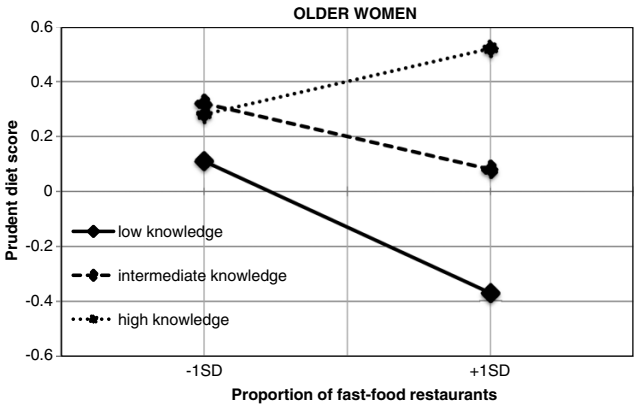

Figure 1. Predicted values for the prudent diet score for older women at low, intermediate and high levels of diet knowledge, and for low (−1 SD) and high (+1 SD) proportion of fast-food restaurants

The residential food environment was not associated with diet scores in women for either type of diet (Model 1, Tables 2 and 3). Men exposed to a higher percentage of fast-food outlets had scores lower on prudent diet ($\beta = -0.18$; $p = 0.02$) (Model 4 of Table 2). Going from low %FFO (−1 SD) to high %FFO (+1 SD) exposure was associated with a 0.32 decrease in predicted prudent diet score (range of scores: −2.87 to 2.28). In other words, men's diet quality decreased as exposure to fast-food outlets increased.

Lower diet knowledge was associated with lower diet quality, i.e., both lower prudent and higher Western diet scores in women (Model 1 in Tables 2 and 3). Lower prudent diet scores in men were associated with lower diet knowledge (Model 4 in Table 2). There was no statistically significant interaction between the food environment and diet knowledge for men (Model 5 and Model 6, Tables 2 and 3).

Two significant negative interactions were found for women. The first was between knowledge and %FFO exposure (Model 3, Table 2). As shown in Figure 1, for women with intermediate or high knowledge, greater %FFO exposure was associated with similar prudent diet scores, and for women with low knowledge greater exposure to %FFO was associated with a decrease of 0.48 in prudent diet scores (range of scores: −2.51 to 2.57). A second negative interaction was found between diet knowledge and HFS exposure (Model 3, Table 3). While the individual coefficients for interaction terms did not achieve statistical significance, the results were plotted to interpret the overall pattern of relationships (Figure 2). Among women with high/intermediate diet knowledge,

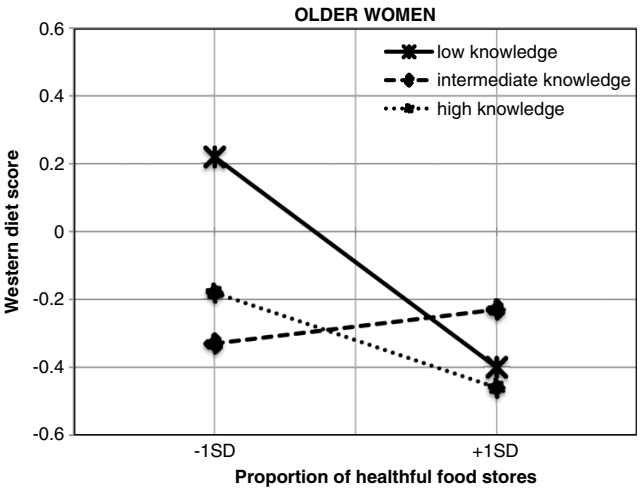

Figure 2. Predicted values for the Western diet score for older women at low, intermediate and high levels of diet knowledge, and for low (−1 SD) and high (+1 SD) proportion of healthy food stores

there was little association with access to HFS; however, women with low diet knowledge were sensitive to the presence of HFS, resulting in lower Western diet scores.

Compared with their more knowledgeable counterparts, women with low diet knowledge were slightly older (aged 76.0 vs. 74.6 years; $p = 0.002$) and had higher (but not clinically significant) scores on GDS (mean 6.3 vs. 5.0; $p = 0.01$) and SMAF (mean 3.7 vs. 3.0; $p = 0.04$).[26,27] Finally, spatial autocorrelation measures computed for all models' residuals were non-significant: Moran's I ranged from −0.18 to 0.12 (all $p > 0.13$), indicating that no spatial autocorrelation remained in residuals.

DISCUSSION

This exploratory study in a healthy sample of urban-dwelling older women and men replicates previous research investigating the role of nutrition knowledge in diet in older adult populations.[3,5] We further extended previous work by considering the local food environment in which many food choices may occur. We observed that lower diet quality was more strongly related to the relative availability of fast food close to home for men. Among women, this relationship was significant only for those with low diet knowledge. These observed associations with prudent diet pattern were weak but similar to the relationship observed in the Multi-Ethnic Study of Atherosclerosis between availability of healthy foods in food store offerings and the dietary patterns of 759 adults.[30]

Existing evidence on the impact of the food environment on diet is conflicting, and the manner in which to test sex differences remains elusive. Two cross-sectional studies in general adult populations[31,32] reported no sex differences between exposure to the fast-food environment and diet, while one longitudinal study showed that low-income men may be responsive to the availability of fast foods.[14] Two other cross-sectional studies observed a relationship between the food store environment and fruit and vegetable intake for men but not women.[12,16]

Limitations

We chose to stratify but not compare our analyses to separately describe patterns in women and men. We observed a significant moderating effect of diet knowledge among women. When living in a supportive food environment, women with lower knowledge reported less harmful dietary patterns, whereas women living in a less supportive environment reported less healthy eating patterns. Possible explanations might be related to gendered social roles, in which food and health tend to be the domains of women.[15,33] In our cohort, 75% of men were living with a spouse. They may not have developed nutrition-related knowledge for food eaten at home because throughout the years they may have had less responsibility for food shopping and preparation.[33] However, men may be more participative in the selection of food eaten outside the home and may also be more sensitive to unhealthy cues furnished by the presence of fast-food outlets in their environment, regardless of knowledge and marital status.[17,34] Since NuAge food frequency questionnaires did not specifically assess food consumption from restaurants, future studies could distinguish between food eaten at home and food eaten away from home and in fast-food restaurants. Also, there is less socio-demographic variability in the NuAge cohort than in the reference population,[35] and the effect of exposure to food sources on dietary patterns is likely underestimated.[4]

Interestingly, we did not find evidence that HFS exposure influenced prudent diet scores of women or that fast-food outlets exposure influenced Western diet scores differentially as a function of diet knowledge. This result might seem counterintuitive. In the context of metropolitan Montréal, where access to food stores is not generally a problem,[36] the presence of fast-food outlets could prevent the adoption of a healthy diet regardless of the relative availability of HFS. However, using food store type as a proxy for access to healthy food is a limitation of this study. Direct measures of healthy to unhealthy foods stocked in these stores may provide a more nuanced assessment of the food environment, which could improve the assessment of its relation to dietary patterns.[11]

Other limitations include the cross-sectional design, which precludes causal inference, and the applicability of our results to cohorts of older urban adults recruited more recently, who may differ from those analyzed here. Our study context was also limited to 248 of a total of 862 census tracts in which our respondents resided in the Montreal metropolitan area and may not be representative of variation in food environments in the entire region. Other important neighbourhood characteristics related to food access, such as safety of walking routes, were not accounted for in our analyses. However, given that there was no spatial autocorrelation in the residuals in final models, these influences may be limited.

CONCLUSION

To date, few studies have investigated interactions between the food environment and psychosocial moderators of adults' diet, such as self-efficacy and social support[15] or other psychological factors,[17] especially among older adults. Subgroup analysis is a promising avenue for food environment research, especially as such work could inform targeted interventions. Better understanding of the psychosocial moderators in the environmental context where people make food choices could

provide valuable insights for public health policy. Older adults are receptive to health education interventions,[37] and strategies aimed at changing perceptions about the cost, availability and access of healthy food in local stores may be valuable.[38] Reducing the imbalance between the supply of healthy and unhealthy foods in neighbourhoods with a high concentration of seniors, or increasing access to healthy food in the vicinity, for example, by establishing mobile vendors of fruits and vegetables, could be considered as potential intervention approaches.[39] More evidence from longitudinal research and intervention studies is needed.

REFERENCES

1. Payette H, Shatenstein B. Determinants of healthy eating in community-dwelling elderly people. *Can J Public Health* 2005;96(S3):S27–31. PMID: 16042161.
2. Garriguet D. Canadians' eating habits. *Health Rep* 2007;18(2):17–32. PMID: 17578013.
3. Ree M, Riediger N, Moghadasian MH. Factors affecting food selection in Canadian population. *Eur J Clin Nutr* 2007;62:1255–62. PMID: 17671441. doi: 10.1038/sj.ejcn.1602863.
4. Hughes G, Bennett KM, Hetherington MM. Old and alone: Barriers to healthy eating in older men living on their own. *Appetite* 2004;43:269–76. PMID: 15527929. doi: 10.1016/j.appet.2004.06.002.
5. Baker AH, Wardle J. Sex differences in fruit and vegetable intake in older adults. *Appetite* 2003;40(3):269–75. PMID: 12798784. doi: 10.1016/S0195-6663(03)00014-X.
6. Guillaumie L, Godin G, Vezina-Im L-A. Psychosocial determinants of fruit and vegetable intake in adult population: A systematic review. *Int J Behav Nutr Phys Act* 2010;7:12. PMID: 20181070. doi: 10.1186/1479-5868-7-12.
7. McEntee J. Highlighting food inadequacies: Does the food desert metaphor help this cause? *Br Food J* 2009;111:349–63. doi: 10.1108/00070700910951498.
8. Mercille G, Richard L, Gauvin L, Kestens Y, Shatenstein B, Daniel M, Payette H. Associations between residential food environment and dietary patterns in urban-dwelling older adults: Results from the VoisiNuAge study. *Public Health Nutr* 2012;15(11):2026–39. PMID: 22789436. doi: 10.1017/S136898001200273X.
9. Sharkey JR, Johnson CM, Dean WR. Food access and perceptions of the community and household food environment as correlates of fruit and vegetable intake among rural seniors. *BMC Geriatr* 2010;10:32. PMID: 20525208. doi: 10.1186/1471-2318-10-32.
10. Glass TA, Balfour JL. Neighborhoods, aging, and functional limitations. In: Kawachi I, Berkman LF (Eds.), *Neighborhoods and Health*. New York, NY: Oxford University Press, 2003.
11. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18:1172–87. PMID: 22717379. doi: 10.1016/j.healthplace.2012.05.006.
12. Clary CM, Ramos Y, Shareck M, Kestens Y. Should we use absolute or relative measures when assessing foodscape exposure in relation to fruit and vegetable intake? Evidence from a wide-scale Canadian study. *Prev Med* 2015;71:83–87. PMID: 25481095. doi: 10.1016/j.ypmed.2014.11.023.
13. Mason KE, Bentley RJ, Kavanagh AM. Fruit and vegetable purchasing and the relative density of healthy and unhealthy food stores: Evidence from an Australian multilevel study. *J Epidemiol Community Health* 2013;67:231–36. PMID: 23100382. doi: 10.1136/jech-2012-201535.
14. Boone-Heinonen J, Gordon-Larsen P, Kiefe CI, Shikany JM, Lewis CE, Popkin BM. Fast food restaurants and food stores: Longitudinal associations with diet in young to middle-aged adults: The CARDIA Study. *Arch Intern Med* 2011; 171:1162–70. PMID: 21747011. doi: 10.1001/archinternmed.2011.283.
15. Hermstad AK, Swan DW, Kegler MC, Barnette JK, Glanz K. Individual and environmental correlates of dietary fat intake in rural communities: A structural equation model analysis. *Soc Sci Med* 2010;71:93–101. PMID: 20462682. doi: 10.1016/j.socscimed.2010.03.028.
16. Macdonald L, Ellaway A, Ball K, Macintyre S. Is proximity to a food retail store associated with diet and BMI in Glasgow, Scotland? *BMC Public Health* 2011; 11:464. PMID: 21663674. doi: 10.1186/1471-2458-11-464.
17. Paquet C, Daniel M, Knauper B, Gauvin L, Kestens Y, Dube L. Interactive effects of reward sensitivity and residential fast-food restaurant exposure on fast-food consumption. *Am J Clin Nutr* 2010;91:771–76. PMID: 20089726. doi: 10.3945/ajcn.2009.28648.
18. Gaudreau P, Morais JA, Shatenstein B, Gray-Donald K, Khalil A, Dionne I, et al. Nutrition as a determinant of successful aging: Description of the Quebec longitudinal study Nuage and results from cross-sectional pilot studies. *Rejuvenation Res* 2007;10:377–86. PMID: 17708689. doi: 10.1089/rej.2007.0596.
19. Daniel M, Kestens Y. *Montreal Epidemiological and Geographical Analysis of Population Health Outcomes and Neighbourhood Effect: MEGAPHONE (Copyright #1046898)*. Montréal, QC: Centre de recherche du Centre hospitalier de l'Université de Montréal, 2007.
20. Shatenstein B, Nadon S, Godin C, Ferland G. Development and validation of a food frequency questionnaire. *Can J Diet Pract Res* 2005;66:67–75. PMID: 15975195. doi: 10.3148/66.2.2005.67.
21. Slattery ML, Boucher KM, Caan BJ, Potter JD, Ma K-N. Eating patterns and risk of colon cancer. *Am J Epidemiol* 1998;148:4–16. PMID: 9663397. doi: 10.1093/aje/148.1.4-a.
22. Paquet C, Daniel M, Kestens Y, Leger K, Gauvin L. Field validation of listings of food stores and commercial physical activity establishments from secondary data. *Int J Behav Nutr Phys Act* 2008;5:58. PMID: 19000319. doi: 10.1186/1479-5868-5-58.
23. Tabachnick BG, Fidell LS. *Using Multivariate Statistics*, 5th ed. Boston, MA: Allyn and Bacon, 2007.
24. American Dietetic Association. Nutrition and you: Trends 2002. Final Report of Findings. Chicago, IL: American Dietetic Association, 2002. Available at: http://www.eatrightpro.org/resources/media/trends-and-reviews/trends-survey (Accessed January 13, 2016).
25. Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36): I. Conceptual framework and item selection. *Med Care* 30;1992:473–83. PMID: 1593914. doi: 10.1097/00005650-199206000-00002.
26. Yesavage JA, Brink T, Rose TL, Lum O, Huang V, Adey M, et al. Development and validation of a geriatric depression screening scale: A preliminary report. *J Psychiatr Res* 1983;17:37–49. PMID: 7183759. doi: 10.1016/0022-3956(82)90033-4.
27. Hébert R, Desrosiers J, Dubuc N, Tousignant M, Guilbeault J, Pinsonnault E. Le système de mesure de l'autonomie fonctionnelle (SMAF). *Revue de Gériatrie* 2003;28(4):323–36.
28. Fillenbaum GG, Smyer MA. The development, validity, and reliability of the OARS multidimensional functional assessment questionnaire. *J Gerontol* 1981; 36(4):428–34. PMID: 7252074. doi: 10.1093/geronj/36.4.428.
29. QualityMetric Incorporated. SF-36® PCS, MCS and NBS Calculator, 2010. Available at: http://www.sf-36.org/nbscalc/index.shtml (Accessed February 17, 2010).
30. Franco M, Diez-Roux AV, Nettleton JA, Lazo M, Brancati F, Caballero B, et al. Availability of healthy foods and dietary patterns: The Multi-Ethnic Study of Atherosclerosis. *Am J Clin Nutr* 2009;89:897–904. PMID: 19144728. doi: 10.3945/ajcn.2008.26434.
31. Moore LV, Diez Roux AV, Nettleton JA, Jacobs DR, Franco M. Fast-food consumption, diet quality, and neighborhood exposure to fast food. *Am J Epidemiol* 2009;170:29–36. PMID: 19429879. doi: 10.1093/aje/kwp090.
32. Pearce J, Hiscock R, Blakely T, Witten K. A national study of the association between neighbourhood access to fast-food outlets and the diet and weight of local residents. *Health Place* 2009;15:193–97. PMID: 18499502. doi: 10.1016/j.healthplace.2008.04.003.
33. Flagg LA, Sen B, Kilgore M, Locher JL. The influence of gender, age, education and household size on meal preparation and food shopping responsibilities. *Public Health Nutr* 2014;17:2061–70. PMID: 23988018. doi: 10.1017/S1368980013002267.
34. Cohen D, Farley T. Eating as an automatic behavior. *Prev Chronic Dis* 2008; 5(1):A23. PMID: 18082012.
35. Daveluy C, Pica L, Audet N, Courtemanche R, Lapointe F. *Enquête sociale et de santé 1998, 2e éd*. Québec, QC: Institut de la statistique du Québec, 2000.
36. Apparicio P, Cloutier MS, Shearmur R. The case of Montreal's missing food deserts: Evaluation of accessibility to food supermarkets. *Int J Health Geogr* 2007;6:4. PMID: 17295912. doi: 10.1186/1476-072X-6-4.
37. Manilla B, Keller HH, Hedley MR. Food tasting as nutrition education for older adults. *Can J Diet Pract Res* 2010;71(2):99–102. PMID: 20525423. doi: 10.3148/71.1.2010.99.
38. Gustafson AA, Sharkey J, Samuel-Hodge CD, Jones-Smith JC, Cai J, Ammerman AS. Food store environment modifies intervention effect on fruit and vegetable intake among low-income women in North Carolina. *J Nutr Metab* 2012;2012. PMID: 22315676. doi: 10.1155/2012/932653.
39. Jennings A, Cassidy A, Winters T, Barnes S, Lipp A, Holland R, et al.Positive effect of a targeted intervention to improve access and availability of fruit and vegetables in an area of deprivation. *Health Place* 2012;18(5):1074–78. PMID: 22705164. doi: 10.1016/j.healthplace.2012.05.001.

RÉSUMÉ

OBJECTIFS : Les liens entre les environnements alimentaires locaux et les habitudes alimentaires sont importants pour les personnes âgées et pourraient différer selon le sexe. Nous avons examiné séparément pour des femmes et des hommes âgés vivant à Montréal en 2003–2005 ($n = 722$) les associations entre l'exposition aux commerces alimentaires du quartier, la consommation d'aliments et le rôle modérateur des connaissances en nutrition.

MÉTHODE : Nous avons estimé la proportion de débits de restauration rapide (DRP) par rapport à l'ensemble des restaurants et la proportion de

magasins d'alimentation pouvant offrir des aliments sains (MAS) par rapport à l'ensemble des magasins dans un rayon de 500 m autour du domicile des participants. Deux types d'habitudes alimentaires, qualifiées d' « occidentales » et de « prudentes » pour indiquer les régimes de qualité inférieure et supérieure, respectivement, ont été cernés à partir des données de questionnaires sur la fréquence de consommation des produits alimentaires. Les effets uniques et interactifs des connaissances en nutrition et de l'exposition aux commerces alimentaires sur les scores des habitudes alimentaires ont été analysés selon des modèles de régression linéaire distincts selon le sexe.

RÉSULTATS : Chez les hommes, un pourcentage supérieure d'exposition aux DRP était lié à des notes plus faibles pour le régime « prudent » ($\beta = -0{,}18$, $p = 0{,}02$), mais nous n'avons observé aucun effet du pourcentage d'exposition aux MAS, et aucune interaction n'était significative. Chez les femmes, la relation inverse entre le %DRP et le régime « prudent » était la plus forte chez les participantes dont les connaissances en nutrition étaient faibles ($\beta = -0{,}22$, $p < 0{,}01$). Aucune autre association n'était significative.

CONCLUSION : Les habitudes alimentaires des hommes peuvent s'expliquer par des repères malsains associés aux débits de restauration rapide. Chez les femmes, les connaissances en nutrition peuvent entraîner à la fois des relations négatives et positives avec l'environnement alimentaire. En l'absence d'effets principaux cohérents de l'environnement alimentaire sur les scores des habitudes alimentaires, l'analyse par sous-groupe est une piste de recherche prometteuse.

MOTS CLÉS : régime alimentaire; personne âgée; population urbaine; approvisionnement en nourriture; effets modificateurs

Walkable home neighbourhood food environment and children's overweight and obesity: Proximity, density or price?

Ha Le, MSc,[1] Rachel Engler-Stringer, PhD,[1,2] Nazeem Muhajarine, PhD[1,2]

ABSTRACT

OBJECTIVES: To identify characteristics of the food environment associated with child overweight/obesity that could, if subjected to intervention, mitigate the risk of childhood overweight/obesity. We examined whether the proximity to or density of grocery and convenience stores or fast food restaurants, or the prices of healthy food options were more strongly associated with overweight/obesity risk in children.

METHODS: We collected geocoded data by residential addresses for 1,469 children aged 10–14 years and conducted a census of all food outlets in Saskatoon. The Nutrition Environment Measures Survey (NEMS)-Stores and the NEMS-Restaurants were used to measure availability, quality and relative price of healthy food items in stores and restaurants. Children's weight status was calculated on the basis of measured height and weight. Logistic regression was used to test the associations between overweight/obesity and food environment variables.

RESULTS: Within an 800 m walking distance from home, 76% of children did not have access to a grocery store; 58% and 32% had access to at least one convenience store or one fast-food restaurant respectively. A significantly lower odds of overweight/obesity was associated with lower price of healthy food items/options in grocery stores (odds ratio [OR] = 0.87, 95% confidence interval [CI] 0.77–0.99) and fast-food restaurants (OR = 0.97, 95% CI 0.95–0.99) within walking distance of home. Neither the distance to the closest food outlet nor the density of food outlets around children's homes was associated with odds of overweight/obesity.

CONCLUSIONS: Improving economic access to healthy food in food outlets or fast-food restaurants is one strategy to counter childhood overweight/obesity.

KEY WORDS: Environment; public health; child health; obesity

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS42–eS47
doi: 10.17269/CJPH.107.5347

With the increasing prevalence of overweight and obesity in Canada over the past few decades[1] and the minimal success of downstream interventions (educational, behavioural and pharmacological) that target the individual,[2] many have now turned to understanding the role of environments (neighbourhoods, schools, communities) to find solutions within them to stem the growing problem of overweight and obesity.[3–5] This paper focuses on one such environment – food environment closest to home – to understand its relationship with overweight and obesity in children, and to propose solutions for mitigation.

Broadly conceptualized, the food environment includes any opportunity to obtain food, such as accessibility to and availability of food stores, as well as marketing and advertising of food and food products.[6] Glanz and colleagues[6] have proposed a model of the food environment consisting of four interlinked components: the community nutrition environment (food sources available in a community at large), the consumer nutrition environment (typically food available within stores or establishments serving food), the organizational nutrition environment (food available in organizational settings such as schools, hospitals, workplaces) and the information environment (all information related to food typically through marketing or mass media channels).

Of these, researchers have argued that community and consumer nutrition environments are likely to have the broadest effects.[6,7] According to Holsten,[7] the research gaps that are most in need of filling include collecting primary data and conducting direct measures of the consumer and community nutrition environments. Additionally, all types of food outlets (grocery, convenience, restaurant) should be examined together to paint a more complete picture of the community and consumer nutrition environments in a particular locale.

The purpose of this study, then, is to identify factors within a walkable home neighbourhood food environment associated with overweight and obesity in young adolescents in Saskatoon, SK. Specifically, we studied three characteristics of the community and consumer food environments as they relate to child overweight and obesity, namely proximity to food outlets, density of available food outlets within a specified geographic area and costs of food or services available within food retailers or restaurants. We hypothesize that children who had convenient access (proximity) to more sources of healthy food, as compared with unhealthy food, at lower costs are less likely to be overweight or obese, and that

Author Affiliations

1. Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK
2. Saskatchewan Population Health and Evaluation Research Unit, Saskatoon, SK

Correspondence: Nazeem Muhajarine, PhD, Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK S7N 5E5, Tel: 306-966-7940, E-mail: nazeem.muhajarine@usask.ca

Source of Funding: This research was funded by the Canadian Institutes of Health Research (Grant #106643).

Conflict of Interest: None to declare.

these effects will be independent of selected dietary and socio-demographic factors related to children.

METHODS

The data used in this paper are from the Smart Cities, Healthy Kids: Food Environment study begun in 2011 in Saskatoon, SK. The design and methods of the Smart Cities, Healthy Kids study have been described in detail previously.[8] Briefly, this cross-sectional, multi-method study used data collected at multiple levels (children, neighbourhoods, food retail stores and services) and focused on 10–14-year-old children and their food environments. There were 1,469 students recruited from 43 of the 79 elementary schools in Saskatoon who agreed to a written request to participate. This sample of children accounted for 11.5% of the 10–14-year age group of the Saskatoon population according to the 2011 census. Since elementary schools are equally represented in all residential neighbourhoods in Saskatoon, the study sample was a good representation (socio-economically, geographically) of the population of children aged 10–14 years in Saskatoon.

The outcome measure, overweight or obese status vs. underweight and normal weight, was derived by measuring standing height without shoes to the nearest 0.1 cm and weight to the nearest 0.1 kg on a calibrated digital scale. The inputs for calculating the body mass index (BMI) were measured height and weight, and the instrument used was the age- and sex-specific BMI calculator from the World Health Organization (WHO) AnthroPlus version 3.1. Using the 2007 WHO reference standards,[9] we classified children as normal weight (±1 SD of the age-sex specific mean), overweight or obese (>1 SD) or obese (>2 SD).

Children's data were obtained from the Youth and Adolescent Food Frequency Questionnaire (YAQ),[10] anthropometric measurements and demographic data. YAQ was initially developed in the US[10] and has been adapted for Canadian use.[11] Detailed procedures for conducting dietary assessment in our study are given elsewhere.[8] For the purpose of this paper, we included as covariables derived nutrition-related factors such as food groups and macro- and micro-nutrient status, since earlier studies have found them to be related to BMI or weight status in children.[11,12] Since demographic characteristics and socio-economic status may influence children's weight status, we considered the following covariables as well: age in years, sex, Aboriginal status and self-reported family economic situation.[13]

A comprehensive database inventory of all restaurants, grocery stores, convenience stores and specialty food stores located within the city limits of Saskatoon was built, initially using the City of Saskatoon business licences database. This list was cross-checked with information from the phone book. The list of food outlets was later confirmed and completed in February 2011, when research assistants visited each neighbourhood in Saskatoon to conduct a census of the food environments. For the research reported here, we focused on all manner of grocery stores, convenience stores and fast-food restaurants. Grocery stores included both large supermarkets and small ones, as well as ethnic groceries, as long as they contained a full range of food items.[14] The convenience store category included gasoline stations and pharmacies where food items are sold.[14] The fast-food restaurants included all types of fast-food restaurant – burger and chicken, pita and sandwich, pizza and ethnic fast-food restaurants, as well as chain coffee shops, which are similar to fast-food restaurants in offering high-calorie foods and beverages (e.g., donuts, pastries) at lower price points and with minimal table service.[15]

The Nutrition Environment Measures Survey for Stores (NEMS-S)[14] and the Nutrition Environment Measures Survey for Restaurants (NEMS-R)[15] are structured observational tools that were used to characterize the nutrition environments of Saskatoon restaurants and retail food stores. The NEMS-S instrument measures the availability and pricing differences between healthier and less healthy options and the quality of fruit and vegetables (based on the percentage of acceptable ratings, and the total amount of varieties available). The scoring procedures for NEMS-S[14] involve positive scores for the availability of healthy food options in a store and the acceptability of fruit and vegetable quality, and negative scores for higher prices for healthy food options: the higher the score the better the consumer food environment. On the basis of the survey results, a total score (ranging from −9, least healthy, to 54, most healthy) was calculated by summing the scores for each NEMS-S item assessed.

The NEMS-R instrument measures the healthfulness of foods and beverages available on restaurants' menus, the main menu and children's, with a focus on availability of healthy entrées, side dishes and beverages; facilitators or supports for healthy eating; barriers to healthy eating; and relative pricing for healthy and less healthy choices. The scoring procedures for NEMS-R[15] involve positive scores for the availability of healthy options in the restaurant, nutrition information and facilitators encouraging healthful eating, and negative scores for barriers to healthy eating as well as extra costs for healthy food. On the basis of the survey results, a total quality score for restaurant food environments (ranging from −27, least healthy, to 63, most healthy) was calculated by summing the scores for each NEMS-R item assessed.

Children's walkable neighbourhood food environment was defined using a buffer zone area of a defined geographic distance from a child's residence. We considered distances of 500 m and 800 m from a child's home along the street network to be within walking distance, labeled "walkable neighbourhood from home". Most urban planners assume a half mile (805 m) to be walking distance.[16] Previous research has also used the half mile measure of proximity.[17,18]

Using ArcGIS 10.2 (Environmental Systems Research Institute Inc, Redlands, CA, 2010), the locations of food outlets were geocoded, along with the children's home addresses. Using these geocoded data we created the following walkable neighbourhood food environment indicators: 1) proximity to a food outlet (closest distance, via street network, from a student's home to each type of food outlet); 2) density of food outlets within the 500 and 800 m network buffer zones (counts of each type of food outlet); and 3) price of the overall quality of food consumable within restaurants and retail stores. Overall quality of food was calculated by summing two totals: the total of NEMS-S scores of each type of food stores (grocery, convenience) and the total of NEMS-R scores of fast-food restaurants within each defined neighbourhood.

Data analysis

After data entry was completed we omitted data for 103 children from further analysis. These non-retained respondents comprised

2 children whose data were incomplete, 59 who resided outside the Saskatoon city boundaries, 3 whose BMIs were either greater than 3 SD from the age- and sex-specific mean or were less than –3 SD,[19] and 39 who reported average energy intakes of less than 500 kcal or greater than 5000 kcal/day.[11,19] A further 145 students did not provide accurate address information, therefore the final sample remaining for logistic regression consisted of 1,221 students.

We used multivariable regression models to estimate associations between respondents' weight status and the variables of the walkable neighbourhood food environment. Variables were entered into multivariable logistic models in blocks. Block 1 consisted of socio-demographic variables such as sex, age, Aboriginal status, self-reported family economic situation; Block 2 dietary intake variables such as food group consumption, macro- and micro-nutrient intakes; and Block 3 the food environment indicators as described above, proximity to food outlets, availability of food outlets and relative price.

Odds ratios (OR) and 95% confidence intervals (CI) were calculated. The final model included only variables that were significant at a p value less than 0.05. SPSS version 18 was used for data analysis.

RESULTS

Of our sample of children aged 10–14 years, 55% were girls and 45% were boys; 15% of children self-identified as Aboriginal; 10.5% of the children reported their family economic situation as well-off, 68% as average and 5% as poor (17% had a missing value). In this sample 24.3% (95% CI 21.2–25.7) were classified as overweight, and 12.0% (95% CI 12.4–16.0) were obese (Table 1).

Table 1. Characteristics of the study participants*

Variable	Frequency (*n*)	Percentage (%)
Sex ($n=1408$)		
Female	776	55.1
Male	632	44.9
Age ($n=1408$)		
10	265	18.9
11	399	28.3
12	363	25.8
13	279	19.8
14	102	7.2
Aboriginal status ($n=1408$)		
Yes	208	14.8
No	1184	84.1
Missing	16	1.1
Self-rated family economic situation ($n=1408$)		
Well-off	148	10.5
Average	958	68.0
Poor	66	4.7
Missing	236	16.8
Body mass index ($n=1331$)		
Normal	678	51.0
Overweight	323	24.3
Obese	160	12.0
Underweight	170	12.7

* 1469 children agreed to participate; 59 cases were removed because they resided outside of Saskatoon, 2 cases were removed because of incomplete information. For calculation of BMI, an additional 43 cases were removed because of extreme or improbable values: 3 with BMI < –3 SD and BMI > 3 SD, and 39 with total calories consumed of <500/d and >5000/d.

Table 2 shows the mean, median, minimum and maximum closest distance (all measures in metres) to a grocery or a convenience store or a fast-food restaurant using road network distance. Overall, the mean closest network distance from children's residence to a grocery store was 1381 m, to a convenience store 803 m and to a fast-food restaurant 1236 m.

Table 3 presents the number and percentage of children who had 0, 1, or 2 or more of the food outlets and fast food-restaurants within walking distance from home. As shown, a large percentage of children (89% within 500 m or 76% within 800 m road network buffers) did not have access to a grocery store within walking distance from their homes; in contrast, 58% and 32% of children could access at least one convenience store or fast-food restaurant respectively within an 800 m walk of their home.

Table 4 presents the final multivariable logistic model showing significant covariables that were associated with overweight or obesity in the participants of this study. We found that a healthier consumer nutrition environment – i.e., healthy food options, at lower prices, in grocery stores or restaurants – was significantly associated with lower odds of overweight or obesity. Children who had access to higher quality and more affordable healthy food options in grocery and convenience stores in their home neighbourhoods had a significantly lower risk of being overweight or obese (OR = 0.87, 95% CI 0.77–0.99). Similarly, children whose walkable neighbourhoods offered more affordable prices and fewer barriers for healthy food options in fast-food restaurants had a lower risk of being overweight or obese (OR = 0.97, 95% CI 0.95–0.99). We did not find, however, statistically significant associations between distance to grocery stores or restaurants, or the density (number of retail or food services outlets within a given geographic area) of food outlets, and overweight and obesity in this study.

We found several other significant factors independently associated with overweight or obesity. The frequency of meat and meat-alternatives consumption increased the odds of being overweight or obese – the more the consumption the higher the odds of being overweight or obese. Children who reported the highest or moderate levels of meat consumption (3rd or 2nd tertiles), compared with those who consumed at the lowest level, had significantly increased odds of overweight or obesity: more than 2 times (OR = 2.14, 95% CI 1.33–3.45) or 77% greater odds (OR = 1.77, 95% CI 1.21–2.56) respectively. In contrast, high intake of monounsaturated fat or low intake of sodium was associated with lower odds of overweight or obesity (OR for monounsaturated fat 0.51, 95% CI 0.34–0.78, and OR for sodium 0.56, 95% CI 0.36–0.87). Significant associations were also found indicating increased odds of overweight and obesity for males, children 11, 12, 13 or 14 years of age compared with 10 years, and for children of Aboriginal status.

DISCUSSION

Prior to this not many studies have described the walkable community nutrition environment centred on children's place of residence (proximity to and density of food outlets and fast-food restaurants) and the consumer nutrition environment (pricing, quality of food items within the stores or restaurants) together. The results here suggest that young children in Saskatoon have greater access to potentially unhealthy food sources, compared with healthy food, within walking distance of 500–800 m from their

Table 2. Closest distance (all in metres) from children's residence to a food outlet or a fast food restaurant

		Mean distance (SD)	Median distance	Minimum distance	Maximum distance
Grocery store	Network distance	1381 (717)	1274	22	4014
Convenience store	Network distance	803 (483)	691	5	3556
Fast-food restaurant	Network distance	1236 (760)	1078	15	3804

Table 3. Density of food outlets or fast-food restaurants within walking distance from home (metres)

		Network buffer distance	
Food outlet	**Counts**	**500 m, *n* (%)**	**800 m, *n* (%)**
Grocery stores	0	1102 (89.2)	939 (76.0)
	1	110 (8.9)	204 (16.5)
	2	24 (1.9)	93 (7.5)
Convenience stores	0	872 (70.6)	517 (41.8)
	1	228 (18.4)	345 (27.9)
	2 or more	136 (11.0)	374 (30.3)
Fast-food restaurants	0	1037 (83.9)	846 (68.4)
	1	89 (7.2)	129 (10.4)
	2 or more	110 (8.9)	261 (21.1)
Retail food outlets (convenience and grocery stores)	0	839 (67.9)	489 (39.6)
	1	212 (17.2)	306 (24.8)
	2 or more	185 (15.0)	441 (35.7)

Table 4. Neighbourhood food environment factors (within an 800 m network buffer zone from home), nutrient intake and socio-demographic factors associated with overweight/obesity in children aged 10–14 years in Saskatoon

Associated factor	**Odds ratio (95% confidence interval)**	***p* value**
Higher quality and lower price (score) for healthier food options in grocery and convenience stores	0.87 (0.77–0.99)	0.032
Higher quality and lower price (score) for healthier food options in fast-food restaurants	0.97 (0.95–0.99)	0.014
Meat and meat alternatives (number of servings daily)		
Low (bottom third)	1.00	
Moderate (middle third)	1.77 (1.21–2.56)	0.003
High (top third)	2.14 (1.33–3.45)	0.002
Monounsaturated fats intake		
High (top half)	0.51 (0.34–0.78)	
Low (bottom half)	1.00	0.002
Sodium intake		
Low (equal to or less than 2000 mg/d)	0.56 (0.36–0.87)	
High (more than 2000 mg/d)	1.00	0.010
Sex		
Female	1.00	
Male	2.20 (1.66–2.93)	<0.001
Age in years		
10	1.00	
11	2.17 (1.34–3.50)	0.002
12	2.10 (1.30–3.41)	0.003
13	4.30 (2.63–7.03)	<0.001
14	4.13 (2.22–7.68)	<0.001
Aboriginal status		
Non-Aboriginal	1.00	
Aboriginal	2.92 (1.92–4.40)	<0.001
Family economic situation		
Well-off	1.00	
Average	1.27 (0.81–1.99)	0.294
Poor	1.99 (0.97–4.10)	0.061

home. The nearest grocery store was, on average, 1381 m from home, whereas the distance to a convenience store was 803 m and to a fast-food restaurant was 1236 m. A large percentage of children did not have access to a grocery store within walking distance from home (89% of children did not have access within 500 m of their home, and 76% children had no access within 800 m). It is normally assumed that grocery stores offer a fuller range of options, including healthy foods at an affordable cost,[20] and that convenience stores and fast-food restaurants sell mostly unhealthy food items.[21] The relevance of designating food stores in this manner for children has been questioned, however; furthermore, as reported here, proximity to food outlets or how many outlets are available within easy access may not be the primary factor of concern in terms of increased risk of overweight or obesity in children.[22,23]

This study reports that another type of accessibility – specifically the cost of food within the stores and meals within restaurants and their quality – around children's homes has a significant association with weight status, independent of factors such as the type of food children consume (i.e., meat and meat alternatives, fat or salt content in food) or key demographic factors such as age, sex, Aboriginal status or economic situation of the family. Children who had access to affordable healthy food options within walking distance from home (800 m) had a lower likelihood of being overweight or obese. These results agree with the findings from a review by Powell and Chaloupka, who found significant effects of food prices on weight outcomes.[24] Similarly, in a longitudinal study, Sturm and Datar showed that changes in children's weight were positively related to the price of fruits and vegetables.[25] In another study, in which Sturm and Datar followed children from kindergarten up to fifth grade, they confirmed their previous finding, that children's BMI was sensitive to changes in fruit and vegetable prices.[26] These results suggest that lower prices for healthy food options such as fruits and vegetables within a walkable distance from home may help to mitigate development of overweight or obesity in children.

Similar to An and Sturm,[22] we found no evidence, however, to support the hypotheses that improved access, i.e., proximity or distance to supermarkets, or decreased exposure to fast-food restaurants or convenience stores within walking distance, is associated with lower odds of overweight or obesity. This may be

due to several reasons. First, our study applied 500 and 800 m definitions of street network buffers around children's homes to operationally define a walkable neighbourhood food environment from home. However, these definitions assume that children, or indeed their parents, do in fact shop for food items closer to where they live. These assumptions need to be tested and measures incorporated in future studies to show that participants actually shop at food outlets closer to their home. Some studies have reported that most people do not shop for food primarily at stores near where they reside.[23] Drewnowski et al.'s study, on adults, reported that only 14% of the respondents in Seattle and 11.4% in Paris shopped for food either at the closest supermarket or in their own residential neighbourhood. They argued that shoppers seem to be willing to travel longer distances from home to arrive at the supermarket of their choice or that they use supermarkets on their daily activity routes rather than specifically near their home.[23]

Second, although it was normally assumed that grocery stores offer healthy foods at an affordable cost[20] and that convenience stores and fast-food restaurants sell mostly unhealthy food items,[21] Powell and Chaloupka argued that much of the revenue in supermarkets comes from the wider selection of soft drinks, sweets, salty snacks or frozen dinners, which are available at lower prices and in larger packaged sizes.[24] According to these arguments, one interpretation and implication of our data is that categorizing food outlets by general types, e.g., grocery stores, convenience stores, fast-food restaurants, is at best a crude and shorthand way of classifying a complex phenomenon and, at worst, would tend to produce uninformative or even misleading results. Future research on food environments should either break with or significantly improve on precedence when using broad classification systems to identify healthy and unhealthy food environments. As our study has shown, continuing to assume that healthy food at affordable prices is available on the basis simply of distance to or availability of broadly classified food outlets (grocery stores, convenience stores) or fast-food restaurants is no longer helpful in this field of study.

Strengths and limitations

Our study has a number of strengths. We conducted a census of food retail and food service establishments in one city, at one point in time, using direct observation and standardized tools. This allowed us to comprehensively document and describe, by direct observation, the neighbourhood food environment: location of food outlets, types, food quality and price. Second, we defined neighbourhood food environments in relation to participating children's homes and used two different distances (500 and 800 m) to define a walkable environment. We used children's actual home address for geocoding, which allows for the correct classification of the presence or absence of certain environmental features.[27,28] Third, our characterization of the local neighbourhood food environment was theoretically driven (i.e., Glanz et al.), and we specifically operationalized Glanz et al.'s food environment dimensions of community and consumer food environments.[6] This enabled us to focus on not only measures that are often used in other studies, such as availability of food establishments and closest distance to establishments,[21,29] but also the price and quality of food within these establishments. Fourth, we also directly measured height and weight, which allows for accurate classification of children's weight status. Socio-economic and demographic data and detailed dietary intake of children allow adjustment for potential confounders in the analyses.

The current study also has limitations. Its cross-sectional nature does not allow for the detection of any cause-and-effect relationship in the association observed. However, Hanibuchi et al. argued that even with longitudinal data the causal association between food outlets or dietary practices and BMI can be problematic because of residential selection and store location preferences.[30] Papas et al. argued that many "desirable" characteristics of neighbourhoods tend to cluster, therefore it is important to check that any putative influence of the food environment on obesity is not confounded by co-occurring built environment characteristics.[29] The measure of children's family socio-economic status from self-reported data likely has limitations (misclassification). Finally, generalizability issues need to be taken into account before applying the results of this study to other cities with similar characteristics of the food environment.

CONCLUSIONS

Guided by a theoretical understanding of the food environment – specifically, community and consumer food environments (Glanz et al.) – this study aimed to provide answers to the questions, Do children have greater (or lesser) access to healthy versus unhealthy food sources from their homes, and What characteristics of the neighbourhood food environment (proximity, density or costs of food and quality) are associated with overweight and obesity in children. A majority of children 10–14 years of age in Saskatoon do not have easy access to healthy food retail establishments. Most important, lower prices for healthy food options in grocery and convenience stores and fast-food restaurants are associated with decreased odds of overweight or obesity. Interventions to reduce food prices for healthy options in food outlets and restaurants in neighbourhoods may have favourable effects on children's weight outcomes.

REFERENCES

1. Roberts KC, Shields M, De Groh M, Aziz A, Gilbert JA. Overweight and obesity in children and adolescents: Results from the 2009 to 2011 Canadian Health Measures Survey. *Health Rep* 2012;23(3):37–41. PMID: 23061263. Catalogue no. 82-003-XPE.
2. Summerbell CD, Waters E, Edmunds LD, Kelly S, Brown T, Campbell KJ. Interventions for preventing obesity in children. *Cochrane Database Syst Rev* 2005;3:1–70. PMID: 16034868. doi: 10.1002/14651858.CD001871.pub2.
3. Morland K, Wing S, Roux AD. The contextual effect of the local food environment on residents' diets: The atherosclerosis risk in communities study. *Am J Public Health* 2002;92(11):1761–68. PMID: 12406805. doi: 10.2105/AJPH.92.11.1761.
4. Laraia BA, Siega-Riz AM, Kaufman JS, Jones SJ. Proximity of supermarkets is positively associated with diet quality index for pregnancy. *Prev Med* 2004; 39(5):869–75. PMID: 15475018. doi: 10.1016/j.ypmed.2004.03.018.
5. Wang MC, Gonzalez AA, Ritchie LD, Winkleby MA. The neighborhood food environment: Sources of historical data on retail food stores. *Int J Behav Nutr Phys Act* 2006;3(1):15. PMID: 16846518. doi: 10.1186/1479-5868-3-15.
6. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *Am J Health Promot* 2005;19(5):330–33. PMID: 15895534. doi: 10.4278/0890-1171-19.5.330.
7. Holsten JE. Obesity and the community food environment: A systematic review. *Public Health Nutr* 2009;12(3):397–405. PMID: 18477414. doi: 10.1017/S1368980008002267.
8. Engler-Stringer R, Muhajarine N, Le H, Del Canto S, Ridalls T. Characterizing the Food Environment in Saskatoon for Families with Children: Research Methods and Descriptive Results. *Saskatchewan Population Health and Evaluation Research Unit, Saskatoon* 2014. Available at: http://www.spheru.ca/publications/files/FINAL%20Food%20Environment%20Technical%20Report.pdf (Accessed April 17, 2016).

9. *WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents*. Geneva: World Health Organization, 2009. Available at: http://www.who.int/growthref/tools/en/.
10. Rockett HR, Berkey CS, Colditz GA. Comparison of a short food frequency questionnaire with the Youth/Adolescent Questionnaire in the Growing Up Today Study. *Int J Pediatr Obes* 2007;2(1):31–39. PMID: 17763008. doi: 10.1080/17477160601095417.
11. Veugelers PJ, Fitzgerald AL. Prevalence of and risk factors for childhood overweight and obesity. *Can Med Assoc J* 2005;173(6):607–13. PMID: 16157724. doi: 10.1503/cmaj.050445.
12. Matthews VL, Wien M, Sabaté J. The risk of child and adolescent overweight is related to types of food consumed. *Nutr J* 2011;10(1):71–74. PMID: 21702912. doi: 10.1186/1475-2891-10-71.
13. Shrewsbury V, Wardle J. Socioeconomic status and adiposity in childhood: A systematic review of cross-sectional studies 1990–2005. *Obesity* 2008; 16(2):275–84. PMID: 18239633. doi: 10.1038/oby.2007.35.
14. Glanz K, Sallis JF, Saelens BE, Frank LD. Nutrition Environment Measures Survey in stores (NEMS-S): Development and evaluation. *Am J Prev Med* 2007; 32(4):282–89. PMID: 17383559. doi: 10.1016/j.amepre.2006.12.019.
15. Saelens BE, Glanz K, Sallis JF, Frank LD. Nutrition environment measures study in restaurants (NEMS-R): Development and evaluation. *Am J Prev Med* 2007;32(4):273–81. PMID: 17383558. doi: 10.1016/j.amepre.2006.12.022.
16. Agrawal AW, Schlossberg M, Irvin K. How far, by which route and why? A spatial analysis of pedestrian preference. *J Urban Des* 2008;13(1):81–98. doi: 10.1080/13574800701804074.
17. Austin SB, Melly SJ, Sanchez BN, Patel A, Buka S, Gortmaker SL. Clustering of fast-food restaurants around schools: A novel application of spatial statistics to the study of food environments. *Am J Public Health* 2005;95(9):1575–81. PMID: 16118369. doi: 10.2105/AJPH.2004.056341.
18. Zenk SN, Powell LM. U.S. secondary schools and food outlets. *Health Place* 2008;14(2):336–46. PMID: 17881277. doi: 10.1016/j.healthplace.2007.08.003.
19. Rockett HR, Berkey CS, Field AE, Colditz GA. Cross-sectional measurement of nutrient intake among adolescents in 1996. *Prev Med* 2001;33(1):27–37. PMID: 11482993. doi: 10.1006/pmed.2001.0850.
20. Larson NI, Story MT, Nelson MC. Neighborhood environments: Disparities in access to healthy foods in the U.S. *Am J Prev Med* 2009;36(1):74–81.e10. PMID: 18977112. doi: 10.1016/j.amepre.2008.09.025.
21. Fleischhacker SE, Evenson KR, Rodriguez DA, Ammerman AS. A systematic review of fast food access studies. *Obes Rev* 2011;12(5):e460–71. PMID: 20149118. doi: 10.1111/j.1467-789X.2010.00715.x.
22. An R, Sturm R. School and residential neighborhood food environment and diet among California youth. *Am J Prev Med* 2012;42(2):129–35. PMID: 22261208. doi: 10.1016/j.amepre.2011.10.012.
23. Drewnowski A, Moudon AV, Jiao J, Aggarwal A, Charreire H, Chaix B. Food environment and socioeconomic status influence obesity rates in Seattle and in Paris. *Int J Obes* 2014;38(2):306–14. PMID: 23736365. doi: 10.1038/ijo.2013.97.
24. Powell LM, Chaloupka FJ. Food prices and obesity: Evidence and policy implications for taxes and subsidies. *Milbank Q* 2009;87(1):229–57. PMID: 19298422. doi: 10.1111/j.1468-0009.2009.00554.x.
25. Sturm R, Datar A. Body mass index in elementary school children, metropolitan area food prices and food outlet density. *Public Health* 2005; 119(12):1059–68. PMID: 16140349. doi: 10.1016/j.puhe.2005.05.007.
26. Sturm R, Datar A. Food prices and weight gain during elementary school: 5-year update. *Public Health* 2008;122(11):1140–43. PMID: 18539306. doi: 10.1016/j.puhe.2008.04.001.
27. Bow CJD, Waters NM, Faris PD, Seidel JE, Galbraith PD, Knudtson ML, Ghali WA. Accuracy of city postal code coordinates as a proxy for location of residence. *Int J Health Geogr* 2004;3(1):5. PMID: 15028120. doi: 10.1186/1476-072X-3-5.
28. Healy MA, Gilliland JA. Quantifying the magnitude of environmental exposure misclassification when using imprecise address proxies in public health research. *Spat Spatiotemporal Epidemiol* 2012;3(1):55–67. PMID: 22469491. doi: 10.1016/j.sste.2012.02.006.
29. Papas MA, Alberg AJ, Ewing R, Helzlsouer KJ, Gary TL, Klassen AC. The built environment and obesity. *Epidemiol Rev* 2007;29(1):129–43. PMID: 17533172. doi: 10.1093/epirev/mxm009.
30. Hanibuchi T, Kondo K, Nakaya T, Nakade M, Ojima T, Hirai H, Kawachi I. Neighborhood food environment and body mass index among Japanese older adults: Results from the Aichi Gerontological Evaluation Study (AGES). *Int J Health Geogr* 2011;10:43. PMID: 21777439. doi: 10.1186/1476-072X-10-43.

RÉSUMÉ

OBJECTIFS : Cerner les caractéristiques de l'environnement alimentaire associées au surpoids/à l'obésité des enfants qui pourraient, si elles étaient soumises à une intervention, atténuer le risque de surpoids/d'obésité juvénile. Nous avons cherché à déterminer si la proximité ou la densité des épiceries, des dépanneurs ou des restaurants rapides, ou les prix des choix alimentaires sains, étaient plus fortement associés au risque de surpoids/d'obésité chez les enfants.

MÉTHODE : Nous avons recueilli des données géocodées par adresse résidentielle pour 1,469 enfants de 10–14 ans et recensé tous les points de vente alimentaires de Saskatoon. Nous avons utilisé les sondages Nutrition Environment Measures Survey (NEMS)-Stores et NEMS-Restaurants pour mesurer la disponibilité, la qualité et le prix relatif des produits alimentaires dans les magasins et les restaurants, respectivement. Le statut pondéral des enfants a été calculé à partir de la taille et du poids mesurés. Nous avons procédé par régression logistique pour tester les associations entre le surpoids/l'obésité et les variables de l'environnement alimentaire.

RÉSULTATS : À distance de marche de 800 m de leur domicile, 75% des enfants n'avaient pas accès à une épicerie; 60% et 33% avaient accès à au moins un dépanneur ou un restaurant rapide, respectivement. Une probabilité significativement plus faible de surpoids/d'obésité était associée aux prix plus bas des produits ou des choix alimentaires sains dans les épiceries (rapport de cotes [RC] = 0.87, intervalle de confiance [IC] de 95%: 0.77–0.99) et les restaurants rapides (RC = 0.97, IC de 95%: 0.95–0.99) situés à distance de marche du domicile. Ni la distance du point de vente alimentaire le plus proche, ni la densité des points de vente alimentaires autour des domiciles des enfants n'était associée à la probabilité de surpoids/d'obésité.

CONCLUSIONS : Améliorer l'accès économique aux aliments sains dans les points de vente alimentaires ou les restaurants rapides est une stratégie pour contrer le surpoids/l'obésité juvénile.

MOTS CLÉS : environnement; santé publique; santé de l'enfant; obésité

An examination of the roles played by early adolescent children in interactions with their local food environment

Rachel Engler-Stringer, PhD,[1] Joelle Schaefer, BSc,[2] Tracy Ridalls, MA[3]

ABSTRACT

OBJECTIVES: The purpose of this study was to examine how pre- and early adolescent (10–14 years old) children from a wide range of neighbourhoods interact with their local food environment (FE), with a focus on the foods and food sources they access and their locations. Children in this age group are developing independence and mobility within (and beyond) their home neighbourhoods but are somewhat geographically bound as they cannot yet drive.

METHODS: This research consists of qualitative interviews with 31 children (15 males, 16 females) aged 10–14 years living in socio-economically diverse neighbourhoods across Saskatoon, SK. A thematic analysis was conducted.

RESULTS: Children's descriptions of what constitutes their neighbourhood FE were varied, ranging from a couple of city blocks to several kilometres from home. Children were familiar with the types of establishment that sell food within their perceived neighbourhood. When children purchased their own food they most frequently cited buying snacks such as ice cream, candy and slushes, and the majority of these purchases were made in convenience stores, gas stations and grocery stores. Few children reported frequenting fast-food or other restaurants without adults, and when they did it was usually to buy snacks such as French fries and ice cream rather than meals.

CONCLUSIONS: Our results highlight the importance of interventions targeted to this age group, in which personal food choices were reported almost exclusively as being energy- but not nutrient-dense snack foods.

KEY WORDS: Children; environment; diet; food and nutrition; eating

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS48–eS52
doi: 10.17269/CJPH.107.5296

Increasing international evidence suggests that the environments in which people live, work and play have an important role in determining their health,[1,2] including obesity and dietary patterns.[3,4] Built environments in North America generally promote energy-dense food and offer little incentive for living active lifestyles,[5] particularly in low-income neighbourhoods.[6] Food environments (FEs) specifically, are increasingly being recognized as a critical determinant of community and population health.[4,7,8]

"The food environment can be broadly conceptualized to include any opportunity to obtain food. This definition of the food environment can include physical, socio-cultural, economic and policy factors at both micro- and macro-levels."[7] Examination of the impact of the FE on families' and children's health will help determine how changes in the FE may result in successful prevention of obesity and its associated health problems.

The FE literature is particularly lacking when it comes to qualitative research. Studies have used primarily cross-sectional designs and geographic information systems to measure the community FE, specifically the accessibility and availability of different types of food sources.[9,10] These studies typically characterize healthy food sources at the neighbourhood level as full-service grocery stores, whereas fast-food restaurants and convenience stores are considered to be unhealthy food sources.[11] Up until quite recently few studies have taken their analyses beyond these simple characterizations.

There are a few studies using qualitative methods to better understand adults' perceptions of and interactions with the FE,[12–15] but children and the FE continues to be a major gap. Previous studies have found that children frequently purchase and consume energy-dense snack foods and sugar-sweetened beverages from stores near their school and home, and when they are guests in others' homes; however, there is limited qualitative research on the local FE of early adolescent children and their food purchasing decisions.[16–19]

The purpose of this study was to examine how pre- and early adolescent (10–14 years old) children from a wide range of neighbourhoods interact with their local FE, with a focus on the foods and food sources they access and their locations. Children in this age group are developing independence and

Author Affiliations

1. Associate Professor, Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK
2. Doctoral student, Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK
3. Research Manager, Saskatchewan Population Health and Evaluation Research Unit, University of Saskatchewan, Saskatoon, SK

Correspondence: Rachel Engler-Stringer, PhD, Department of Community Health and Epidemiology, University of Saskatchewan, Health Science Building, 107 Wiggins Road, Saskatoon, SK S7N 5E5, Tel: 306-966-7839, E-mail: Rachel.engler-stringer@usask.ca

Acknowledgements: We thank the Canadian Institutes of Health Research (fund 106643) and the Saskatchewan Health Research Foundation New Investigator Establishment Grant program for funding this study; the Smart Cities, Healthy Kids: Food Environment research team for its assistance; and Nazeem Muhajarine in particular for his mentorship and Mel Brockman for her critical review of the first draft.
Conflict of Interest: None to declare.

mobility within (and beyond) their home neighbourhoods but are somewhat geographically bound as they cannot yet drive.

METHODS

Data collection consisted of in-depth qualitative interviews with children aged 10–14 years living in socio-economically diverse neighbourhoods across Saskatoon, a mid-sized Canadian city. The interviews were the final phase of a four-phase study characterizing the FE in Saskatoon for families with children. The detailed study design and some results from the first three phases of the study have been reported on previously.[20–22] The study received approval from the Behavioural Research Ethics Board at the University of Saskatchewan.

Letters inviting participation in the qualitative interviews were sent to 900 families who had consented to further contact for research purposes after the third phase of the research. When parents responded, their neighbourhood of residence was confirmed and they were asked whether or not they owned a vehicle. A total of 43 families responded, and a final sample of 28 families was chosen using maximum variation purposeful sampling.[23] The 28 reflect a wide range of neighbourhoods across the city that were based on median income level, geographic characteristics and neighbourhood types and included households that did not own a vehicle. After interviews had been conducted with the 28 families we found that data saturation had been reached.[24]

In three of the 28 families there were two children in the 10–14 year age group, and so both children were interviewed. In-depth semi-structured interviews were conducted with parents and children separately (interviews with the parent and the child were conducted at the same time in two different parts of the family home). This research reports only on the interviews with the children, while the results of the interviews with the parents are in publication. The purpose of these interviews was to investigate how pre-adolescent children understand and interact with their local FE. Questions included whether, where, when and how children access the food they eat on their own and with others, and the types of food they purchase on their own as compared with their stated food preferences.

Interviews were 20 to 60 minutes in length. All child interviews were conducted by the third author, tape-recorded and transcribed verbatim, then returned for child participants and their parents to review along with a transcript release form to be signed.

Data analysis was done using QSR NVivo 10 qualitative analysis software (QSR International (Americas) Inc., Burlington, MA). For the purposes of this publication, transcripts were reviewed and data categories were created on an emergent basis from the data, with a focus on participants' descriptions of their local FE, the food outlets they access on their own and with others, their food choices within these establishments as compared with their stated food preferences, and their explanations of how and why they interact with their FE in the ways that they do. All data within each category were then analyzed for nuanced meanings and compared with other categories. This was done so that the themes that emerged could be incorporated into theories of the topic.

RESULTS

Of the 31 participants, 15 were male and 16 were female; 7 were 13 and 14 years of age, 21 were 11 and 12 years of age, and 3 were 10 years of age. The income level of participants' neighbourhoods of residence were categorized as low ($n = 10$), mid ($n = 13$) and high ($n = 8$). Neighbourhood of residence was used as the socio-economic indicator for each family. There was one family without a vehicle and one in which the mother could not drive because of health reasons (both lived in low-income neighbourhoods). All high-income neighbourhood participants lived in suburbs where the most high-income neighbourhoods in Saskatoon are located.

One child participant had moved to Canada in the previous five years, and five self-identified as Aboriginal. The child who was a newcomer and three of the Aboriginal children lived in low-income neighbourhoods.

While the children's interviews focused on various aspects of their FE, the results reported on here focus primarily on the local FE as described by the children, the food types purchased by children in these outlets and their stated food preferences. The main themes that emerged on these topics included 1) knowledge and meaning of the local FE, 2) preferred food sources and choices made, 3) favourite foods and cooking, and 4) safety concerns.

Overall, regardless of neighbourhood of residence the children had similar responses, and the results are first presented showing common patterns among all participants, followed by the few results that were divergent according to neighbourhood of residence.

Theme 1 – Knowledge and meaning of local FE

The child participants' sense of distance was not consistent, but they were almost all very aware of places near their homes where food could be purchased. Some children (less than a third) thought their neighbourhood included just a few blocks around their home, whereas others named places several kilometres away as being within their neighbourhood. Most could name a long list of outlets and were familiar with grocery stores, fast food restaurants, convenience stores, gas stations and pharmacies located in what they considered their neighbourhood. Only a few participants mentioned other types of restaurants. Some participants listed places that were as far as 2–3 km away from their homes:

> **Child:** *Yeah, restaurants, there is lots of fast food, it's Dairy Queen, McDonald's, Tim Horton's, there's a KFC, a Wendy's, a Wok Box, lots of places like that. Convenience stores there's Macs, that's all I can think of.*
>
> **Interviewer:** *Okay and grocery stores?*
>
> **Child:** *Yeah, there is Extra Foods, Shoppers if that counts… From my house, if I was walking, for sure an hour.*

The shopping area that she was referring to was just under 2.5 km from her home and was indeed the closest shopping area. Overall, the high-income neighbourhood residents described their neighbourhoods as being slightly larger in terms of geographic size, which is consistent with those neighbourhoods being suburban, with larger houses more distant from each other.

Theme 2 – Preferred food sources and choices made

When asked which grocery stores were their favourites to frequent, almost all of the children reported liking big box stores (Superstore, Walmart, Costco), where there were non-food items to be examined or purchased (specifically toys):

They have books and PlayStations, movies place. So I think it's maybe Walmart … because I can get a lot of electronics there like cameras and stuff. I can get videogames, movies.

Participants also reported liking what they perceived as a wider variety of food choices available, but overall their reasons for liking these stores appeared to have little to do with the food available but, rather, with what they could look at and ask their parents to buy.

About three quarters of participants reported making food purchases without an adult somewhat regularly. While participants were almost all aware of the fast food restaurants within their local FE, these were not the primary source of their food purchases. Restaurants were rarely reported as places frequented without parents. Children reported that when they bought food within their neighbourhood, it was most often at stand-alone convenience stores, gas stations, pharmacies and places where ice cream was sold. Less often participants mentioned fast food establishments (particularly those that sell primarily ice cream or donuts) as places where they went to purchase food. The specific foods purchased without an adult were most often reported to be candy, slushes and ice cream.

Even when children reported living within walking distance of a full-service grocery store, candy and snack foods continued to be the foods they purchased when on their own (the only exception was when they were sent to the store by a parent to buy something in particular for a meal). Children did not use these food sources for healthy food purchasing but, instead, for the same types of purchases they made in convenience stores and, to a lesser degree, fast-food restaurants.

There were no clear differences in food sources accessed or food choices made as reported by children living in different income-level neighbourhoods. We did not ask participants if they had their own money, which would have helped contextualize some of the purchasing responses. On the basis of responses to various questions, though, the only children for whom access to money may have limited their ability to make purchases were some of the low-income neighbourhood residents. The others talked about buying various things for themselves at least once or twice, leading us to assume that they had some access.

Theme 3 – Favourite foods and cooking

When asked to report their favourite foods the vast majority of child participants did not report the same foods they reported buying on their own. Instead, the top five reported foods were various meats (steak and bacon in particular), pasta dishes (macaroni and cheese was common), vegetables (carrots often), fruit (berries often) and pizza. When asked which foods they specifically requested their parents to buy for them, children most often reported snack foods such as granola bars and cookies; breakfast foods such as cereals, yogurt and waffles; and some fruit, especially berries. When asked to name their favourite foods, fewer than five participants began by listing the same foods they reported purchasing on their own (ice cream in two cases and candy in two cases). A few children specifically asked if they could include any food they wanted in their response and separated out what they called "healthy" or "real" food from "junk" food:

Interviewer: *So what are your favourite foods then?*

Child: *Favourite foods? … There's a lot of them.*

Interviewer: *Okay, well tell me.*

Child: *Including junk food?*

Interviewer: *Including junk food.*

Child: *Okay, sour cherry balls, chips, dill pickle dip, skittles, sour skittles I really like those, sour soothers, apples, hey first real food! White rice, whole wheat bread, celery, carrots, steak, I really like steak, bacon, ham, milk, chocolate milk, cheese…*

When asked why these were their favourite foods, most said that the foods they had listed "taste good", but some children appeared to have more complex reasons for reporting particular foods, related to their role in creating a family meal:

Child: *I really like home made macaroni and cheese and all kinds of pastas. I like grilled cheese sandwiches. I like almost all fruits. I actually like shepherd's pie a lot and that's honestly what I really, really like. Perogies.*

Interviewer: *… Why do you like those kinds of foods the best?*

Child: *Because for one thing I know that they're not bad for me and that they're just tasty in general, that they are some things that my parents can cook for the whole family and not just me and my parents have a separate meal, I like having that and that's all I can think of.*

The vast majority of the child participants reported their favourite foods as being different from their food choices when making their own purchases. Favourite foods did not appear to differ according to neighbourhood income level, although more high- and mid-income neighbourhood residents mentioned vegetables and fruit among their favourite foods.

When asked about their own roles in food preparation and grocery shopping, very few participants (only four) reported cooking meals for their family, and another five described preparing sandwiches and other simple foods for themselves on occasion. On the other hand, about a third of participants reported a desire to cook for themselves and their family, either listing specific foods or food in general. Overall, the majority of participants did not have major roles in food acquisition or preparation other than asking for certain foods when their parents shopped.

Theme 4 – Safety concerns

About a quarter of participants did not report going to any stores or restaurants without adults, on a regular basis, to buy food. This response was given most often by girls living in high-income neighbourhoods and boys and girls living in low-income neighbourhoods. When probed as to why they did not purchase food on their own, participants said that it was because of their parents' concern for their safety. A 12-year-old girl who lived in a high-income neighbourhood said:

Sometimes I go by myself to the Macs, I'll just bike there in ten minutes and because I want to get something for my sister or …for me and my friends. But usually I'll go with someone because my parents don't allow me really to go anywhere without a friend in case anything happens.

The children who most often reported buying food on their own were those who lived in mid-income neighbourhoods. They reported being allowed to go to gas stations and convenience stores on their own or with their friends to buy snacks: *"Well, usually I get a small, like Slurpee this big* [showing with hands] *and then we just go sit on a bench, we go to our school and drink it."* Consistent with this, the mid-income neighbourhood participants almost all walked to and from school, whereas those living in high-income neighbourhoods more often reported being driven to and from school.

Despite not specifically mentioning safety concerns, participants who did go to stores or restaurants without adults typically went with other children, both friends and older siblings. The social aspect of these trips to buy food was emphasized as they spoke about going with friends to convenience stores to buy "treats".

DISCUSSION AND CONCLUSIONS

Consistent with other research on this topic, there was wide variation in what children considered to be their neighbourhood FE,[25] but they were very aware of the places near their homes where food could be purchased. Consistent with Pearce et al.[25] most of the children reported a preference for big box stores, but this appeared to have nothing to do with food and, rather, with being able to look at other items of interest. We argue that this preference for large format stores may, in part, be due to our participants' alienation from food acquisition and preparation, as indicated by their reporting of minimal roles in these household tasks. These stores may have been preferred because within them the children could find items specifically intended for their use (toys for example) rather than only food, which they may have perceived as the domain of their caregivers.

Children appeared to have minimal roles in planning meals or in choosing what the family might eat and were relegated to the role of pestering their parents to buy certain foods or to looking at toys while their parents shopped. Children's food choices are a way in which their independence is expressed,[16] and when our participants made food purchases they most often purchased snack foods. Brembeck et al.[19] state that children's foodscapes are dependent on adults' foodscapes, and the healthy-unhealthy discourse often means that children are viewed as victims and protected by adults regarding healthy-unhealthy food. Brembeck et al.[19] state that this perception of vulnerability and required protection disregards children's own agency.

Overall, we found that children living in mid-income neighbourhoods most often reported being allowed to go to stores on their own (or with others). This is consistent with research on the built environment for children and their physical activity levels also conducted in Saskatoon.[26] In that study, families with children perceived mid-income neighbourhoods to be the safest, and children living in those neighbourhoods travelled on their own more often. Overall, we found that going to buy foods was a social activity and that children who went to buy food did so with other children. This social aspect is consistent with literature stating that social relations are an important concept in the FE as identified by children.[19] A focus on the importance of the social aspects of eating may be a potential point of intervention in the food choices of children, whereby food preparation and tasting interventions may improve children's choices when accessing food on their own.

While FE literature typically characterizes grocery stores as being sources of healthy food,[11] when children in the current study accessed them they most frequently cited purchasing unhealthy snack foods. Few of the participants in the current study reported frequenting fast-food restaurants without adults (and if they did it was for pop and snacks rather than for meals). Similarly, a study of food purchases among children during the school day found that although students frequented fast-food restaurants their purchases were most often snack items such as ice cream, canned drinks and chips.[27] In that study, older children (14 years of age) were found to be purchasing more meal-based items in comparison with younger students. This possibly highlights a key characteristic of how children in the pre-adolescent age group interact with their FE and the importance of research and interventions targeted specifically to this age group.

In a study of eighth grade girls, meals such as burgers, pizza and chicken nuggets were purchased and consumed away from home an average of almost four times per week.[18] The next most frequently purchased items were sweet and salty snacks and beverages,[18] similar to the snack items purchased by children in the current study. One of the differences between the cited and the current study is that, in Saskatoon, children in the eighth grade go to elementary school rather than middle school or high school, as is typical in other jurisdictions. Typically, elementary school children are not allowed to leave the schoolyard during the lunch hour; therefore, this difference may influence the freedom of the children in our study to purchase food. As children grow older they transition to a greater level of independence regarding meals and have access to more spending money.

It appears as if what are considered positive characteristics of the local FE for adults are not necessarily so for children. Regardless of the options available, the children in our study used all food sources that were available to them for unhealthy food purchasing. Interestingly, though, when participants were asked what their favourite foods were, very few listed the unhealthy snacks they chose to purchase when on their own. Instead, most chose foods that would be prepared as part of a family meal. The choice of unhealthy food when purchasing on their own could be a result of taste preference for sugary and fatty foods[19] or an opportunity for children to exert power and control over their own food consumption, given their minimal described roles in food acquisition and consumption.

This is consistent with Curtis et al.,[28] who argue that children's food practices can be understood as a part of their own conceptualized role and related responsibilities within a family unit. Hierarchical adult–child relations result in distinct statuses within a family, with children's snack food practices being marginalized.[28] Therefore, a child–adult relation in which children's independence is fostered through active participation in family food decisions may positively influence the food choices made by the child.

Future research should focus on different age groups of children, based upon their differing levels of independence and mobility. For example, younger children (under the age of 10) are generally limited by their parents' food choices. Older children, between 10 and 15 years, on the other hand, are developing some

independence and mobility and may be more limited by what is available in their home and school neighbourhoods as they travel on foot. Children in this age group may also have less freedom to leave their school grounds during the lunch hour and may have access to smaller amounts of money with which to buy food, resulting in only snack purchases. Once adolescents reach driving age, their FE changes once again. Each of these age groups should be studied separately in order to understand how they may interact with the FE differently. While there is some qualitative[19] and quantitative research in this area,[16–18] there is a need for more of both to better understand how children interact with their community and consumer nutrition environments.

REFERENCES

1. Liese AD, Weis KE, Pluto D, Smith E, Lawson A. Food store types, availability, and cost of foods in a rural environment. *J Am Diet Assoc* 2007;107(11):1916–23. PMID: 17964311. doi: 10.1016/j.jada.2007.08.012.
2. Li F, Harmer P, Cardinal BJ, Bosworth M, Johnson-Shelton D. Obesity and the built environment: Does the density of neighborhood fast-food outlets matter? *Am J Health Promot* 2009;23(3):203–9. PMID: 19149426. doi: 10.4278/ajhp.071214133.
3. Sallis JF, Glanz K. The role of built environments in physical activity, eating, and obesity in childhood. *Fut Child* 2006;16(1):89–108. PMID: 16532660. doi: 10.1353/foc.2006.0009.
4. Townshend T, Lake AA. Obesogenic urban form: Theory, policy and practice. *Health Place* 2009;15(4):909–16. PMID: 19201641. doi: 10.1016/j.healthplace.2008.12.002.
5. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: The development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med* 1999;29(6 Pt 1):563–70. PMID: 10600438. doi: 10.1006/pmed.1999.0585.
6. Cummins S, Macintyre S. Food environments and obesity – Neighbourhood or nation? *Int J Epidemiol* 2006;35(1):100–4. PMID: 16338945. doi: 10.1093/ije/dyi276.
7. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *Am J Health Promot* 2005;19(5):330–33. PMID: 15895534. doi: 10.4278/0890-1171-19.5.330.
8. Kirk SF, Penney TL, McHugh TL. Characterizing the obesogenic environment: The state of the evidence with directions for future research. *Obes Rev* 2010;11(2):109–17. PMID: 19493302. doi: 10.1111/j.1467-789X.2009.00611.x.
9. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Public Health* 2014;14:522. PMID: 24884443. doi: 10.1186/1471-2458-14-522.
10. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18(5):1172–87. PMID: 22717379. doi: 10.1016/j.healthplace.2012.05.006.
11. Lamichhane AP, Warren J, Puett R, Porter DE, Bottai M, Mayer-Davis EJ, et al. Spatial patterning of supermarkets and fast food outlets with respect to neighborhood characteristics. *Health Place* 2013;23:157–64. PMID: 23933445. doi: 10.1016/j.healthplace.2013.07.002.
12. Gittelsohn J, Franceschini MCT, Rasooly IR, Ries AV, Ho LS, Pavlovich W, et al. Understanding the food environment in a low-income urban setting: Implications for food store interventions. *J Hunger Environ Nutr* 2008;2(2–3):33–50. doi: 10.1080/19320240801891438.
13. Thompson C, Cummins S, Brown T, Kyle R. Understanding interactions with the food environment: An exploration of supermarket food shopping routines in deprived neighbourhoods. *Health Place* 2013;19:116–23. PMID: 23220374. doi: 10.1016/j.healthplace.2012.10.003.
14. Inglis V, Ball K, Crawford D. Socioeconomic variations in women's diets: What is the role of perceptions of the local food environment? *J Epidemiol Community Health* 2008;62(3):191–97. PMID: 18272732. doi: 10.1136/jech.2006.059253.
15. Alkon A, Block D, Moore K, Gillis C, DiNuccio N, Chavez N. Foodways of the urban poor. *Geoforum* 2013;48:126–35. doi: 10.1016/j.geoforum.2013.04.021.
16. McKinley MC, Lowis C, Robson PJ, Wallace JM, Morrissey M, Moran A, et al. It's good to talk: Children's views on food and nutrition. *Eur J Clin Nutr* 2005;59(4):542–51. PMID: 15714214. doi: 10.1038/sj.ejcn.1602113.
17. Borradaile KE, Sherman S, Vander Veur SS, McCoy T, Sandoval B, Nachmani J, et al. Snacking in children: The role of urban corner stores. *Pediatrics* 2009;124(5):1293–98. PMID: 19822591. doi: 10.1542/peds.2009-0964.
18. Cohen DA, Ghosh-Dastidar B, Beckman R, Lytle L, Elder J, Pereira MA, et al. Adolescent girls' most common source of junk food away from home. *Health Place* 2012;18(5):963–70. PMID: 22818589. doi: 10.1016/j.healthplace.2012.06.011.
19. Brembeck H, Johansson B, Bergström K, Engelbrektsson P, Hillén S, Jonsson L, et al. Exploring children's foodscapes. *Child Geogr* 2013;11(1):74–88. doi: 10.1080/14733285.2013.743282.
20. Engler-Stringer R, Muhajarine N, Del Canto S, Le H, Ridalls T. *A Characterization of the Food Environment in Saskatoon for Families with Children: Research Methods and Descriptive Results*. Saskatoon: Saskatchewan Population Health and Evaluation Research Unit (SPHERU), 2014.
21. Del Canto S, Engler-Stringer R, Muhajarine N. Characterizing Saskatoon's food environment: A neighbourhood-level analysis of in-store fruit and vegetable access. *Can J Urban Res* 2015;24(1):62–77.
22. Engler-Stringer R, Shah T, Bell S, Muhajarine N. Geographic access to healthy and unhealthy food sources for children in neighbourhoods and from elementary schools in a mid-sized Canadian city. *Spat Spatiotemporal Epidemiol* 2014;11:23–32. PMID: 25457594. doi: 10.1016/j.sste.2014.07.001.
23. Patton MQ. *Qualitative Research and Evaluation Methods*, 3rd ed. Thousand Oaks, CA: Sage Publications, 2002.
24. Lincoln YS, Guba EG *Naturalistic Inquiry*. Beverly Hills, CA: Sage Publications, 1985.
25. Pearce A, Kirk C, Cummins S, Collins M, Elliman D, Connolly AM, et al. Gaining children's perspectives: A multiple method approach to explore environmental influences on healthy eating and physical activity. *Health Place* 2009;15:614–21. PMID: 19083258. doi: 10.1016/j.healthplace.2008.10.007.
26. Loptson K, Muhajarine N, Ridalls T, Smart Cities, Healthy Kids Research Team. Walkable for whom? Examining the role of the built environment on the neighbourhood-based physical activity of children. *Can J Public Health* 2012;103(9 Suppl 3):eS29–34. PMID: 23618085.
27. Caraher M, Lloyd S, Madelin T. The "School Foodshed": Schools and fast-food outlets in a London borough. *Br Food J* 2014;116(3):472–93. doi: 10.1108/BFJ-02-2012-0042.
28. Curtis P, James A, Ellis K. Children's snacking, children's food: Food moralities and family life. *Child Geogr* 2010;8(3):291–302. doi: 10.1080/14733285.2010.494870.

RÉSUMÉ

OBJECTIFS : Nous avons cherché à examiner comment les préadolescents et les jeunes adolescents (10–14 ans) vivant dans toutes sortes de quartiers interagissent avec leur environnement alimentaire (EA) local, en insistant sur les aliments et les sources de nourriture auxquels ils ont accès et sur leur emplacement. Les enfants de ce groupe d'âge développent leur indépendance et leur mobilité à l'intérieur (et au-delà) de leur quartier d'attache, mais ils sont un peu circonscrits géographiquement, car ils n'ont pas encore l'âge de conduire.

MÉTHODE : L'étude a comporté des entretiens qualitatifs avec 31 enfants (15 garçons, 16 filles) de 10–14 ans vivant à Saskatoon (Saskatchewan) dans des quartiers diversifiés sur le plan socioéconomique. Nous avons fait l'analyse thématique des entretiens.

RÉSULTATS : Les descriptions par les enfants de ce qui constitue l'EA de leur quartier variaient beaucoup, de quelques pâtés de maisons à plusieurs kilomètres de distance de leur domicile. Les enfants connaissaient bien les types d'établissements qui vendent des aliments dans leur quartier subjectif. Quand les enfants achetaient leurs propres aliments, ils disaient le plus souvent acheter des collations (crème glacée, bonbons, barbotines), et la majorité de ces achats étaient faits dans les dépanneurs, les stations-services et les épiceries. Peu d'enfants disaient fréquenter des rapido-restaurants ou d'autres restaurants sans la présence d'adultes; quand ils le faisaient, c'était habituellement pour acheter des collations comme des frites et de la crème glacée plutôt que des repas.

CONCLUSIONS : Nos résultats soulignent l'importance des interventions qui ciblent ce groupe d'âge, où les choix alimentaires personnels déclarés sont presque exclusivement des grignotines riches en calories, mais peu nutritives.

MOTS CLÉS : enfant; environnement; régime alimentaire; aliments et nutrition; consommation d'aliment

Exploring experiences of the food environment among immigrants living in the Region of Waterloo, Ontario

Paulina I. Rodriguez, MA,[1] Jennifer Dean, PhD,[1] Sharon Kirkpatrick, PhD,[2] Lisbeth Berbary, PhD,[3] Steffanie Scott, PhD[4]

ABSTRACT

OBJECTIVES: This exploratory study aimed to shed light on the role of the food environment in shaping food access among immigrants living in the Region of Waterloo, Ontario.

METHODS: In this qualitative case study, in-depth interviews aided by photovoice were conducted with nine immigrants, and key informant (KI) interviews were conducted with nine community stakeholders (e.g., settlement workers, planners) who held expert knowledge of the local context with respect to both the food system and experiences of immigrants in interacting with this system. In this paper, we focus specifically on insights related to the food environment, applying the Analysis Grid for Environments Linked to Obesity Framework to assess economic, physical, socio-cultural and political aspects.

RESULTS: Economic features of the food environment, including food prices and differential costs of different types of food, emerged as factors related to food access. However, interactions with the food environment were shaped by broader economic factors, such as limited employment opportunities and low income. Most immigrants felt that they had good geographic access to food, though KIs expressed concerns about the types of outlet and food that were most accessible. Immigrants discussed social networks and cultural food practices, whereas KIs discussed political issues related to supporting food security in the Region.

CONCLUSION: This exploratory case study is consistent with prior research in highlighting the economic constraints within which food access exists but suggests that there may be a need to further dissect food environments.

KEY WORDS: Food supply; emigrants and immigrants; food intake; environment; refugees; immigrant

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS53–eS59
doi: 10.17269/CJPH.107.5310

Immigrants currently account for just over 20% of the total population in Canada and are a major contributor to population growth, with projections suggesting that this population will be the nation's sole source of growth by 2030.[1] Recent evidence demonstrates that over time the health of immigrants declines with respect to chronic diseases,[2] self-reported health[3] and depression,[4] among others. Several explanations for this decline in health have been hypothesized, including poor access to the health care system, increased stress from migration and early settlement experiences, and acculturation (adoption of an unhealthy Canadian lifestyle).[2] The latter explanation includes the uptake of an unhealthy diet, which studies have acknowledged can be attributed to both individual (e.g., cultural food preferences, individual income) and environmental (e.g., food accessibility and availability) factors.[5–7]

A growing body of research has focused on the role of diet in the health inequalities of immigrants.[7] Recent immigrants are two times more likely to be food insecure than the general population,[8] and are at risk of inadequate nutritional intakes.[9] Food insecurity contributes to an increased burden on the health care system[10] and may interfere with the integration of immigrants into their new environment in Canada, because it limits their opportunities to engage in an active and healthy life.[11–13] Furthermore, addressing diet-related health inequalities is a moral imperative, as access to high-quality food is a fundamental human right.[14]

The importance of environmental factors that shape individual eating habits is recognized by the Public Health Agency of Canada[15] and has been central to recent major health promotion frameworks.[16] Similarly, Health Canada has explicitly emphasized the importance of food environments, including "retail food outlets (RFOs)…where people can purchase foods, such as grocery stores and restaurants, as well as environments where people acquire food in traditional ways, such as hunting and fishing."[17]

Much of this research on food environments in Canada has focused on the geographic location of RFOs and the cost of high-quality, nutrient-dense food.[17] Results in this field offer mixed evidence for the existence of food deserts in Canada, those areas where nutritious food is absent, but supports the presence of food

Author Affiliations

1. School of Planning, University of Waterloo, Waterloo, ON
2. School of Public Health and Health Systems, University of Waterloo, Waterloo, ON
3. Recreation and Leisure Studies, University of Waterloo, Waterloo, ON
4. Geography and Environmental Management, University of Waterloo, Waterloo, ON

Correspondence: Jennifer Dean, PhD, School of Planning, University of Waterloo, 200 University Avenue W, Room EV3 3221, Waterloo, ON N2L 3G1, Tel: 519-888-4567, ext. 39107, E-mail: jennifer.dean@uwaterloo.ca

Acknowledgements: This study was made possible through financial contributions from a SEED Grant through the University of Waterloo's Chronic Disease Prevention Initiative at the Propel Centre for Population Health Impact. We also thank the participants who kindly contributed their time and insights to this study.

Conflict of Interest: None to declare.

swamps, where access to fast food and low-nutritional food is high.[17] This is problematic since neighbourhoods with inadequate food environments appear to exacerbate the hardships faced by families living in poverty and struggling to afford adequate food.[18]

Recent work in Canada and elsewhere attempts to understand how individuals navigate their food environment.[17,19–23] Beyond examining environmental factors related to geographic and economic access, there is an absence of research investigating additional factors, such as those within the socio-cultural and political realm, which are also related to diet and obesity.[17,22] Further, there is a scarcity of Canadian research on the food environment and its impact on the lifestyle of immigrants. Given the potential role of diet in the decline of immigrants' health status over time, this is an important area for exploration.[17] Thus, this study aims to better understand how the food environment is experienced by this growing segment of the population.

METHODS

This multi-method qualitative case study examines individual and environmental factors influencing immigrant food security in a mid-sized Ontario municipality.

The Region of Waterloo is a mid-sized urban municipality located in south-western Ontario and includes the three cities of Cambridge, Kitchener and Waterloo and four surrounding townships. Immigration has contributed to approximately 20% of the population growth in the Region in recent years, and currently immigrants account for 22.3% of the total population.[24] These rates, combined with the ethno-cultural diversity of the immigrant population in the Region (over 190 different ethnic origins are represented), make it a typical Canadian municipality and a suitable case from which to glean insights into immigrant experiences of food environments.

We used multiple methods in order to triangulate the data and gain a comprehensive understanding of immigrants' experiences of the local food environment. This involved interviewing nine immigrants directly and purposefully sampling nine key informants (KIs) who a) worked directly with the immigrant population in either a settlement or social services capacity and thus had expert knowledge of collective issues related to food access for this population; or b) worked within the food access sector (e.g., food bank employees, public health planners, urban planners) and had knowledge of the food environment. The study received ethical clearance from the University of Waterloo.

Data collection took place between July and December 2014. The research team created a list of KIs in the Region who held expertise in one of the two areas noted above. The KIs were contacted by the first author directly by e-mail, and this was followed by a phone call. In total 11 KIs were contacted, 2 were in contact with the research team and 9 agreed to take part in the study. All interviews were conducted in person at a time and place convenient for the participants. They were audio recorded and the recording was later transcribed verbatim.

Immigrant participants (see Table 1) were recruited from local community organizations using the gatekeeping method common in community-based health studies, whereby a representative in an organization acts as an access point to disseminate information about the study to members of the organization.[25] These semi-structured interviews were conducted in English by the first author with translation assistance from a community gatekeeper for two interviews. Interviews lasted approximately 60 minutes on average and took place within community settings (e.g., coffee shops, community centres). Questions focused on broader issues of health and food security before narrowing in on the food environment. Participants were provided with a broad definition of the food environment (i.e., anything in their environment that influenced their eating habits).

Participants were given a disposable camera to complete a photovoice exercise requiring them to take photographs of their food environment. In this way, photographs helped to clarify ideas that emerged during the initial in-depth interview by having participants gather concrete examples of assets and obstacles in their food environment, thus allowing for more direct questions about their perspectives in a follow-up interview. This method has successfully been used in previous environment and health research[26,27] and with immigrant populations.[27] The method was selected to better engage participants who may not be proficient in the English language and as an empowerment tool for participants to express their own perspectives through an accessible means.

Approximately two weeks later, a second photo-elicited interview took place that focused on the photos. The SHOWeD method[28] facilitates in-depth discussion of photos by asking exploratory

Table 1. Socio-demographic characteristics of immigrant participants

	Total	Percentage of total
Population		
Total	9	100
Female	6	67
Male	3	33
Age (years)		
29–39	3	33
40–49	2	22
50–59	1	11
59–69	3	33
Marital status		
Married/living with a partner	5	56
Separated or divorced	2	22
Widowed	2	22
Country of birth		
Haiti	1	11
Iraq	4	44
India	2	22
Lebanon	1	11
South Korea	1	11
Years living in Canada		
0 to 3	4	44
3 to 10	4	44
10+	1	11
Highest level of education		
Middle school	1	11
High school	2	22
University degree	4	44
Postgraduate degree	1	11
Immigrant class		
Family class	2	22
Refugee/humanitarian class	4	44
Skilled worker class	3	33
Income		
Under $5,000	4	44
$10,000 to $14,999	3	33
N/A	2	22

questions such as "What do you see here?" and "What's really happening here?"[28] After the second interview, participants received a $25 gift card to a local grocery store as a token of appreciation.

While we did not attempt to secure a representative sample, because generalizations were not the objective, we did seek heterogeneity in terms of cultural background and time since migration to explore a diversity of experiences. Further, the combination of KIs and immigrant interviews paired with photovoice served to triangulate the data, and a point of saturation was met.[29] This exploratory study gleaned important insights into experiences of local food environments among immigrant populations, although additional research is necessary to examine specific food access issues in depth and among specific ethno-cultural groups of immigrants.

Analysis

All interviews were conducted, audio recorded and transcribed by the first author (PR). Thematic analysis was conducted by developing codes in the form of words or phrases to represent themes identified in the data following a six-step process.[30] We framed the analysis using the Analysis Grid for Environments Linked to Obesity (ANGELO) Framework, which dissects environments by type and scale.[31] This framework was selected because of its usefulness in identifying the myriad environmental factors potentially relevant to diet while assessing which factors are most influential and which are overlooked.

ANGELO identifies four environmental types: a) physical: resources available for obtaining a healthy diet; b) economic: the costs associated with a healthy diet; c) political: the formal and informal policies that influence eating habits; and d) socio-cultural: societal attitudes, beliefs and values that affect eating habits. ANGELO also takes a scalar approach to examining environments, in which the microenvironment consists of those settings that influence diet (e.g., home, neighbourhood) and the macroenvironment relates to sectors such as food-related industries, services or supporting infrastructure.[31] While the ANGELO framework was designed to examine the influence of the environment on obesity through both dietary behaviour and physical activity, it is also useful in thoroughly analyzing the food environment and has been used in the past to examine factors of the food environment that potentially influence eating habits.[22]

RESULTS

During analysis of the data, three main themes emerged and will be discussed individually below. Throughout this section, quotes from participants will be used to highlight important findings; identification of the relevant factors in the food environment is included in Table 2.

Affordability and economic stability

The most prominent theme was related to food affordability: participants' concerns focused on a) the high cost of nutritious food and b) participants' ability to earn an adequate income. These individual barriers were exacerbated by economic barriers to accessing the food environment. For instance, recent immigrants in this study perceived food in Canada to be more expensive than "back home":

> *First impression, [food] is very expensive…. all my money is going to food. Especially the vegetables and fruit … a small package [of fruit] is $2.50 and I have to use at least four, every week. (IP5)*

This was directly related to the affordability of food in RFOs, most immigrants discussing how healthy foods (e.g., fresh produce) are costly in comparison with less healthy foods (e.g., pre-packaged food), which often went on sale in local stores (see Figure 1). Four of the nine participants reported cost as the main determinant, and in this group the high-quality food presumed to be healthier, such as organic fruits and vegetables, was often deemed to be unobtainable because of the cost. The other participants tried to balance the quality of food with their limited income. For instance, many immigrants practised coping strategies by being selective in where they shopped:

> *[Store A] has good quality [food], it's not excellent quality like [Store B] but [at Store A] I can afford to buy as much as I want to eat. [I can afford] 90 or 85 per cent of what I want to buy in [Store A]. For this reason usually I go to [Store A], because it's not a bad quality and I can afford the price (IP7)*

Table 2. Determinants of the food environment by type and size

Environmental size/type	Physical	Economic	Political	Socio-cultural
Microenvironments (settings)	Adequate geographic access to food stores	Affordability of food in food stores (regular stores and ethnic stores)	Rules in the home around eating	Strong attachment to culturally specific food practices
	Adequate geographic access to alternative sources of food (farmers' markets, community gardens, temporary markets)	Household socio-economic status (income, employment)	Zoning bylaws governing land use	Availability of social networks
	Accessibility to unhealthy food retail (fast food, convenience stores)	Employment circumstances that diminish time available for food purchasing/preparation	Availability of community services for immigrants	Acceptability of food available in food stores (restaurants, superstores)
	Accessibility to transit			Adapting to Canadian food environment
Macroenvironments (sectors)	Transportation system	Housing affordability	Food labelling	Societal values of food in Canadian context
	Accessibility to farmland	Affordability of transportation	Government support for immigrants	Food advertising

Figure 1. Pre-packaged food sold in local grocery store (Interview Participant 1)

Other immigrants coped by accessing alternative sources of food in the physical environment, such as food banks and community cooking classes, and these often became important places for socializing and resource sharing.

A second key issue was participants' ability to earn enough income to afford the high-quality foods they preferred. While most recent immigrants arrive in the country with significant savings, a requirement of the immigration process, seven participants discussed the depletion of financial resources arising from inability to secure employment. These participants shared their reluctance to spend money on the high-quality foods they preferred because of the precarious nature of their employment situation:

> *You're always thinking… you don't know when they tell you "no more job for you". You have to have some money saved… you can't throw money and buy what you want, make sure you can save for your rent. (IP1)*

As the above participant implies, high food costs and low income were exacerbated by the high cost of housing in the Region. Most immigrants shared a discourse of negotiation in terms of whether to spend on high-quality food, housing or other crucial payments, as one KI articulates:

> *Average apartment in Kitchener-Waterloo is $900, two bedroom. And a family of four, a family of five will receive $800, so they need $100 more, from where, from food of course, they will take money from food to put towards the rent. (KI6)*

In addition, KIs indicated that although recent immigrants receive financial support, it is not enough to meet their basic living expenses. Immigrant participants indicated that they adopt a variety of strategies to cope with their low income, including frequenting discount RFOs, buying items only when on sale, paying attention to weekly flyers, budgeting and, when necessary, using food banks.

Geographic access to culturally appropriate and high-quality food

The majority of immigrants reported having adequate geographic access to stores within their immediate community, demonstrating a strong physical food environment. In most cases this was within participants' residential neighbourhood, but in others it was near the location of employment or the homes of people in their social network. RFO access was most often to mainstream and discount grocery stores as well as conveniences stores, all of which sold culturally appropriate food:

> *… there are a lot of shops like [convenience store], they have Mediterranean food. We don't eat something that contains ingredients that are difficult to find. Everything is provided here. It's good. (IP7)*

Despite proximity to RFOs, the majority of immigrants stated that geographic access to healthy foods (i.e., organic, fresh produce) and some specialty foods was poor. Five participants stated that their preference was to shop at local farmers' markets (see Figure 2), which they believed offered the highest quality foods, a larger diversity of fruits and vegetables, and better taste: *"I will never eat a food from a can. They say it's healthy, but it's not, I want everything fresh." (IP3)* Many also indicated that they had grown their own food in private or community gardens. However, these preferred places were less accessible to participants, and KIs stated that they were in short supply in the Region. Accordingly, participants stated that they often negotiated by selecting the closest RFO while sacrificing food quality:

> *[Store]… is better for organic food. Farmer stores use organic soil so the food is healthier… but what can we do? We can't go every time to the market, so we buy from [store]. It's here and it's close so we have to buy here. (IP5)*

Geographic proximity was less important when it came to accessing ethnic grocery stores. The participants who were part of the ethno-cultural majority in the Region felt that ethno-cultural food was often available in nearby grocery stores, but those who were in the ethnic minority stated that access to ethnic stores (and in some cases specific foods) was poor, some participants reporting that they travelled to other cities to access specific foods at specialty grocery stores. To compensate, some immigrants used temporary markets and "pop-up shops" to fill the void, even though these were not regulated. As one KI highlighted:

> *…in Cambridge, a man sells vegetables for the ethnic community [out of his car]. They come to the parking lot and*

Figure 2. Food from the farmers' market (Interview Participant 4)

they grab all their vegetables and they leave and he leaves before a bylaw [officer] catches them. (KI5)

KIs discussed how the existence of food deserts and food swamps[17] in the Region of Waterloo might be undermining the food security of immigrants. They highlighted the inconsistency of bylaws that regulate land use in the Region, which differ across all of the lower tier municipalities and make it difficult to present a regional strategy to create healthy food environments. Further, they indicated that the current land use policies in those municipalities hinder the establishment of the food spaces preferred by immigrants, such as community gardens and temporary markets.

Keeping traditional food practices

For participants in this study, food played a central role not just in health and well-being but also in cultural identity: "…everything that is considered part of culture, we have our own literature, our own language, dance music, of course the food. Food is the biggest part." (IP8). KIs acknowledge pressures for immigrants to adopt the unhealthy eating patterns of the general population, including acculturating to the current social environment in which fast and prepared foods predominate. The responses of most immigrant participants, however, highlighted strong attachment to culturally specific food practices, such as cooking from scratch despite pressure to do otherwise, especially pressure from younger children.

The importance of these practices was also emphasized through photovoice, when participants were asked to select a meaningful photo; their selection was food that they liked eating, considered to be healthy and was traditional to them (see Figure 3). This appeared to influence food purchasing and preparation habits that for some participants resulted in prohibition of outside food in the home, especially for children:

I cook my meals…I want to [teach] my kids that it's not good to eat out all the time: "We can eat [at the restaurant] once per month, because your health, I don't want you to be fat" They understand. (IP7)

The parents shape the political environment for their children's food access, and in this respect participants discussed additional strategies they use to maintain their traditional ethnic diets, including purchasing fresh food from the market when accessible, travelling to ethnic grocery stores or even using informal channels like "pop-up shops".

Often recent immigrants arrived with little knowledge of Canadian food practices or the local food environment but relied on other immigrants for information. Strong social networks, an element of the social environment, both within their cultural group and outside (often with other immigrants) was important for sharing information (e.g., local programs, food bank locations) and other resources (e.g., food, transportation, time).

People I know from the same country, they told us which place has good quality [food]…Now we know where to go, to buy lower [priced food]. But for new people, it's hard for them, they don't know the places here. Especially the first year it will be difficult for them. (IP4)

Figure 3. This is my routine food (Interview Participant 3)

This study highlighted the importance of various environmental factors – physical, social, economic and political – that shape experiences of the food environment in Canada. In addition, the findings showed that immigrants are unique populations in the way that they interact with the food environment. This interaction is often guided by their food-related needs, such as having access to high-quality and culturally appropriate food, and by being able to maintain their traditional food practices.

DISCUSSION

This research sought to explore experiences of the food environment among immigrants living in the Region of Waterloo, ON. Perceptions of the food environments were captured through KI interviews and in-depth interviews with immigrants along with a photovoice exercise, and they were assessed using thematic analysis guided by the ANGELO Framework to dissect various environmental factors. Using the ANGELO Framework as an analytic tool for the data collected from the three sources, we found that all four types of environment were relevant to participants. Economic and physical environments were most widely and explicitly discussed, while socio-cultural environments were relevant particularly in the context of culturally appropriate food. Political environments were discussed least often but comments in this realm were important for understanding broader legal issues (e.g., municipal bylaws) or informal policies (e.g., familial rules about eating outside the home during the month). Given the focus of this study on local food environments, the majority of the findings were discussed in relation to the microenvironment (See Table 2).

A few limitations need to be addressed. We sought to find commonalities in the experiences of the food environment in a diverse group of immigrants in the Region of Waterloo. However, our small sample represents the perspectives of a heterogeneous group of immigrants. The high number of female participants in this study very likely reflects a selection bias, in that most of the food purchasers are, in fact, women and likely have the most interaction with the food environment. Future studies should seek to explain homogeneous experiences of the food environment in immigrant populations.

Limitations aside, the results indicate that economic environmental factors, such as household income (micro scale) and food affordability (macro scale), were most relevant to participants, a finding that supports the results of previous research.[18,32] For instance, as in the findings of a study of Latin American immigrants in Toronto, ON, our participants utilized several coping strategies to deal with their low income status coupled with the high cost of food, including comparing prices, cooking from scratch and purchasing items on sale.[33] In this study we found that participants balanced the quality of food with affordability, and prioritized healthy and culturally appropriate food. This suggests that economic circumstances are a crucial component of how immigrants navigate the food environment.[18,32]

In the Canadian context, it is widely recognized that to address issues of food access, strategies are needed to promote adequate incomes.[8,18] The role of food price has been previously examined, a prior study suggesting that price can outweigh other considerations such as health in a low-income population.[32] In this study, immigrants suggested that the high cost of food in the Region restricted their access to RFOs. However, the issue of most concern for the immigrants studied is having the economic means to purchase what they perceived to be high-quality food.

Furthermore, this study showed that the geographic access or physical factors related to the food environment directly influence the kind of food that immigrants can access, which echoes past research.[19,23] Such findings align with previous studies suggesting that areas in the Region of Waterloo are indeed food swamps on the basis of the high access to poor-quality food in RFOs.[17,34] Yet, participants in this study consistently expressed their preference for organic and high-quality fruit and vegetables and ethno-cultural food, and there is very little research examining whether food deserts or swamps do exist in the context of RFOs that cater to the specific food preferences of immigrants and other cultural minorities. From a policy perspective, modification of existing municipal bylaws that relate to community gardens, pop-up shops and temporary markets is required to improve access to the high-quality food that is preferred by the population.

Last, the study suggests that immigrants preferred to consume ethnic food, which they perceived to be healthier than "Canadian food". Past research identifies an acculturation process by which immigrants adopt the cultural practices and norms of the host country as their length of residence increases.[7] Similar to Latin-American immigrant women in a US study,[23] participants in this study resisted acculturation by being the "gatekeepers" of food access and monitoring their children's eating habits. In fact, some participants indicated that they go to great lengths to obtain their ethnic food, including driving outside the Region and obtaining food from informal food stores like unregulated temporary markets. As this was a small and diverse group of immigrants with an average time in Canada of three years, future research could help address whether these habits change over time and through subsequent generations of immigrants. An important avenue for future research would be to explore the role that time since migration might play in diet-related practices as immigrants transition into their new life in the Canadian food environment.

CONCLUSION

The results of this study support prior calls for action on the upstream determinants of health for food access, such as gainful employment opportunities, affordable housing and adequate public transportation.[8,18,32–34] Strides made in any of these factors will have positive impacts on the health inequalities faced by immigrant populations. Further, challenges in accessing nutritious and culturally appropriate foods may exacerbate financial challenges among immigrants. There is a need to continue to develop local RFOs that are desirable to the immigrant population, such as food markets, community gardens and even "temporary markets" that offer fresh food. Funding, zoning and regulating these non-traditional RFOs are crucial to moving forward. Last, there is an urgent need for further research to better understand how immigrants to Canada navigate the food environment and how the role of the food environment changes over time as immigrants become settled.

REFERENCES

1. Canadian Demographics at a Glance. Ottawa, ON: Statistics Canada. 2008. Available at: http://www.statcan.gc.ca/pub/91-003-x/2007001/4129907-eng.htm (Accessed August 21, 2015).
2. Newbold KB. Chronic conditions and the healthy immigrant effect: Evidence from Canadian immigrants. *J Ethn Migr Stud* 2006;32(5):765–84. doi: 10.1080/13691830600704149.
3. Ng E, Russell W, François G, Berthelot J. Dynamics of immigrants' health in Canada: Evidence from the National Population Health Survey. In *Healthy Today, Healthy Tomorrow? Findings From the National Population Health Survey (82-618-MWE)*. Ottawa, ON: Statistics Canada, 2005;2:1–11. Available at: http://www.statcan.gc.ca/pub/82-618-m/2005002/pdf/4193621-eng.pdf (Accessed April 17, 2016).
4. Ali J. Mental health of Canada's immigrants. Ottawa, ON: Statistics Canada. Available at: http://www.statcan.gc.ca/pub/82-003-s/2002001/pdf/82-003-s2002006-eng.pdf (Accessed June, 2015).
5. Dean JA, Wilson K. "My health has improved because I always have everything I need here…": A qualitative exploration of health improvement and decline among immigrants. *Soc Sci Med* 2010;70(8):1219–28. PMID: 20167409. doi: 10.1016/j.socscimed.2010.01.009.
6. Newbold B. The short-term health of Canada's new immigrant arrivals: Evidence from LSIC. *Ethn Health* 2009;14(3):315–36. PMID: 19263262. doi: 10.1080/13557850802609956.
7. Sanou D, O'Reilly E, Ngnie-Teta I, Batal M, Mondain N, Andrew C, et al. Acculturation and nutritional health of immigrants in Canada: A scoping review. *J Immigr Minor Health* 2014;16(1):24–34. PMID: 23595263. doi: 10.1007/s10903-013-9823-7.
8. Tarasuk V, Dachner N. Household Food Insecurity in Canada, 2012. Toronto, ON: Research to Identify Policy Options to Reduce Food Insecurity (PROOF). 2014. Available at: http://nutritionalsciences.lamp.utoronto.ca/wp-content/uploads/2014/05/Household_Food_Insecurity_in_Canada-2012_ENG.pdf (Accessed June 15, 2015).
9. Kirkpatrick SI, Dodd KW, Parsons R, Ng C, Garriguet D. Household food insecurity is a stronger marker of adequacy of nutrient intakes among Canadian compared to American youth and adults. *J Nutr* 2015;145(7):1596–603. PMID: 25995277. doi: 10.3945/jn.114.208579.1.
10. Tarasuk V, Cheng J, de Oliveira C, Dachner N, Gundersen C, Kurdyak P. Association between household food insecurity and annual health care costs. *CMJA* 2005;187(14):E429–36. PMID: 26261199. doi: 10.1503/cmaj.150234.
11. Lindsay AC, Sussner KM, Greaney ML, Peterson KE. Influence of social context on eating, physical activity, and sedentary behaviors of Latina mothers and their preschool-age children. *Health Educ Behav* 2009;36(1):81–96. PMID: 18689491. doi: 10.1177/1090198107308375.
12. Chaufan C, Davis M, Constantino S. The twin epidemics of poverty and diabetes: Understanding diabetes disparities in a low-income Latino and immigrant neighborhood. *J Community Health* 2011;36(6):1032–43. PMID: 21533887. doi: 10.1007/s10900-011-9406-2.
13. Hamelin A-M, Beaudry M, Habicht J-P. Characterization of household food insecurity in Quebec: Food and feelings. *Soc Sci Med* 2002;54(1):119–32. PMID: 11820676. doi: 10.1016/S0277-9536(01)00013-2.
14. Special Rapporteur on the Right to Food. United Nations Human Rights, Geneva, Switzerland, 2015. Available at: http://www.ohchr.org/EN/Issues/Food/Pages/FoodIndex.aspx (Accessed June 10, 2015).

15. Food Security. Ottawa, ON: Public Health Agency of Canada, 2014. Available at: http://cbpp-pcpe.phac-aspc.gc.ca/public-health-topics/food-security/ (Accessed September 25, 2015).
16. Curbing Childhood Obesity. Ottawa, ON: Public Health Agency of Canada, 2010. Available at: http://www.phac-aspc.gc.ca/hp-ps/hl-mvs/framework-cadre/pdf/ccofw-eng.pdf (Accessed March 10, 2015).
17. Measuring the Food Environment in Canada. Ottawa, ON: Health Canada, 2013, p. 7. Available at: http://www.foodsecuritynews.com/resource-documents/MeasureFoodEnvironm_EN.pdf (Accessed April 21, 2015).
18. Kirkpatrick SI, Tarasuk V. Assessing the relevance of neighbourhood characteristics to the household food security of low-income Toronto families. *Public Health Nutr* 2010;13(7):1139–48. PMID: 20196916. doi: 10.1017/S1368980010000339.
19. Park Y, Quinn J, Florez K, Jacobson J, Rundle A. Hispanic immigrant women's perspective on healthy foods and the New York City retail food environment: A mixed-method study. *Soc Sci Med* 2011;73(1):13–21. PMID: 21658831. doi: 10.1016/j.socscimed.2011.04.012.
20. Lake A, Townshend T. Obesogenic environments: Exploring the built and food environments. *J R Soc Promot Health* 2006;126(6):262–67. PMID: 17152319. doi: 10.1177/1466424006070487.
21. Raine K, Church J, Boulé N, Slater L, Marko J, Gibbons K, et al. *State of the Evidence Review on Urban Health and Healthy Weights*. Ottawa, ON: Canadian Institute for Health Information, 2008.
22. Dean JA, Elliot SJ. Prioritizing obesity in the city. *J Urban Health* 2011; 89(1):196–213. PMID: 22042539. doi: 10.1007/s11524-011-9620-3.
23. Greder K, De Slowing FR, Doudna K. Latina immigrant mothers: Negotiating new food environments to preserve cultural food practices and healthy child eating. *Fam Consum Sci Res J* 2012;41(2):145–60. doi: 10.1111/fcsr.12004.
24. Region of Waterloo Public Health. Waterloo Region Immigration Fact Sheet, 2015. Available at: http://www.immigrationwaterlooregion.ca/Immigrant_Arrivals.pdf (Accessed September 28, 2015).
25. Johnson BH, Hayes SC, Ekundayo OT, Wheeler P, Ford DM. Health literacy of an urban business community. *J Health Care Poor Underserved* 2012; 23(1):242–53. PMID: 22643474. doi: 10.1353/hpu.2012.0028.
26. Heidelberger L, Smith C. The food environment through the camera lenses of 9- to 13-year-olds living in urban, low-income, midwestern households: A photovoice project. *J Nutr Educ Behav* 2015;47(5):437–45.e1. PMID: 26142725. doi: 10.1016/j.jneb.2015.05.005.
27. Wang CC, Yi WK, Tao ZW, Carovano K. Photovoice as a participatory health promotion strategy. *Health Promot Int* 1998;13(1):75–86. doi: 10.1093/heapro/13.1.75.
28. Wang C, Burris MA. Photovoice: Concept, methodology, and use for participatory needs assessment. *Health Educ Behav* 1997;24(3):369–87. PMID: 9158980. doi: 10.1177/109019819702400309.
29. Patton MQ. *Qualitative Research and Evaluation Methods*. Thousand Oaks, CA: Sage Publications, 2002.
30. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3:77–101. doi: 10.1191/1478088706qp063oa.
31. Swinburn B, Egger G, Raza F. Dissecting obesogenic environments: The development and application of a framework for indentifying and prioritizing environmental interventions for obesity. *Prev Med* 1999;29:563–70. PMID: 10600438. doi: 10.1006/pmed.1999.0585.
32. Dachner N, Ricciuto L, Kirkpatrick SI, Tarasuk V. Food purchasing and food insecurity among low-income families in Toronto. *Can J Diet Pract Res* 2010; 71(3):e50–56. PMID: 20825694. doi: 10.3148/71.3.2010.e50.
33. Vahabi M, Damba C. Perceived barriers in accessing food among recent Latin American immigrants in Toronto. *Int J Equity Health* 2013;12(1):1. PMID: 23286318. doi: 10.1186/1475-9276-12-1.
34. Minaker LM, Raine KD, Wild TC, Nykiforuk CIJ, Thompson ME, Frank LD. Objective food environments and health outcomes. *Am J Prev Med* 2013; 45(3):289–96. PMID: 23953355. doi: 10.1016/j.amepre.2013.05.008.

RÉSUMÉ

OBJECTIFS : Cette étude préliminaire visait à faire la lumière sur le rôle de l'environnement alimentaire dans l'accès aux aliments des immigrants vivant dans la Région de Waterloo, Ontario.

MÉTHODE : Dans cette étude de cas qualitative, des entretiens en profondeur aidés par Photovoice ont été menés auprès de neuf immigrants; des entretiens avec des informateurs ont aussi été menés auprès de neuf acteurs communautaires (p. ex., travailleurs en services d'établissement, planificateurs) possédant une connaissance approfondie du contexte local en ce qui a trait à la fois au système alimentaire et aux expériences des immigrants par rapport à ce système. Dans cet article, nous traitons spécifiquement des idées liées à l'environnement alimentaire en appliquant le cadre ANGELO (Analysis Grid for Environments Linked to Obesity) pour évaluer les aspects économiques, physiques, socioculturels et politiques.

RÉSULTATS : Les caractéristiques économiques de l'environnement alimentaire, dont le prix des aliments et les coûts différentiels de divers types d'aliments, se sont avérés être des facteurs liés à l'accès aux aliments. Toutefois, les interactions avec l'environnement alimentaire étaient influencées par des facteurs économiques plus généraux, comme les occasions d'emploi limitées et les faibles revenus. La plupart des immigrants considéraient qu'ils avaient un bon accès géographique aux aliments, mais les informateurs ont exprimé des préoccupations quant aux types d'établissements et aux aliments qui étaient les plus accessibles. Les immigrants ont discuté de réseaux sociaux et de pratiques alimentaires culturelles, tandis que les informateurs ont discuté des enjeux politiques liés au soutien de la sécurité alimentaire dans la Région.

CONCLUSION : Comme la recherche antérieure, cette étude de cas exploratoire souligne les contraintes économiques dans lesquelles l'accès aux aliments existe, mais elle suggère aussi qu'il pourrait être nécessaire de disséquer davantage les environnements alimentaires.

MOTS CLÉS : approvisionnement en nourriture; émigrants et immigrants; ration alimentaire; environnement; réfugiés; immigrant

COMMENTARY

Challenges in assessing food environments in northern and remote communities in Canada

Kelly Skinner, PhD,[1] Kristin Burnett, PhD,[2] Patricia Williams, PhD, PDt,[3] Debbie Martin, PhD,[4] Christopher Stothart, PDt,[5] Joseph LeBlanc, PhD,[6] Gigi Veeraraghavan, BA,[7] Amanda Sheedy, MPH[8]

ABSTRACT

Effective tools for retail food environments in northern and remote communities are lacking. This paper examines the challenges of conducting food environment assessments in northern and remote communities in Canada encountered during our experience with a food costing project. One of the goals of the *Paying for Nutrition in the North* project is to develop guidelines to improve current food costing tools for northern Canada. *Paying for Nutrition* illustrates the complex context of measuring food environments in northern and remote communities. Through the development of a food costing methodology guide to assess northern food environments, several contextual issues emerged, including retail store oligopolies in communities; the importance of assessing food quality; informal social food economies; and the challenge of costing the acquisition and consumption of land- and water-based foods. Food environment measures designed for northern and remote communities need to reflect the geographic context in which they are being employed and must include input from local residents.

KEY WORDS: First Nations; food supply; cost analysis; rural population

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS60–eS63
doi: 10.17269/CJPH.107.5324

A recent report on measuring food environments in Canada has identified a significant research gap regarding information about retail food environments in northern and remote communities; food assessment tools relevant for the northern context are lacking.[1] In this commentary, we outline our experiences in carrying out the *Paying for Nutrition in the North* project in order to examine the challenges and considerations for food environment assessment in northern and remote communities in Canada. We begin by describing two food costing tools that are most commonly used in northern and southern Canada, include some details about the *Paying for Nutrition* project and briefly explain the context of the northern food environment. The paper then examines the challenges and contextual issues we encountered in the process of developing a food costing methodology guide for northern Canada, specifically the provincial norths, and some of the factors that must be considered in further developing appropriate assessment tools for food environments in the provincial norths.

Common food costing tools in Canada

Current food costing studies in southern and urban environments rely on the National Nutritious Food Basket (NNFB), which is a "survey tool that is a measure of the cost of basic healthy eating that represents current nutrition recommendations and average food purchasing patterns".[2] The NNFB is a list of 67 food items and is used to cost the lowest priced items available. Data collection is conducted with a minimum of six stores surveyed, and the average cost of each food item in the basket is calculated across all stores sampled. When five or more items are not available in an individual store, that store is usually not included in the average.

The Revised Northern Food Basket (RNFB) is the tool that Indigenous and Northern Affairs Canada uses to monitor "trends in the cost of healthy eating in isolated northern communities eligible for the Nutrition North Canada (NNC) program".[3] The RNFB was revised in 2007 to ensure that it was consistent with the newest version of Canada's Food Guide and the Aboriginal version of the Food Guide.[4] In comparison with the NNFB, the RNFB differs in a number of respects: it is intended to be more consistent with current food consumption patterns of northern residents (e.g., meat and non-perishable foods account for a relatively larger percentage and fresh fruit and vegetables a relatively smaller proportion of the basket), and it uses average prices for each product in the basket rather than the lowest price available in the community.[3,4] Neither the NNFB nor the RNFB considers the costs of land- or water-based food acquisition. Because of the differences in the items in the NNFB and the RNFB it is not possible to compare them with each other, thus complicating direct

Author Affiliations

1. School of Public Health and Health Systems, University of Waterloo, Waterloo, ON
2. Department of Indigenous Learning, Lakehead University, Thunder Bay, ON
3. Department of Applied Human Nutrition, Mount Saint Vincent University, Halifax, NS
4. School of Health and Human Performance, Dalhousie University, Halifax, NS
5. Centre for Population Health Sciences, University of Edinburgh, Edinburgh, UK
6. Social Planning Council of Sudbury, Sudbury, ON
7. Peetabeck Health Services, Fort Albany, ON
8. Food Secure Canada, Montreal, QC

Correspondence: Kelly Skinner, PhD, School of Public Health and Health Systems, University of Waterloo, 200 University Avenue West, Waterloo, ON N2L 3G1, Tel: 519-888-4567, ext. 38164, E-mail: kskinner@uwaterloo.ca

Supporting Agencies: This study was funded by several sources, including Industry Canada, a Social Sciences and Humanities Research Council Insight Development Grant, the Lakehead University Research Chair program, and a Canadian Institutes of Health Research postdoctoral fellowship.
Conflict of Interest: None to declare.

comparisons between the costs of food currently collected in northern and southern Canada.

The *Paying for Nutrition* project

The initial goals of the *Paying for Nutrition* project were to 1) improve upon current food costing tools (i.e., the NNFB) for northern Canada and determine the comparability of data across regions; 2) compare the cost of living (affordability) of the NNFB and food prices between two different regions of Canada (subsequent discussions with the stakeholders involved determined that direct comparisons across regions were not appropriate); 3) strengthen the work of the Northern and Remote Food Network through a Community of Practice (CoP – see description below) on food costing in the north and report on the cost of food in the north to support advocacy efforts; and 4) apply and promote participatory food costing methods where feasible. This commentary reports on the first goal of the project, describes our challenges in improving food costing tools for northern and remote locations, and makes suggestions for further developing these tools.

The project is a community/academic partnership between Food Secure Canada and two university-based research management teams (RMT): one in Halifax, NS, (Food Action Research Centre [FoodARC] out of Mount Saint Vincent University) ($n = 5$) and one in Thunder Bay, ON, (Lakehead University) ($n = 2$); a Research Advisory Team (RAT) ($n = 5$) provides oversight. The RAT is made up of key academics and organizations with the role of overseeing and advising on the methodology of the project. The northern and remote communities involved in our project are located in the provincial north, specifically northern Ontario, and the northern RMT includes a project coordinator from one of these communities. Other northern community members ($n = 5$) were also trained to conduct food costing.

In addition to the RMT and RAT, Food Secure Canada formed a Community of Practice (CoP). The CoP is a mixed group of food costing practitioners made up of community members, service providers and academics. The project supports CoP meetings by teleconference about once a month; the discussions on these calls are used to inform the RMT and the RAT. Fifty people signed up for the CoP, and approximately 12–15 people have participated in each of the six CoP calls to date. The topics of each call are determined by the project coordinator in consultation with the RMT. In particular, the CoP has been instrumental in identifying the limitations of the existing food costing methodology as well as the importance of including land- and water-based food acquisition during the development of the food costing methodology guide.

Food environments in the provincial North

Communities located in the provincial North that are only accessible by plane or seasonally by winter ice roads have different food environments than those of urban and southern locations. These households generally rely on two co-existing food systems to sustain themselves: the land-based forest and freshwater food harvesting system and the market-based retail food purchasing system. Typically, these communities only have one major retailer, which provides the majority of goods and services in the community (i.e., food, gas, pharmacy, financial services, fast food and, increasingly, health care services). The northern communities included in the *Paying for Nutrition* project are specifically First Nations communities in northern Ontario. We acknowledge that there is great diversity among communities across the country.

Developing the methodology guide

Drafting the food costing methodology guide was the responsibility of the project coordinator, in consultation with RMT members and drawing from the FoodARC participatory food costing methodology used in Nova Scotia.[5] Producing a methodology guide that reflects both the unique environments of northern First Nations as well as the diversity of food acquisition experiences and varied community contexts in northern Ontario has posed significant challenges.

During the development of the guide, two of the key challenges that arose from discussions among the CoP, the RAT and the RMT were 1) how to measure the cost of harvested land- and water-based food and 2) how to measure food quality. Other contextual issues that emerged were the existence of retail store oligopolies in communities and the importance of informal social food economies. There were also challenges using participatory approaches across southern and northern contexts. For example, the approach to data collection has been different in Nova Scotia, where permission was obtained from grocery stores to record prices, whereas in northern Ontario, instead of obtaining permission from the store, all food items on the RNFB list were purchased and the receipts used as data.

Retail Store Oligopolies

An oligopoly is a state of limited competition in which the market is shared by only a few producers or sellers. In the process of collaborating on this project it has become very clear that generating one costing model is extremely challenging given the diversity of food environment contexts across northern Ontario and in comparison with Nova Scotia. For example, while some northern communities may have only one or two retailers, others have none. Therefore, any food assessment in such a community needs to account for the cost of travel to the nearest food retail outlet outside of the community. Determining these costs is further complicated because modes of travel can change, depending upon the time of year. For instance, during the winter, snow/ice roads allow access between northern communities that is impossible without planes or boats during the rest of the year. Often the major and only retailer in the provincial North is the North West Company (the Northern Store) or one of its subsidiaries. Without a competitive market there is very little incentive for stores to offer lower prices. Some of the communities we worked with in northern Ontario, in addition to a large corporate retailer, have a locally owned store. However, the goods and services offered at these locally owned stores vary widely, some providing a full range of goods and services, and others serving as a convenience store with limited fresh food options.

Measuring Food Quality

Considering the long supply chain that food must travel to reach northern communities, the quality of fresh and perishable foods is extremely variable. There is also no accountability for food

Table 1. Assessing/measuring food quality

Packaging – Is the package in good condition (e.g., not broken, dented, ripped, leaking)?
YES **NO**
If no, describe:
Labeling – Is the food item labeled correctly?
YES **NO**
If no, describe:
Temperature – Was the food item held at the correct temperature (e.g., frozen, refrigerated)?
YES **NO**
If no, describe:
Freshness of the product – Is the item past its best-before date?
YES **NO**
How would you rate the freshness of this product?
0 – Very poor freshness
1 – Poor freshness
2 – Fair freshness
3 – Good freshness
4 – Very good freshness
If 0–3, please describe (e.g., smell, appearance, feel):

Table 2. Hunting/fishing items survey tool

Item	Purchase size	Price	On sale	Comments and calculations
Gasoline	1 L		N/A	
Snare wire, 20 gauge, brass	20 feet		☐ Yes Regular price: $_____ ☐ No	
Fishing net (gill net)	100 feet		☐ Yes Regular price: $_____ ☐ No	
Fishing line, 50 lb strength	120 yards (360 feet)		☐ Yes Regular price: $_____ ☐ No	
Shotgun ammunition, 12 gauge	25 cartridges, box		☐ Yes Regular price: $_____ ☐ No	

quality in northern stores. For example, fresh foods like fruits and vegetables are sometimes packaged in such a way that it is impossible to assess their freshness/quality before purchase and home inspection. Foods are frequently sold past their best-before dates, show visible signs of mould, have been refrozen or have damaged packaging.[6] The CoP and RMT discussed how to assess food quality. One option was to take photographs from a select list of foods and assess them according to a four-point "quality" scale, designed by the RMT from literature sources and including packaging, labeling, temperature and freshness (see Table 1).

Cost of Land- and Water-based Foods

There is no definitive methodology for costing land- and water-based foods. A study in Wapekeka and Kasabonika First Nations relied on detailed logs generated by active harvesters and estimated the annual cost of hunting at approximately $25,000 with the average cost of harvested meat at $14 per kilogram.[7] However, this kind of detailed information is extremely difficult to obtain, and the experiences of these two communities and the hunters involved in the study are not necessarily generalizable to other communities. Although the CoP and RMT initiated discussions about how to measure the cost of harvested land- and water-based foods, and a list of harvesting items (Table 2) have been costed during this project, the items included in a more broadly relevant assessment tool would need to better reflect the diversity of local and regional harvesting practices.

Informal Social Food Economies

Food sharing is an integral part of Aboriginal culture and traditions, and has been documented widely in the literature.[8–11] The First Nations Regional Health Survey[8] found that nearly 9 of 10 respondents (85.5%) had had traditional food shared with their household in the year leading up to the survey. Recent work from Nova Scotia on how people from both rural and urban contexts engage in the informal food economy,[5,12] along with our work on this project, suggests that informal social food economies are another important aspect of food environments in northern Canada and other contexts that is not captured by current food costing methods and needs to be addressed.

CONCLUSION

While this paper has focused on food environments in northern Ontario, similarities can be drawn with food environments in other remote and northern communities elsewhere in Canada. Effective standardized tools that accurately measure consumer food environments should reflect the geographic and demographic context in which they are being employed, and would benefit from the involvement of a community of practice and participatory and collaborative approaches that include input from local residents.[5,13] Current assessments are not meeting the needs of such communities. Further attention and investment needs to be given to establishing better methodologies of assessing food systems, particularly retail food environments, in northern and remote areas of Canada.

REFERENCES

1. Minaker L. *Measuring the Food Environment in Canada*. Ottawa, ON: Health Canada, 2013.
2. Standards, Programs, and Community Development Branch. *Nutritious Food Basket Guidance Document*. Ottawa, ON: Ministry of Health Promotion, 2010.
3. Government of Canada. Fact Sheet: Revised Northern Food Basket. Nutrition North Canada, 2013. Available at: http://www.nutritionnorthcanada.gc.ca/eng/1369314079798/1369314090524 (Accessed September 30, 2015).
4. Indian Affairs and Northern Development. The Revised Northern Food Basket. Ottawa, ON: INAC, 2007. Available at: http://publications.gc.ca/collections/collection_2008/inac-ainc/R3-56-2007E.pdf (Accessed September 30, 2015).
5. Food Action Research Centre (FoodARC), Nova Scotia Food Security Network (NSFSN) and Collaborating Family Resource Centres/Projects. *What Does it Cost to Eat Healthy in Your Community? A Training Guide to Participatory Food Costing*. Halifax, NS: Mount Saint Vincent University, 2014.
6. Burnett K, Skinner K, LeBlanc J. From Food Mail to Nutrition North Canada: Reconsidering federal food subsidy programs for Northern Ontario. *Can Food Stud* 2015;2(1):141–56. doi: 10.15353/cfs-rcea.v2i1.62.
7. Pal S, Haman F, Robidoux M. The costs of local food procurement in two Northern Indigenous communities in Canada. *Food Foodways* 2013; 21(2):132–52. doi: 10.1080/07409710.2013.792193.
8. First Nations Information Governance Centre (FNIGC). *First Nations Regional Health Survey (RHS). Phase 2 (2008/10) National Report on Adults, Youth and Children Living in First Nations Communities*. Ottawa, ON: The First Nations Information Governance Centre, 2012.

9. Robidoux MA, Haman F, Sethna C. The relationship of the burbot (Lota lota L.) to the reintroduction of off-the-land foods in the Sandy Lake First Nation Community. *Biodemography Soc Biol* 2009;55:12–29. PMID: 19835098. doi: 10.1080/19485560903054630.
10. Skinner K, Hanning RM, Desjardins E, Tsuji LJS. Giving voice to food insecurity in a remote indigenous community in sub-arctic Ontario, Canada: Traditional ways, ways to cope, ways forward. *BMC Public Health* 2013;13:427. PMID: 23639143. doi: 10.1186/1471-2458-13-427.
11. Socha T, Zahaf M, Chambers L, Abraham R, Fiddler T. Food security in a northern First Nations community: An exploratory study on food availability and accessibility. *J Aborig Health* 2012;8(2):5–14. Available at: http://www.naho.ca/jah/english/jah08_02/08_02_food-security.pdf.
12. Knezevic I. Illicit food: Canadian food safety regulation and informal food economy. *Crit Pol Stud* 2015. doi: 10.1080/19460171.2015.1102750.
13. Williams PL, Amero M, Anderson B, Gillis D, Green-LaPierre R, Johnson C, et al. A participatory food costing model in Nova Scotia. *Can J Diet Pract Res* 2012;73(4):181–88. PMID: 23217445. doi: 10.3148/73.4.2012.181.

RÉSUMÉ

On manque d'outils efficaces pour analyser les environnements alimentaires au détail dans les communautés nordiques et éloignées. Nous examinons les difficultés de mener des évaluations de l'environnement alimentaire dans ce type de communautés au Canada d'après notre expérience dans le cadre d'un projet de calcul des coûts des aliments. L'un des objectifs du projet *Paying for Nutrition in the North* est d'élaborer des lignes directrices afin d'améliorer les outils actuels de calcul des coûts des aliments dans le Nord du Canada. *Paying for Nutrition* illustre la complexité du contexte de mesure des environnements alimentaires dans les communautés nordiques et éloignées. Durant l'élaboration d'un guide méthodologique de calcul des coûts des aliments pour évaluer les environnements alimentaires nordiques, plusieurs problèmes contextuels se sont posés, dont la présence d'oligopoles de magasins de vente au détail dans ces communautés; l'importance d'évaluer la qualité des aliments; les économies sociales informelles de l'alimentation; et la difficulté de calculer les coûts d'acquisition et de consommation d'aliments de la terre et des cours d'eau. Les indicateurs de l'environnement alimentaire conçus pour les communautés nordiques et éloignées doivent refléter le contexte géographique où ils sont employés et doivent inclure la participation des résidents.

MOTS CLÉS : Premières Nations; approvisionnement en nourriture; analyse des coûts; population rurale

COMMENTARY

Policy options for healthier retail food environments in city-regions

Catherine L. Mah, MD, PhD,[1,2] Brian Cook, PhD,[3] Karen Rideout, PhD,[4] Leia M. Minaker, PhD[5]

ABSTRACT

Public policy is central to health promotion: it determines the distribution of resources in a society and establishes the structural context for the actions of both corporations and consumers. With this in mind, the purpose of this paper is to begin a discussion on promising policy options for a health-promoting retail food environment. Drawing on specific municipal examples, we examine four groups of policy options for healthier retail food environments in city-regions: planning for health; transforming consumer environments; economic and fiscal instruments; and a culture of transparency and participation. We introduce examples of policy options that are receiving increasing attention in the public health and urban planning literature and that function at the municipal level. We also highlight how public health professionals have an important role to play in policy that shapes retail food environments, especially in making explicit the linkages between health and other policy goals. In doing so, this commentary aims to motivate public health practitioners in a variety of community contexts to consider the policy supports they need to advance their exploration, development, testing and evaluation of interventions for healthier retail food environments.

KEY WORDS: Policy; social planning; environment and public health; food supply

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS64–eS67
doi: 10.17269/CJPH.107.5343

Public policy is central to health promotion.[1] Public policy determines the distribution of resources in a society and establishes the structural context for the actions of both corporations and consumers.[2] Policy thus plays an important role in creating the supportive environmental contexts necessary for nutritional improvement.[3]

The evidence on the retail food environment suggests that it affects health through consumption. However, the literature is methodologically heterogeneous, and mixed on how specific food environment features (such as proximity to supermarkets, or availability of and pricing of foods in stores) affect dietary and health outcomes, such as obesity.[4,5] Beyond consumption, there are other socially important reasons for considering retail food environments: among them, local economic development, social equity and food system sustainability. Public policy presents opportunities to align these diverse societal goals with health considerations.

The purpose of this commentary is to begin a discussion on promising policy options for a health-promoting retail food environment, based on a breadth of options that are receiving increasing attention in the public health and urban planning literature. This commentary will be of interest to public health practitioners who are exploring, developing, testing and evaluating retail food environment interventions in their jurisdictions. Drawing on specific municipal examples, we will examine four groups of policy options for healthier retail food environments in city-regions: planning for health; transforming consumer environments; economic and fiscal instruments; and a culture of transparency and participation.

We have categorized the policy options into four groups, so that readers can see how they tackle different constituent parts of the food environment. The widely used Glanz et al. conceptual framework divides the food environment into four constituent parts:[6]

- Community nutrition environments (geographic access to food, such as proximity to stores) – addressed by *planning for health*;
- Consumer nutrition environments (features of the shopping experience, such as pricing, availability and placement of certain foods) – addressed by *transforming consumer environments*;
- Organizational environments (environments shaped by the buildings and institutional settings that they are in, such as hospitals and schools) – addressed by *economic and fiscal instruments*; and
- Information environments (food and consumer information, such as advertising or nutrition labelling) – addressed by *a culture of transparency and participation*.

POLICY OPTIONS FOR CITY-REGIONS

Planning for health

The public health approach to policy options for addressing *community food environments* owes a debt to the urban and regional planning profession. In the last decade, planners have

Author Affiliations

1. Division of Community Health and Humanities, Faculty of Medicine, Memorial University, St. John's, NL
2. Dalla Lana School of Public Health, University of Toronto, Toronto, ON
3. Toronto Food Strategy, Toronto Public Health, Toronto, ON
4. BC Centre for Disease Control and National Collaborating Centre for Environmental Health, Vancouver, BC
5. Propel Centre for Population Health Impact, University of Waterloo, Waterloo, ON

Correspondence: Dr. Catherine L. Mah, Health Sciences Centre, Memorial University, 300 Prince Philip Drive, Rm 2840, St. John's, NL A1B 3V6, Tel: 709-864-4939, E-mail: catherine.mah@mun.ca

Acknowledgements: Parts of this commentary were previously prepared in a report for the National Collaborating Centre for Environmental Health.

Conflict of Interest: None to declare.

pushed the boundaries of policy and program options to create healthier municipal environments through healthy and sustainable city-region food systems.

Professional planning organizations have increasingly called for explicit consideration of healthier food environments in planning practice.[7,8] For example, in municipalities such as Victoria, BC,[9] Waterloo Region, ON[10,11] and London, ON,[12] partnerships between public health practitioners and urban planners have led to broader intersectoral collaborations to incorporate food access directly into the language of a regional official plan.

Zoning policies are another set of options typically employed to prevent land uses thought to be harmful to neighbourhoods. Zoning is a policy tool that can also proactively promote health.[13,14] Zoning can address community and consumer nutrition environments together, by establishing requirements for geographic food access that take into account the food options available for sale within retail settings.[15] For example, a recent analysis of zoning options for Quebec municipalities describes bylaws that incorporate retail food outlet development around schools.[16]

Land-use planning and zoning instruments typically address health through built environment factors, such as walkability, transportation and physical access. Food retail is a major aspect of the built environment that has been relatively underexamined.[17] However, changing the built environment is not the only way in which planning policy can affect the food system and retail food environments. For example, policies that support primary agricultural production in city-regions can enable a healthier retail environment by strengthening local economic relationships, including direct producer–consumer relationships, which could help to establish complementary routes for retail food distribution and purchasing.[18]

Transforming consumer environments

Public health professionals are traditionally involved in the *consumer food environment* through program activities in food safety inspection, food basket costing, healthier shopping education and, more recently, in nutrition information disclosure. These activities fall within public health core functions but when combined with planning and policy tools can help to make the consumer food environment more health-promoting. For example, mobile vending models, such as Toronto's Mobile Good Food Market and Ottawa's MarketMobile, use a combination of licensing policy instruments and public health program activities to develop new mobile retail premises to increase the availability of fresh produce in underserved neighbourhoods. Licensing is a powerful tool to influence the quality of food establishments in an area but requires substantial cooperation of public and private sector actors to develop "win-win" approaches.

Others have combined health and social development efforts, such as the community-run Good Food Junction cooperative grocery store opening in an underserved neighbourhood in Saskatoon, which co-located housing development, health and social services delivery, university outreach and community development; the closing of the store in January 2016 illustrated the high level of economic risk that such interventions must overcome to be successful.[19]

Indeed, the sustainability of consumer environment initiatives depends crucially on resident and retailer capacity-building and financial feasibility, an alignment of local and regional economic development and community development (discussed further below). The comprehensive "healthy corner store" intervention model is a good example of this integration of efforts. Healthy corner store interventions typically aim to improve geographic access to healthier options; increase availability, affordability and consumer appeal of healthier foods within stores; build capacity among small retailers and their supply chains; and build demand at the community level.[20] To our knowledge, healthy corner store initiatives have been implemented with current or planned evaluations to address population health impact in BC, MB (Winnipeg), ON (Ottawa and Toronto) and NL (Branch).

Economic and fiscal instruments

Municipalities have often considered the *organizational environments* under their authority as a health promotion setting. For example, municipalities have adopted marketing/sponsorship policies, or set standards for the nutritional quality of foods served.[21] In some cases these have been supported through provincial mandates, such as school food and nutrition policy guidelines. Municipal governments and other publicly funded institutions have also begun to leverage their public purchasing power through procurement policies that prioritize local economic development or environmental sustainability considerations. For example, some jurisdictions have developed procurement guidelines that establish a benchmark for the proportion of locally produced food used in food outlets in municipal facilities such as recreation centres.

Municipalities can also use economic development policy tools to support social enterprises or social finance initiatives. Municipal government services, taxes and practical programs for new and entrepreneurial companies can create a hospitable (or otherwise) environment for innovation, investment and small business development. For example, food business incubators are physical spaces where new entrepreneurs can rent low-cost commercial kitchen space to grow their business; in successful cases, business supports, such as marketing, investment advice, and links to capital, are also offered. These types of policy approaches could be leveraged to encourage healthier retail food environments that improve the availability of and access to high-quality, nutritious foods.

Traditional fiscal instruments, such as taxation, have also been proposed as having the potential to increase consumption of healthier foods and decrease consumption of items such as sugar-sweetened beverages in retail settings. In 2014, Berkeley, CA, was the first municipal jurisdiction in North America to adopt a tax on sugar-sweetened beverages.[22] It has been argued that revenues generated by such approaches could be earmarked for public health purposes.

A culture of transparency and participation

Public health actors have taken a proactive approach to the retail *information environment* in the area of nutrition information disclosure. For example, Ontario's menu labelling legislation drew from evidence generated through local public health units. Menu labelling policy has been set forth on the basis that if nutrition information can be made transparent at the point of purchase in places where people eat out, then it helps people to factor nutritional considerations into decision-making; as well, the majority of the public is supportive of it.[23]

Municipalities can also promote transparency in the retail food environment through supports for participatory approaches to food system deliberation and planning. Food policy councils and other types of citizen roundtables are forums where a wide variety of stakeholders can come together to identify policy issues of importance.[24–26] Where public health professionals have been involved in such activities, they tend to act as an enabling force by offering dedicated staff time in support of council activity or by acting as a convenor between civil society groups, businesses and government.[27] They can also bring a health lens and provide access to health evidence for food policy council activities that may be focused primarily on sustainability, economic development or other goals.

DISCUSSION

Public policy can be used innovatively to shift retail food environments in ways that are health promoting. Public health professionals have an important role to play in making explicit the linkages between health and other policy goals. Retail food environment interventions often focus on behaviour change, with the understanding that individuals make decisions based on cognitive and social inputs. Healthy public policy from a healthy behaviour standpoint can make decision-making inputs more accessible to cognitive processing by individuals, who are boundedly rational. Healthy public policy can also change social norms in ways that alter both material and ideational incentives to decision-making. Therefore, policy that addresses health behaviour needs to go beyond the grocery shelf or till. It should incorporate a holistic view on access to and availability of high-quality, local, healthier and affordable food options; the availability and accessibility of information for consumer decision-making; leveraging alignments in government, civil society and market imperatives; and finding opportunities to make the healthier choices easier for individuals as well as the food retailers and distributors who need to operationalize these goals in the retail environment.

Health equity is an overarching goal for intervening in the retail food environment. This means assessing and addressing social, economic and spatial disparities in the food environment; examining how food environment disparities affect different populations disproportionately; promoting a fair distribution of resources; and enabling individual capacities. A gradient exists in Canada whereby the lower the income quintile, the greater the proportion of food spending in stores.[28] Supportive retail food environment policy thus also requires co-existing social policy that addresses the economic constraints that households face in acquiring food in socially acceptable ways.

Effective policy requires evidence, but evidence is not sufficient for successful implementation of interventions; public health professionals who lead retail food environment interventions also need to consider factors such as policy readiness in their community, at an early stage in intervention development. For example, different municipalities reflect different organizational cultures of adopting innovations, with varying levels of comfort among municipal actors to be "innovators" or "early adopters".[29] Enacting public policy in the food environment requires the cooperation of public and private actors whose interests, values and power may not align.[30] Retail food environment initiatives are often led by public health professionals, but formal authority and power for retail is concentrated outside the control and mandates of the health sector.

Reshaping retail food environments will require experimentation with a range of policy options that act across the food system, from producers to processors, distributors, retailers and eaters. Because the food system overlaps with so many other modes of social organization (markets, firms, associations, communities, families), actors from different sectors and networks are usually implicated in any retail food environment intervention. Multi-sector approaches are essential and offer municipalities more flexibility than might be assumed. The "food" portfolio was historically used to refer to food security issues for a nation; the "health" portfolio has traditionally focused on nutritional well-being; and the "public health" portfolio on risk, food safety and hygiene. When municipalities enact policies to address retail food environments, they can look for inspiration in diverse portfolios from agricultural production, community development, culture, economic development and regulation, environment, finance, health and social care, nutrition and others. More importantly, these diverse mandates should be adapted to the appropriate scale for municipalities with different policy authority and capacity. As "creatures of the provinces", municipal governance varies substantially among Canadian jurisdictions, so this is an equity challenge, especially since the majority of evidence (7 in 10 studies on the retail food environment in Canada to date) has been based on studies in urban centres.[5] In policy areas such as transportation and climate change adaptation, municipalities have demonstrated how they can develop collective approaches on a horizontal basis (in other words, aligning policy objectives across jurisdictions at the same order of government) or scale up their capacity through regional governance models for specific policy agendas.

Public health professionals can play a key role in bringing individuals and groups together, drawing on their unique mix of expertise and experience in coordination, facilitation, community engagement, research and evaluation. These actions can have an important role to play in driving retail food environment renewal where health is a priority.

REFERENCES

1. World Health Organization, Health and Welfare Canada, Canadian Public Health Association. *Ottawa Charter for Health Promotion*. Ottawa, ON: World Health Organization, Health and Welfare Canada, and the Canadian Public Health Association, 1986.
2. Milio N. Making healthy public policy; developing the science by learning the art: An ecological framework for policy studies. *Health Promot Int* 1987; 2(3):263–74. PMID: 10303001. doi: 10.1093/heapro/2.3.263.
3. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: Policy and environmental approaches. *Annu Rev Public Health* 2008;29(1):253–72. PMID: 18031223. doi: 10.1146/annurev.publhealth.29.020907.090926.
4. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18(5):1172–87. PMID: 22717379. doi: 10.1016/j.healthplace.2012.05.006.
5. Minaker LM, Shuh A, Olstad DL, Engler-Stringer R, Black JL, Mah CL. Retail food environments research in Canada: A scoping review. *Can J Public Health* 2016;107(Suppl 1):eS4–eS13.
6. Glanz K, Sallis JF, Saelens BE, Frank LD. Healthy nutrition environments: Concepts and measures. *Am J Health Promot* 2005;19(5):330–33. PMID: 15895534. doi: 10.4278/0890-1171-19.5.330.
7. Ontario Provincial Planners Institute. *Planning for Food Systems in Ontario: A Call to Action*. Toronto, ON: Ontario Provincial Planners Institute, 2011. Available at: http://ontarioplanners.ca/PDF/Healthy-Communities/2011/a-call-to-action-from-oppi-june-24-2011.aspx (Accessed April 17, 2016).

8. Pothukuchi K, Kaufman JL. The food system: A stranger to the planning field. *J Am Plann Assoc* 2000;66(2):113–24. doi: 10.1080/01944360008976093.
9. City of Victoria Planning and Development Department – Community Planning Division. *City of Victoria Official Community Plan*. Victoria, BC: City of Victoria, 2015.
10. Minaker LM, Fisher P, Raine KD, Frank LD. Measuring the food environment: From theory to planning practice. *J Agric Food Syst Community Dev* 2011; 2(1):65–82. doi: 10.5304/jafscd.2011.021.021.
11. Wegener J, Raine KD, Hanning RM. Insights into the government's role in food system policy making: Improving access to healthy, local food alongside other priorities. *Int J Environ Res Public Health* 2012;9(12):4103–21. PMID: 23202834. doi: 10.3390/ijerph9114103.
12. City of London. *The London Plan: Second Draft*. London, 2015.
13. Hirschborn JS. Zoning should promote public health. *Am J Health Promot* 2004;18(3):258–60. PMID: 14748317. doi: 10.4278/0890-1171-18.3.258.
14. Schilling J, Linton LS. The public health roots of zoning: In search of active living's legal genealogy. *Am J Prev Med* 2005;28(2):96–104. PMID: 15694517. doi: 10.1016/j.amepre.2004.10.028.
15. Ashe M, Graff S, Spector C. Changing places: Policies to make a healthy choice the easy choice. *Public Health* 2011;125(12):889–95. PMID: 21917279. doi: 10.1016/j.puhe.2011.04.010.
16. Association pour la sante publique du Quebec. *The School Zone and Nutrition: Courses of Action for the Municipal Sector*. Montreal, QC: Association pour la sante publique du Quebec, 2011. Available at: http://www.aspq.org/guide-zonage-version-finale-anglaise.pdf (Accessed April 17, 2016).
17. British Columbia Provincial Health Services Authority. *Built Environment Linkages: A Toolkit for Design-Planning-Health*. Vancouver, BC, 2014.
18. Sonnino R, Marsden T. Beyond the divide: Rethinking relationships between alternative and conventional food networks in Europe. *J Econ Geogr* 2006; 6(2):181–99. doi: 10.1093/jeg/lbi006.
19. Good Food Junction. Core Neighbourhood Grocery Store Closing: Low Sales and Challenging Market Environment Force Good Food Junction to Shut its Doors, 2016. Available at: http://goodfoodjunction.com/ (Accessed April 17, 2016).
20. Healthy Corner Stores Network. Healthy Corner Stores Network [Website]. Available at: http://www.healthycornerstores.org (Accessed April 17, 2016).
21. Mah CL, Cook B, Hoang S, Taylor E. Municipal action on food and beverage marketing to youth. In:Barrett D, Ortmann L, Dawson A, Saenz C, Reis A, Bolan G (Eds.), *Public Health Ethics: Cases Spanning the Globe*. Madrid: Springer, 2016.
22. Falbe J, Rojas N, Grummon AH, Madsen KA. Higher retail prices of sugar-sweetened beverages 3 months after implementation of an excise tax in Berkeley, California. *Am J Public Health* 2015;105(11):2194–2201. PMID: 26444622. doi: 10.2105/AJPH.2015.302881.
23. Mah CL, Timmings C. Equity in public health ethics: The case of menu labelling policy at the local level. *Public Health Ethics* 2015;8(1):85–89. doi: 10.1093/phe/phu011.
24. Harper A, Shattuck A, Holt-Gimenez E, Alkon A, Lambrick F. *Food Policy Councils: Lessons Learned*. Oakland, CA: Institute for Food and Development Policy, 2011.
25. Food Policy Networks. http://www.foodpolicynetworks.org/ (Accessed April 17, 2016).
26. Blay-Palmer A. The Canadian pioneer: The genesis of urban food policy in Toronto. *Int Plann Stud* 2009;14(4):401–16. doi: 10.1080/13563471003642837.
27. MacRae R, Donohue K. *Municipal Food Policy Entrepreneurs: A Preliminary Analysis of how Canadian Cities and Regional Districts are Involved in Food System Change*. Toronto, ON: Toronto Food Policy Council, Vancouver Food Policy Council, and Canadian Agri-Food Policy Institute, 2013.
28. Industry Canada. *The Consumer Trends Report: Industry Canada Research Paper*. Ottawa, ON: Industry Canada, 2005.
29. Nykiforuk CIJ, Atkey K, Niewendyk LM, Raine KD, Reed S, Kyle K. *Policy Readiness Tool: Understanding a Municipality's Readiness for Policy Change and Strategies for Taking Action*. Edmonton, AB: School of Public Health, University of Alberta, 2011.
30. Mah CL, Vanderlinden L, Mamatis D, Ansara DL, Levy J, Swimmer L. Ready for policy? Stakeholder attitudes toward menu labelling in Toronto, Canada. *Can J Public Health* 2013;104(3):e229–34. PMID: 23823887.

RÉSUMÉ

La politique publique est au cœur de la promotion de la santé : elle détermine la répartition des ressources dans une société et établit le contexte structurel des actions des entreprises et des consommateurs. Cela dit, l'objet de cet article est d'amorcer une discussion sur les possibilités d'action prometteuses pour rendre l'environnement alimentaire au détail favorable à la santé. D'après des exemples précis recueillis dans le monde municipal, nous examinons quatre groupes de possibilités d'action visant à créer des environnements alimentaires au détail plus sains dans les villes-régions: la planification pour la santé; la transformation des environnements de consommation; les instruments économiques et financiers; et une culture de transparence et de participation. Nous présentons des exemples de possibilités d'action qui reçoivent une attention accrue dans les articles de santé publique et d'urbanisme et qui fonctionnent à l'échelle municipale. Nous soulignons aussi le rôle important que peuvent jouer les professionnels de la santé publique dans les politiques qui influencent les environnements alimentaires au détail, surtout en explicitant les liens entre la santé et d'autres objectifs stratégiques. Ce faisant, notre commentaire vise à motiver les praticiens de la santé publique dans divers contextes communautaires à examiner les soutiens stratégiques dont ils ont besoin pour faire progresser leur exploration, leur élaboration, leur mise à l'essai et leur évaluation d'interventions pour créer des environnements alimentaires au détail plus sains.

MOTS CLÉS : politique; organisation sociale; environnement et santé publique; approvisionnement en nourriture

Retail food environments research: Promising future with more work to be done

Daniel Fuller, PhD,[1,2] Rachel Engler-Stringer, PhD,[2,3] Nazeem Muhajarine, PhD[2,3]

ABSTRACT

As members of the scientific committee for the Food Environments in Canada conference, we reflect on the current state of food environments research in Canada. We are very encouraged that the field is growing and there have been many collaborative efforts to link researchers in Canada, including the 2015 Food Environments in Canada Symposium and Workshop. We believe there are 5 key challenges the field will need to collectively address: theory and causality; replication and extension; consideration of rural, northern and vulnerable populations; policy analysis; and intervention research. In addressing the challenges, we look forward to working together to conduct more sophisticated, complex and community-driven food environments research in the future.

KEY WORDS: Food; environment; research; exposure

La traduction du résumé se trouve à la fin de l'article.

Can J Public Health 2016;107(Suppl. 1):eS68–eS70
doi: 10.17269/CJPH.107.5622

As members of the scientific committee for the Food Environments in Canada conference, we are delighted to reflect on the importance of this *Canadian Journal of Public Health* special supplementary issue. This special issue has provided an important opportunity for our field to reflect on our successes and discuss our challenges. As Minaker et al. point out, retail food environments research has expanded rapidly in Canada, only one paper having been published before 2005 and 66 between 2010 and 2015.[1] The increase in publications is a reflection of a concerted effort from researchers across Canada, but is not unique to Canada.[2] This special supplement covers a wide range of methodological approaches, populations and geographic foci. Taken together, we believe there are five broad challenges that need addressing for food environments research in Canada. Along with the challenges, we propose potential solutions.

CHALLENGE 1: THEORY AND CAUSALITY

Food environments researchers are taking theory and causality more seriously in their work. We believe that efforts should be made to link theory and causal mechanisms with data analysis. To date, studies include only implicit assumptions about both the theoretical justification and causal mechanisms. Relatedly, many implicit assumptions about the association between food environments and health involve statistically testable assumptions about effect modification. It is clear from the articles in this supplement that examining effect modification is increasingly of interest for researchers. Whether this is effect modification by age, sex, First Nations status, or rurality, there is a strong desire to explore hypothesized mechanisms that may explain observed associations. Additional mechanisms that must be explicitly theorized and statistically tested could include childhood exposure to foods, participation in traditional, alternative or cultural food practices, and social preferences for food taste.

CHALLENGE 1: SOLUTIONS

Researchers should explicitly state their theoretical framework and the specific hypothesized causal mechanisms under study. Continued examination of effect modification is warranted, with the caveat that the mechanisms and causal pathways that are postulated be explicitly described. To date, very few studies have included any examination of mediated or effect-modified mechanisms that link the food environment and its health effects on populations. Including mediation or effect modification in hypothesized pathways and analysis could prove fruitful. Pre-publication of study protocols and data analysis plans can support the presentation of theoretical and statistical testing of hypothesized mechanisms.[3] Pre-publication can also avoid data-driven fishing expeditions.

CHALLENGE 2: EXPOSURE

The second major challenge is related to exposure conceptualization and measurement. Issues of defining exposure to food stores, whether through use of road network buffers from the centroid of a geographic location or GPS(global positioning systems)-based activity spaces are crucial to advance the field. Gilliland et al. (in this issue) use a promising method to define exposure that is based on GPS traces. Combining measures of exposure to food stores with improved measurement of whether healthy or unhealthy food is available in those stores is important. In addition, exposure to the consumer or in-store/in-restaurant food environment needs to be captured more accurately.

Author Affiliations

1. School of Public Health, University of Saskatchewan, Saskatoon, SK
2. Saskatchewan Population Health and Evaluation Research Unit
3. Department of Community Health and Epidemiology, University of Saskatchewan, Saskatoon, SK

Correspondence: Rachel Engler-Stringer, PhD, Dept of Community Health and Epidemiology, University of Saskatchewan, 104 Clinic Place, Saskatoon, SK S7N 2Z4, Tel: 306-966-7839, E-mail: Rachel.engler-stringer@usask.ca

Commonly used tools, such as the Nutrition Environment Measures Survey for Stores/Restaurants, have important limitations, which need to be acknowledged and improved upon.[4]

CHALLENGE 2: SOLUTIONS

Measurement of the food environment needs to move beyond simply counting different types of food retailers in a geographic area and equating healthy/unhealthy food sources with simple definitions of retail types. Similarly, definitions of environments using Euclidean buffer zones of a given distance from a food retailer or from a participant's residence should be avoided. The measurement of activity spaces using GPS is an improvement in measuring food environment exposure. The data and computational requirements are substantial when using GPS methods, but food environments researchers must develop collaborations and expertise in this area. We caution, however, that moving solely toward research using individual-level exposure measures based on GPS has the potential to limit our understanding of shared environmental exposure contexts (e.g., food deserts, food swamps and food mirages) and may add new challenges for causal inference.[5] Furthermore, measurement of the environment in food stores using shelf space or other relative measures is another way to improve exposure measurement.[6] Combining spatial access with food pricing and quality measures within stores will be an important advance, allowing a better understanding of the associations between food environments and health.[7] Lebel et al., in this issue, describe the importance of this type of exposure measurement in rural areas.[8]

CHALLENGE 3: REPLICATION AND EXTENSION

Replication and extension of past research is a foundation of the scientific process. Replication has recently been highlighted as a key challenge for psychology and, we would argue, for food environments research.[9] We interpret the calls for replication in two ways, to confirm the results of past work and to generalize results to new contexts. For example, Mercille et al. (in this issue) express concern that their study included only 248 of 862 census tracts in Montreal and may not be generalizable to Montreal, let alone other cities.[10] Polsky et al. (in this issue) suggest their results should be replicated in rural or remote settings. Both authors are concerned with generalizability to new contexts.[11]

CHALLENGE 3: SOLUTIONS

The primary solutions to addressing the replication challenge for food environments research in Canada are open data and data sharing among researchers. In particular, sharing geographic information systems with food environment exposure measures is crucial for the replication of past research. To improve measurement of food store "healthfulness", researchers need to develop open databases that limit reliance on proprietary commercial use data.[12] Also, a focus on replication and extension by improving the comparability of exposure measures used in published studies is important. A possible solution is to publish replications as online supplements and results from new exposure measures as the primary result in a manuscript.

CHALLENGE 4: CONSIDERATION OF RURAL AND NORTHERN AND VULNERABLE POPULATIONS

Equity is an important aspect of food environments research. It is clear that food affordability and access create extreme inequities in healthy food consumption in rural and northern areas and in vulnerable populations. As Skinner et al. discuss in this issue, limited work has examined food costing in the north.[13] Economic barriers appear to be the major driver of differential access to healthy food among rural, northern and vulnerable populations, yet little research to date has been conducted in these settings and with these populations.

CHALLENGE 4: SOLUTIONS

Food environments research with rural, northern and other vulnerable populations must be community driven in order to ensure that historical and ongoing traumas are not repeated, and that any proposed interventions reflect the needs and desires of communities. The social and historical contexts of these communities must also be carefully considered in food environments research. For example, if the underlying issue is poverty, we must study and address poverty in relation to the food environment. We also must use theory and explicitly state our assumptions when extending or replicating urban-based food environment research to other settings, particularly among rural, remote or vulnerable populations.

CHALLENGE 5: POLICY ANALYSIS AND INTERVENTION RESEARCH

Policy analysis and intervention research are important challenges for studying food environments in two ways. First, as discussed by Mah et al. in this issue, conceptualizing and discussing potential policy options at various government levels can improve our understanding of the plausible impacts of food environment policies.[14] Second, intervention research can empirically evaluate the implementation of real world policies. This is important in order for food environments researchers to contribute to the public discussion about food and health. It is also important because well-designed natural experiment studies may be one of our best chances to estimate causal effects.[15] Combining quantitative and qualitative research can also be beneficial in helping identify mechanisms.

CHALLENGE 5: SOLUTIONS

Policy analysis and intervention research requires researchers having an "ear to the ground" in urban planning and food policy at federal, municipal and community levels. There is a need to develop strong partnerships with these sectors and maintain funding for policy evaluation research.

CONCLUSION

At the heart of this reflection is the idea that addressing these challenges will require continued collaboration between food environment researchers. We hope that our perspectives, informed by several years of researching food environments and food environment interventions, on the future directions that are needed in this research area can contribute to increasingly sophisticated approaches in our field. As Minaker et al. found in

this special issue, most of the Canadian research has been published in the last 5 years.[1] The field is growing and dynamic.

To us, this is consistent with the dynamism and engagement we saw when we brought 100 people from across Canada together for the Food Environments in Canada Symposium and Workshop in May 2015. Given how quickly this field has grown, we look forward to working together with you to conduct more sophisticated, complex and community-driven food environments research in the future.

REFERENCES

1. Minaker LM, Shuh A, Olstad DL, Engler-Stringer R, Black JL, Mah CL. Retail food environments research in Canada: A scoping review. *Can J Public Health* 2016;107 (Suppl 1):eS4–eS13. doi:10.17269/CJPH.107.5344.
2. Caspi CE, Sorensen G, Subramanian SV, Kawachi I. The local food environment and diet: A systematic review. *Health Place* 2012;18(5):1172–87. doi:10.1016/j.healthplace.2012.05.006.
3. Engler-Stringer R, Le H, Gerrard A, Muhajarine N. The community and consumer food environment and children's diet: A systematic review. *BMC Public Health* 2014;14(1):1. doi:10.1186/1471-2458-14-522.
4. Saelens BE, Glanz K, Sallis JF, Frank LD. Nutrition Environment Measures Study in Restaurants (NEMS-R): Development and evaluation. *Am J Prev Med* 2007;32(4):273–81. doi:10.1016/j.amepre.2006.12.022.
5. Roux AVD. The study of group-level factors in epidemiology: Rethinking variables, study designs, and analytical approaches. *Epidemiol Rev* 2004; 26(1):104–11. doi:10.1093/epirev/mxh006.
6. *Food Environment Assessment Manual*. Health Canada, In Press.
7. Le H, Engler-Stringer R, Muhajarine N. Walkable home neighbourhood food environment and children's overweight and obesity: Proximity, density or price? *Can J Public Health* 2016;107 (Suppl 1):eS42–eS47. doi:10.17269/CJPH.107.5347.
8. Lebel A, Noreau D, Tremblay L, Oberlé C, Girard-Gadreau M, Duguay M, Block JP. Identifying rural food deserts: Methodological considerations for food environment interventions. *Can J Public Health* 2016;107 (Suppl 1): eS21–eS26. doi:10.17269/CJPH.107.5353.
9. Open Science Collaboration. Estimating the reproducibility of psychological science. *Science* 2015;349(6251):aac4716. doi:10.1126/science.aac4716.
10. Mercille G, Richard L, Gauvin L, Kestens Y, Shatenstein B, Daniel M, Payette H. The food environment and diet quality of urban-dwelling older women and men: Assessing the moderating role of diet knowledge. *Can J Public Health* 2016; 107 (Suppl 1):eS34–eS41. doi:10.17269/CJPH.107.5309.
11. Polsky JY, Moineddin R, Glazier RH, Dunn JR, Booth GL. Relative and absolute availability of fast-food restaurants in relation to the development of diabetes: A population-based cohort study. *Can J Public Health* 2016;107 (Suppl 1):eS27–eS33. doi:10.17269/CJPH.107.5312.
12. Forsyth A, Lytle L, Van Riper D. Finding food: Issues and challenges in using Geographic Information Systems to measure food access. *J Transport Land Use* 2010;3(1):43–65. doi:10.5198/jtlu.v3i1.105.
13. Skinner K, Burnett K, Martin D, Williams P, Stothart C, LeBlanc J, et al. Challenges in assessing food environments in northern and remote communities in Canada. *Can J Public Health* 2016;107 (Suppl 1):eS60–eS63. doi:10.17269/CJPH.107.5324.
14. Mah C, Cook B, Rideout K, Minaker LM. Policy options for healthier retail food environments in city-regions. *Can J Public Health* 2016;107 (Suppl 1): eS64–eS67. doi:10.17269/CJPH.107.5343.
15. Petticrew M, Cummins S, Ferrell C, Findlay A, Higgins C, Hoy C, et al., Natural experiments: An underused tool for public health? *Public Health* 2005; 119(751–57):751. doi:10.1016/j.puhe.2004.11.008.

RÉSUMÉ

En tant que membres du comité scientifique de la conférence « Food Environments in Canada », nous réfléchissons à l'état actuel de la recherche sur les environnements alimentaires au pays. Nous sommes très encouragés par la croissance du domaine et par les nombreux efforts concertés pour établir des liens entre les chercheurs à l'échelle nationale, dont le colloque et l'atelier « Food Environments in Canada » de 2015. Nous croyons qu'il y a cinq grands défis à relever collectivement dans ce domaine : la théorie et la causalité; la répétition et la vulgarisation des résultats; la prise en compte des populations rurales, nordiques et vulnérables; l'analyse des politiques; et la recherche d'intervention. Pour aborder ces défis, nous envisageons avec intérêt de travailler ensemble à mener des études de recherche sur les environnements alimentaires plus élaborées, plus complexes et plus axées sur les communautés à l'avenir.

MOTS CLÉS : nourriture; environnement; recherche; exposition