The Geography of Overweight in Quebec: A Multilevel Perspective

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ABSTRACT

Objectives: Explore the contextual aspects of overweight in Québec through multilevel modelling, using a purposely designed set of spatial units and a few area-based characteristics.

Methods: Data came from the Canadian Community Health Survey (CCHS Cycle 2.1). Multilevel logistic regressions were performed to test for the presence of an independent contextual effect on overweight and obesity (BMI ≥ 25 kg/m²), separately for men and women. Modelling considered individual attributes, including some lifestyle aspects, and contextual characteristics. A geographic grid integrating spatial elements related to overweight and obesity in the literature was developed. Also, an area-level residuals analysis was carried out to identify spatial units presenting higher or lower odds of being overweight.

Results: After accounting for individual and area-level characteristics, there remain significant geographic variations in overweight in Québec. Although this contextual effect is small for men and women, many spatial units differ significantly from the provincial average. There are differences between the geography of overweight in men and women which suggest that socio-economic mechanisms and land use patterns underlying overweight might be different between genders. Also, there is considerable variability within rural and urban areas.

Conclusion: A complex geography of overweight is revealed. Small-scale studies, as well as methodological and data developments, are needed to deepen our understanding of this geography.

Key words: Overweight; obesity; Québec; medical geography; multilevel analysis; population health

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

Can J Public Health 2009;100(1):18-23.

Public health administrators are greatly concerned about overweight or obesity¹⁻³ and various initiatives to reduce this health problem are being undertaken in Europe,^{4,5} the USA,⁶ and Canada.⁷ Although valuable, these initiatives show limited effects because they often neglect that “environmental factors play a role, and that environmental solutions will be required to address the epidemic.”⁸

In recent years, many studies reported relationships between contextual measures and overweight or obesity, after controlling for individual characteristics. However, a review of these studies highlights the fact that these were based, in large part, on weak research designs and theories.⁸ Brug et al.⁸ pointed out that only the most recent studies used multilevel analysis. In a review of 30 multilevel-based studies on overweight or obesity,⁹⁻³⁸ we further found that these may be improved in three ways, namely by: 1) using a longitudinal design, 2) including both diet and physical activity indicators in the modelling, and 3) providing a proper geographic grid to depict the area effect. These remarks are consistent with the literature review of Papas et al.³⁹ on the built environment and obesity.

Longitudinal data as well as individual lifestyle indicators are prized by researchers but are unfortunately hard to find. Designing geographic grids that can be used to assess contextual effect is often possible but rarely done.⁴⁰ Usually, those grids are simply created with available administrative units.⁴¹⁻⁴⁴ For instance, Canadian studies refer to health regions,^{45,46} census tracts,³³ or dissemination areas.²⁹ Furthermore, rural areas are hardly defined, or considered as a whole, if not discarded altogether from the analysis.⁴⁷⁻⁴⁹

The main objective of this study is to explore the contextual aspects of overweight in Québec through multilevel modelling, with specially designed spatial units and a few area-based variables.

METHOD

Data

We used the Québec sample of the Canadian Community Health Survey Cycle 2.1 (CCHS 2.1, 2003). This database provides information on individual characteristics and allows the geocoding of respondents. Pregnant women, underweight individuals (BMI < 18.5 kg/m²)⁵⁰ or those with an exceptionally high body mass index (BMI > 70 kg/m²),⁵¹ and those with missing socio-economic and lifestyle information were excluded. This study is based on 20,449 adults.

Individual-level variables

The dependent variable is binary and refers to either being overweight (BMI ≥ 25 kg/m²) or having a normal weight (18.5 kg/m² $\leq$ BMI < 25 kg/m²).⁵⁰

Three categories of independent variables are considered: demographic, socio-economic, and lifestyle (Table 1). Their inclusion is essential to control for the compositional effect, as it usually explains most of the variance.

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Acknowledgements: This research could not have been carried out without the financial support of the Quebec Population Health Research Network (QPHRN), the Quebec Inter-University Centre for Social Statistics (QICSS), and the Fonds de la recherche en santé du Québec (FRSQ). The Institut national de santé publique du Québec (INSPQ) and the Natural Science and Engineering Research Council of Canada (NSERCC) also contributed to this study. Finally, we thank William Pederson and Pierre Masson for their revision of an earlier version of this manuscript, as well as Philippe Gamache and Patricia Lamontagne, both from INSPQ, for their valuable advice.

Area-level variables

Three independent contextual variables are considered (Table 1). The first is rurality by dissemination area (DA), which corresponds to population concentrations of fewer than 1000 inhabitants and a residential density below 400 individuals/km². The other indicators are the two components of a deprivation index developed in Québec.⁵² They refer to the material and social dimensions of small area (DA) deprivation. While the material dimension mainly reflects income, education, and employment, the social dimension refers primarily to marital status, living alone or in single-parent families. The index was recalculated to match our geographic grid. Both dimensions were categorized into quintiles for each area and then dichotomized, the two higher quintiles indicating deprivation. These variables are considered derived contextual variables since they summarize values from censuses at an area level, and thus provide information distinct from their individual namesake.⁵³

Geographical areas

For studying contextual effect, the way geography is structured is crucial.^{40,54,55} In order to explore whether there is a significant difference associated with the probability of being overweight between areas, we built a set of geographical units based on several criteria known to be associated with this health outcome: rural vs. urban areas,⁴⁷ variability among rural regions,⁴⁸ suburban or inner city locations (density, urban sprawl, etc.),⁵⁶ and area deprivation.³³

The setup of those units was initially based on the 15 southern administrative health regions (Figure 1). Then each health region was subdivided into three types of areas based on whether it was: 1) part of the census metropolitan area (CMA) of Montreal or Quebec City, 2) part of any other urban area (other CMAs and census agglomerations (CA)), or 3) part of a rural area as defined by the metropolitan-influenced zone concept (MIZ).^{57,58} Respectively, these three groups of areas were further subdivided into three categories: 1) centres or peripheries, 2) cities or towns, or 3) proximal or remote rural areas. Finally, the centres and peripheries of Montreal and Quebec City were split into privileged and deprived areas, according to the deprivation index.

The Province of Quebec was then subdivided into 51 spatial units (not contiguous) categorized as major city centres (a) and peripheries (b), privileged or deprived, other cities (c) or towns (d), and proximal (e) or remote (f) rural areas (Figure 1). Our CCHS sample shows an average of 342 respondents per unit, with a minimum of 30 observations. (For more information, a methodological supplement is available on the CRAD website: ftp://ftp.crad.ulaval.ca/Pub/crad/Lebel_2008_Area.pdf. The actual geographic files, including deprivation index quintiles, are also freely available in Map Info format: ftp://ftp.crad.ulaval.ca/Pub/crad/Lebel_2008_Area.zip. Files accessed December 4, 2008.)

Statistical analysis

We performed multilevel logistic regressions distinguishing two levels: individual and geographical. Analyses were stratified by gender to control for weight differences between males and females.⁵⁹

For modelling, a four-step strategy was adopted. The first step refers to the variance component model (or null model) and expresses the distribution of variance between levels. This distribution is given by the intraclass correlation coefficient (ICC).⁵⁴ The second step incorporates demographic and socio-economic vari-

Table 1. Sample Characteristics

	Women n=10,927 43.3%	Men n=9,522 55.8%
Outcome: BMI ≥25		
Age		
18-24	11.3%	12.4%
25-44	38.9%	40.3%
45-64	35.9%	35.2%
65+	16.9%	21.1%
Marital Status		
Single*	21.1%	26.0%
Previously Married	19.0%	8.9%
Married	59.9%	65.2%
Disposable Income		
High Income†	56.3%	66.2%
Low Income	33.8%	26.5%
Missing Income	9.9%	7.3%
Education Level		
University	17.3%	19.5%
College or High School	58.3%	58.6%
Lower than High School	25.3%	21.9%
Food consumption		
5 Fruits or Vegetables/Day	52.0%	35.1%
Smoking Status		
Current Smoker	24.1%	26.6%
Former Smoker	44.7%	50.6%
Never a Smoker	31.2%	22.8%
Leisure Physical Activity Level		
Active‡	35.2%	38.9%
Moderately Active	20.6%	17.5%
Somewhat Active	19.9%	16.9%
Sedentary	24.2%	26.7%
Occupational Physical Activity		
Physically Difficult	3.5%	12.1%
Usually Standing	68.0%	59.3%
Usually Seated	28.5%	28.6%
Contextual		
Rural	19.3%	20.4%
Materially Deprived	41.9%	42.4%
Socially Deprived	52.5%	51.5%

* Includes common-law spouses

† The disposable income index takes into account the number of people in each household.

‡ Considers duration, frequency, intensity and energy expenditure of 18 leisure-time physical activities⁶⁸

Source: Canadian Community Health Survey, 2003 and Canadian Census, 2001.

ables. Lifestyle variables are added to the third step, and the fourth step incorporates area-level variables (full model). All regressions were estimated by the residual iterated generalized least squares (RIGLS) and predictive quasi-likelihood (PQL) methods using MLwiN (Release 2.02). Sampling weights were deduced by normalizing population weights in the CCHS database and took into account the design effect. Using Kendall's Tau, no multi-collinearity was found between variables (all VIF < 2).

Finally, in order to deepen our understanding of the geography of overweight, we looked at the area-level residuals in order to identify which of our 51 areas differed significantly from the provincial average.

RESULTS

Men

The full model (model 4) reveals that the typically overweight man in Québec is between 45 and 64 years old, married, with a low education level. He eats fewer than five servings of fruit or vegetables daily, is a non-smoker, lives in a rural environment and tends to stay in a materially privileged area.

As demographic, socio-economic, lifestyle, and environmental variables are incrementally added to the model, the ICC goes down from 1.23% in the null model to 1.08% in the full model. This indicates that these variables globally explain a part of the variance that

Figure 1. Global framework for the geographic grid conception

Figure 2. Ranking of area-level residuals for A) men and B) women

was initially attributed to the area level. It also shows that, after controlling for these variables, there is still a significant part of the variation associated with geographical areas. This small but significant variation could be better understood with a detailed analysis of the area-level residuals. Figure 2A presents these residuals for the full model and points out which areas differ significantly from the Québec average, after controlling for covariates. Six areas are found to have significantly lower risk of being overweight while nine areas display higher risk. One can notice that there are rural and urban areas in both groups.

Women

Results are slightly different for women. The full model reveals that the typical overweight woman is between 45 and 64 years old, with a low disposable household income and a low education level. She is a non-smoker, is sedentary, and tends to live in a materially deprived area. As observed in the male models, adding demo-

graphic, socio-economic, lifestyle and environmental variables decreases the ICC from 2.61% to 1.59%. Area-level residuals show that eight areas display a significantly lower probability of having overweight residents (Figure 2B). An interesting point is the fact that the Montreal privileged city centre and its privileged periphery area (West Island), two adjacent sectors with very different land use patterns,⁶⁰ are at opposite ends of the overweight spectrum (Figure 2B). As for men, low- and high-value groups include both rural and urban areas.

DISCUSSION

In this study, we explored the contextual aspects of overweight in Québec. This was done through multilevel modeling, with specially designed spatial units and a few area-based variables. Individual attributes, including lifestyle, were considered in the modeling. After accounting for these attributes, our results show that place makes a difference with respect to overweight.

Table 2. Multilevel Analysis Results Assessing the Influence of Demographic, Socio-economic, Lifestyle and Environment Factors on Men's Overweight

Outcome: BMI ≥ 25	Null Model			Model 2			Model 3			Model 4		
				OR	95% CI	Sig.	OR	95% CI	Sig.	OR	95% CI	Sig.
<i>Demographic & Socio-economic</i>												
Age												
18-24				ref			ref			ref		
25-44				2.44	1.94-3.06	*	2.48	1.99-3.10	*	2.48	1.99-3.10	*
45-64				2.76	1.98-3.83	*	2.75	2.03-3.72	*	2.74	2.03-3.71	*
65+				2.32	1.82-2.96	*	2.14	1.66-2.76	*	2.14	1.66-2.75	*
Matrimonial Status												
Single				ref			ref			ref		
Previously Married				1.10	0.85-1.42		1.12	0.89-1.42		1.13	0.89-1.42	
Union				1.57	1.28-1.92	*	1.51	1.21-1.90	*	1.50	1.23-1.83	*
Disposable Income												
High Income				ref			ref			ref		
Low Income				1.00	0.84-1.20		1.05	0.89-1.23		1.05	0.89-1.24	
Missing Income				1.05	0.82-1.33		1.07	0.83-1.37		1.06	0.83-1.37	
Education Level												
University				ref			ref			ref		
College or High School				1.32	1.17-1.49	*	1.43	1.23-1.66	*	1.43	1.23-1.66	*
None				1.39	1.13-1.72	*	1.55	1.24-1.95	*	1.54	1.22-1.95	*
<i>Lifestyle</i>												
Fruits or Vegetables												
Eat less than 5 /Day							ref			ref		
Eat 5 or more /Day							0.79	0.69-0.91	*	0.79	0.68-0.91	*
Smoking Status												
Current Smoker							ref			ref		
Former Smoker							1.74	1.47-2.06	*	1.75	1.48-2.06	*
Never a Smoker							1.62	1.22-2.16	*	1.62	1.22-2.16	*
Leisure Physical Activity Level												
Active							ref			ref		
Moderately Active							1.14	0.99-1.31		1.15	1.00-1.32	
Somewhat Active							1.00	0.77-1.30		0.99	0.77-1.29	
Sedentary							1.01	0.87-1.18		1.01	0.85-1.19	
Occupational Physical Activity												
Physically Difficult							ref			ref		
Usually Standing							0.86	0.70-1.07		0.86	0.70-1.07	
Usually Seated							1.07	0.83-1.39		1.08	0.83-1.40	
<i>Contextual</i>												
Rural										1.17	1.02-1.33	*
Materially Deprived										0.86	0.74-1.01	
Socially Deprived										0.93	0.80-1.08	
Intercept	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.
	0.231	0.04	*	-1.14	0.101	*	-1.464	0.171	*	-1.406	0.171	*
Area Level Variance	0.041	0.013	*	0.038	0.012	*	0.04	0.012	*	0.036	0.008	*
ICC	1.23%			1.14%			1.20%			1.08%		

* Significant with $\alpha=0.05$

Source: Canadian Community Health Survey, 2003.

One contextual variable, namely rurality, appears to have a significant role in overweight. The literature suggests that people living in a rural environment tend to be overweight or obese.^{47,48} Our results show that this is true mainly for men and that, depending on where one lives in the countryside, the probability of being overweight varies, both among men and women (as shown in Figure 2). The reasons for this remain unknown, however it is possible that access to infrastructures favouring good nutrition may be involved.⁶¹ Similarly, long distances to basic facilities and the absence of public transport in rural areas may prevent people from walking or cycling for recreational or utilitarian purposes.^{62,63}

The area level of material deprivation is another place characteristic whose impact on overweight is close to reaching statistical significance. The most intriguing fact about that characteristic is that it plays differently for men and women. Deprived areas seem to favour overweight among women, while the opposite is true for men. Such results are hard to interpret and raise some questions. Do men living in privileged areas tend to spend more time in cars?⁵⁶ And do women living in deprived areas have less access to a variety of healthy foods?^{64,65} However, as other studies have put forward,^{59,66} these findings suggest that socio-economic mechanisms and land use patterns underlying overweight might be different between genders.

After accounting for these place characteristics and individual attributes, all models show that a small but significant part of the variance in overweight remains unexplained at the area level. Also, this part differs between genders, suggesting that contextual effects might be more important for women than for men. Because our spatial units were based on known associations with overweight, one can hypothesize that this unexplained variance could be linked to built environment or other contextual characteristics. The difference observed on Montreal Island indeed suggests a relation with the type of land use, as observed by Apparicio with regard to food deserts.⁶⁰ Moreover, we observed that the ICC rose from model 2 to model 3 for both genders (Tables 2 and 3) when lifestyles were introduced in the models. Such an increase is interesting as it points out that lifestyles are related to a significant but unexplained geographical component, which can refer to attributes of the built environment. Unfortunately, variables describing this environment for rural as well as urban settings are not yet available for all of southern Québec and, therefore, could not be tested here. However, it would certainly be of great interest for future studies.

Some limitations of the present study should be mentioned. The cross-sectional nature of the data limits our ability to draw causal inferences, particularly concerning contextual effects. Also, since a

Table 3. Multilevel Analysis Results Assessing the Influence of Demographic, Socio-economic, Lifestyle and Environment Factors on Women's Overweight

Outcome: BMI ≥ 25	Null Model			Model 2			Model 3			Model 4		
				OR	95% CI	Sig.	OR	95% CI	Sig.	OR	95% CI	Sig.
<i>Demographic & Socio-economic</i>												
Age												
18-24				ref			ref			ref		
25-44				2.19	1.70-2.83	*	2.12	1.63-2.75	*	2.12	1.63-2.76	*
45-64				3.36	2.55-4.44	*	3.27	2.44-4.37	*	3.28	2.45-4.38	*
65+				3.16	2.31-4.33	*	2.83	2.01-4.00	*	2.85	2.02-4.03	*
Matrimonial Status												
Single				ref			ref			ref		
Previously Married				0.97	0.76-1.24		0.95	0.76-1.20		0.95	0.76-1.20	
Union				1.05	0.86-1.28		1.03	0.87-1.22		1.03	0.87-1.22	
Disposable Income												
High Income				ref			ref			ref		
Low Income				1.30	1.10-1.54	*	1.30	1.09-1.55	*	1.30	1.09-1.54	*
Missing Income				1.06	0.90-1.26		1.06	0.90-1.25		1.06	0.89-1.25	
Education Level												
University				ref			ref			ref		
College or high school				1.53	1.21-1.94	*	1.54	1.20-1.99	*	1.54	1.19-1.99	*
None				2.44	1.96-3.03	*	2.40	1.93-3.00	*	2.39	1.91-2.98	*
<i>Lifestyle</i>												
Fruits or Vegetables												
Eat less than 5 /Day							ref			ref		
Eat 5 or more /Day							1.07	0.94-1.21		1.07	0.94-1.21	
Smoking Status												
Current Smoker							ref			ref		
Former Smoker							1.29	1.06-1.56	*	1.29	1.06-1.56	*
Never Smoker							1.32	1.01-1.74	*	1.32	1.00-1.74	*
Leisure Physical Activity Level												
Active							ref			ref		
Moderately Active							1.14	0.96-1.35		1.14	0.96-1.35	
Somewhat Active							1.48	1.23-1.78	*	1.48	1.23-1.78	*
Sedentary							1.61	1.35-1.92	*	1.61	1.35-1.92	*
Occupational Physical Activity												
Physically Difficult							ref			ref		
Usually Standing							1.02	0.76-1.37		1.03	0.77-1.37	
Usually Seated							1.17	0.89-1.54		1.17	0.89-1.55	
<i>Contextual</i>												
Rural										0.96	0.83-1.10	
Materially Deprived										1.16	0.98-1.37	
Socially Deprived										0.93	0.77-1.12	
Intercept	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.	Coeff.	S.E.	sig.
	-0.29	0.05	*	-1.87	0.183	*	-1.874	0.171	*	-2.376	0.33	*
Area Level Variance	0.088	0.037	*	0.057	0.024	*	0.058	0.023	*	0.053	0.018	*
ICC	2.61%			1.70%			1.73%			1.59%		

* Significant with $\alpha=0.05$

Source: Canadian Community Health Survey, 2003.

substantial part of the population moves frequently, these persons might be influenced by a variety of contexts over time that is not accounted for here. Furthermore, BMI values used here are self-reported and these are known to be lower than those directly estimated.⁶⁷ Finally, the CCHS offers few measures of lifestyle, particularly food consumption. Therefore, methodological and data developments are needed to advance our knowledge concerning the geography of overweight.

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Received: January 9, 2008

Accepted: June 20, 2008

RÉSUMÉ

Objectifs : Explorer l'aspect contextuel de l'excès de poids au Québec avec une modélisation multiniveau basée sur un cadre de référence spatial adapté à la thématique.

Méthodes : Les données analysées proviennent de l'Enquête sur la santé dans les collectivités canadiennes (cycle 2.1). Afin de vérifier la présence d'un effet contextuel indépendant sur l'excès de poids (IMC ≥ 25 kg/m²), nous avons réalisé une série de régressions logistiques multiniveaux séparément pour les hommes et les femmes. La modélisation comprend des caractéristiques individuelles, incluant certaines habitudes de vie, et contextuelles. Nous avons développé un cadre de référence spatial qui considère des éléments de l'espace qui sont habituellement associés à l'excès de poids dans la littérature. De plus, une analyse des résidus de second niveau nous a permis d'identifier les unités spatiales qui présentent les plus fortes et les plus faibles valeurs de risque d'excès de poids.

Résultats : Après avoir considéré les caractéristiques individuelles et contextuelles, une part significative des variations géographiques reste inexpliquée. Bien que cette part soit faible, plusieurs unités spatiales diffèrent de la moyenne provinciale. Des différences entre la géographie de l'excès de poids des hommes et de femmes suggèrent que certains mécanismes socioéconomiques et d'utilisation du sol diffèrent entre les sexes. De plus, nous avons observé qu'il existe une importante variabilité à l'intérieur des milieux ruraux et des milieux urbains.

Conclusion : La géographie de l'excès de poids est complexe. Des analyses locales et des développements méthodologiques sont nécessaires pour mieux comprendre cette géographie.

Mots clés : excès de poids; obésité; Québec; géographie de la santé; analyse multiniveau; santé de la population