OBESITY AND URBAN TRANSPORT[1]

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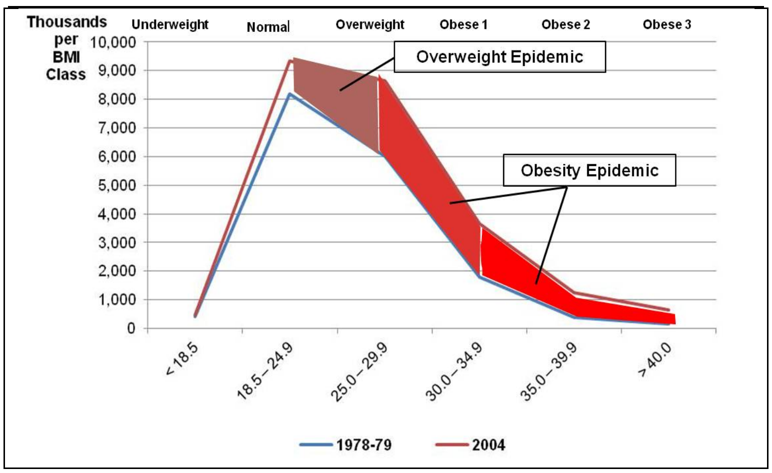
Introduction

Obesity[2] is a growing health and social/economic concern. OECD countries have seen obesity rates rise since 1980 with the US seeing the greatest increase and levels. The Canadian obesity rate increased from 14% to 23% (1978–2004) and there were 5.5 million obese adult Canadians (2004), an increase of 140% over the 25-year period (Tjepkema, 2005).

Obesity rates have risen across all age/gender sub-groups and peak in middle age (45-64 years) (see Figure 1). As the Canadian population ages the trend has resulted in a concern about a growing lifestyle-related *obesity epidemic* (Sassi et al., 2009).

Canadian estimates (Katzmarzyk & Janssen, 2004), reviewed in Starkey (2005) are that ~5% of direct health care costs (~$5 billion per annum) result from obesity. The principal health concerns are high blood pressure, diabetes (Type II), heart disease and premature mortality. Obesity raises various disease prevalence by factors of >2.5x to >5x and premature mortality by a factor of 2x to 3x (for highly obese persons) (Tjepkema, 2005). Obesity-related premature deaths may amount to 8,400 per annum or 4% of all Canadian deaths (Katzmarzyk & Ardern, 2004; Luo et al., 2007).

There are significant regional and urban/rural variations in obesity rates and strong evidence that vehicle dependency, urban form, physical activity and transport and other personal time/budget choices are linked in creating individual/group differences in obesity. Canadian obesity rates are correlated with: daily fruit and vegetable consumption, socio-economic status, marital status, leisure time physical activity, transit ridership and active transport share of commuting and urban sprawl.



Source: original based on Tjepkema (2005)

Figure 1. BMI Category & Number of Adults (1978/9 & 2004)

Obesity Theory

Obesity (and weight gain in general) is fundamentally determined by a *positive energy imbalance* between energy intake (from food consumption) and energy expenditure (from physical activity). There are many theories and possible causal relationships for the prevalence of obesity. These can be characterized into three types:

1. *Genetic Factors* (some portion of cross-individual variation);
2. *Cultural/Socio-Economic/Individual Factors* (influencing education, occupation, physical activity and nutrition decisions);
3. *Obesogenic Environmental Factors* (mediating between transport, physical exercise and food consumption decisions).

There is compelling evidence (Sassi et al., 2009; Lakdalwalla & Philipson, 2002; Philipson & Posner, 1999) that *technological* and *lifestyle changes* in:

a) less physically demanding work;
b) labour-saving agricultural production and food preparation (which have resulted in declining real food prices and an abundance of non-healthy foods);
c) labour-saving transport and homework; and
d) time pressures from modern life and affluence (which have raised the value of time)

have been responsible for much of the obesity change over the past half-century.[3]

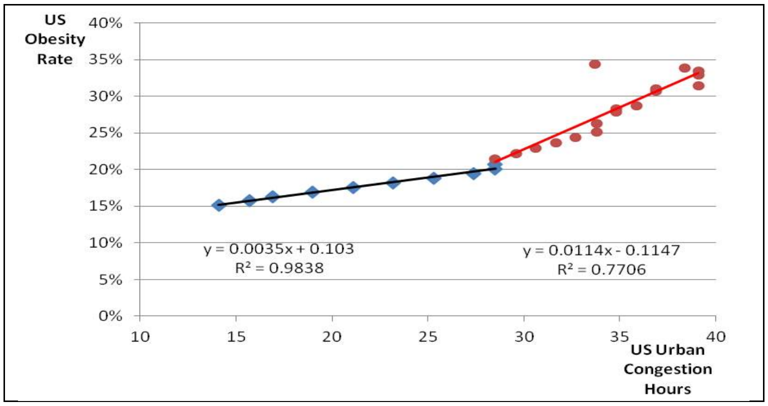
Obesity, Urban Form and Transport

Urban form and built environment factors and their co-determined (or consequential) transport and physical activity outcomes have been linked to obesity rates (Booth et al., 2005; Saelens et al., 2003; Frank, 2004; Shields & Tjepkema, 2006). These include:

- single-use neighbourhood land-use/zoning (Frank et al., 2004);
- urban sprawl (Adams et al., 2011; Eweing et al., 2003);
- automobile dependence (Frank et al., 2004);
- pedestrian, cycling and public transit modes (Adams et al., 2011; Shields & Tjepkema, 2006; Lindström, 2008);
- proximity of fast-food outlets (Morland et al., 2002); and
- absence of safe exercise and recreational amenities etc (AHPA, 2010; Boarnet et al., 2008).

It is believed that these factors can magnify cultural, socio-economic, individual choice and genetic factors in promoting obesity. For example, urban sprawl, vehicle dependence and proximity of fast-food outlets can influence culturally and socially vulnerable groups to make less healthy lifestyle (i.e. nutrition, physical activity) choices.

There is strong evidence that the rise in US and Canadian obesity is related to urban congestion (see Figure 2), mixed neighbourhood land use, residential density and urban size or proximity to metropolitan zones (see Figure 3), transit ridership and active transport (commuting) (see Figure 4), active transport (functional and leisure) and relative prices between transport options (e.g. parking, gasoline, transit) and food options (healthy food, prepared food, eating out).

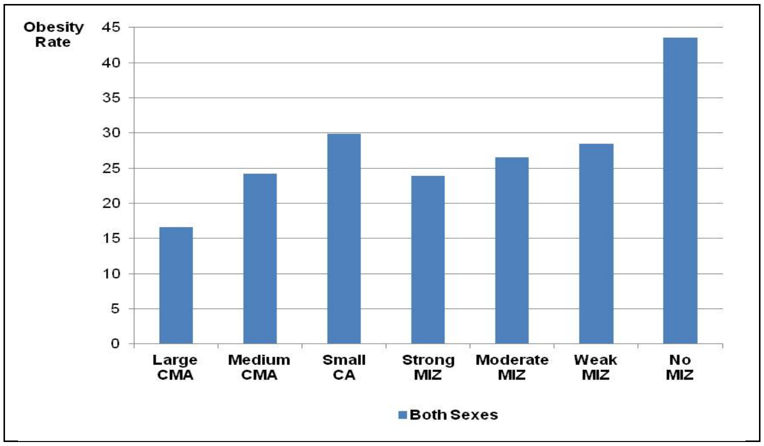


Source: Original based on urban congestion annual hours (TTI, 2011) and obesity rates (Sassi et al., 2009). A discontinuity (c.1990-91) has accelerations of obesity rates and congestion.

Figure 2. USA Obesity Rate & Urban Congestion (1982-2008)

The interaction between urban form and transport involves: a) how transport infrastructure shapes and facilitates development; and b) how urban form influences individual choices with respect to:

a. commuter travel (i.e. transit efficiency requires a dense urban form and a centralized employment hub);
b. other functional travel (i.e. walking and cycling opportunities to access local services); and
c. leisure time physical activity (i.e. walking/cycling amenities and/or local physical exercise facilities including parks and recreational paths).



Source: Original based on Shields-Tjepkema (2006, p. 63). CMA Average Obesity Rate is 20.2%. MIZ is Metropolitan Influence Zone.

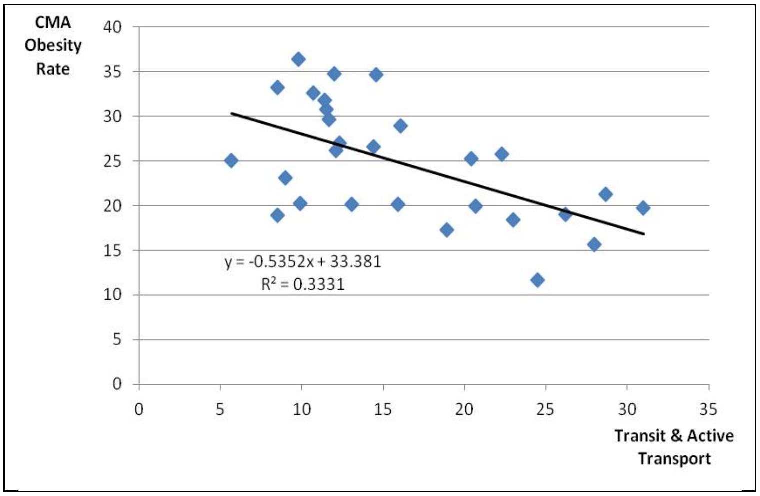
Figure 3. Canada Obesity Rate by CMA Size/Urban Proximity (2004)

Evidence from the Ottawa Neighbourhood Study

A unique dataset (Ottawa Neighbourhood Study at the Institute of Population Health, University of Ottawa[4]) has been used to investigate the relationship between physical activity and obesity and various neighbourhood amenities (e.g. green space, walk/cycling pathways, food stores and restaurants (Prince et al., 2011).

Preliminary analysis is presented here for Ottawa neighbourhood variables on: socio-economic status, built environment; food availability, recreational amenities, physical activity (leisure time and daily), transit and active transport mode for commuting, and several health outcomes (including obesity) and behaviours (smoking in home, fruit and vegetable consumption).

We are particularly interested in seeing whether analysis at the neighbourhood level supports the CMA cross-sectional result on the negative relationship (Figure 4) between obesity rates and transit ridership and active transport share of commuting, especially when other confounding variables are introduced.



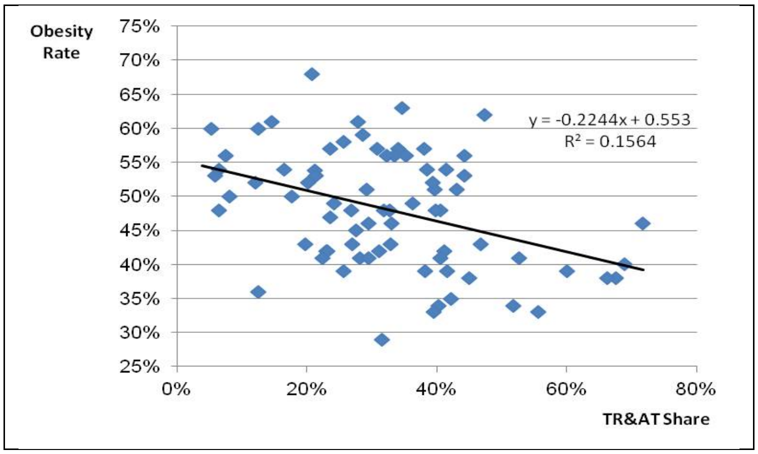
Source: Original based on Shields-Tjepkema (2006) and Census (2006). CMA Average Transit & Active Transport share of commuter travel is 22.2%.

Figure 4. Canada Obesity Rate by Transit & Active Transport Shares

Variable correlations demonstrate the inter-relationship between urban form characteristics (e.g. density; distance to nearest grocery store); transport (transit ridership and active transport share); socio-economic status (e.g. post-secondary education) and health outcomes (obesity, hospitalization) and lifestyle choices (daily physical activity and fruit and vegetable consumption). Annex-Table 1 provides some of the strong variable correlations (for a full sample of 91 Ottawa neighbourhoods).

Analysis, not reported here, confirms that neighbourhood transit ridership and active transport commuting share is positively associated with: a) percent of population aged 20-39 years; b) percent of dwellings built before 1981; and c) population density.

The Ottawa neighbourhood counterpart to Figure 4 (i.e. obesity rates and commute share for transit and active transport) is replicated at the local level (see Figure 5).



Source: Original based on Ottawa Neighbourhood Study 'Neighbourhood Profiles' using data for 75 (of 91) neighbourhoods for which obesity rates were available.

Figure 5. Ottawa Neighbourhood Obesity Rates (2001-07) by Transit & Active Transport Shares for Commuters (2006)

There is strong evidence that the rise in US and Canadian obesity is related to urban congestion (see Figure 2), mixed neighbourhood land use, residential density and urban size or proximity to metropolitan zones (see Figure 3), transit ridership and active transport for commuting (see Figure 4), active transport (both functional and leisure) and relative prices between transport options (e.g. parking, gasoline, transit) and food options (healthy food, prepared food, eating out).

Regression analysis was undertaken for 59 aggregated Ottawa neighbourhoods with a full panel of variables[5].

The dependent variable is the normalized neighbourhood obesity rate (i.e. % standard deviation from mean) while explanatory variables (except urban form dummy variables) are also in normalized form. The standard model is:

$$(1) \quad OR_i = a\ TR\&AT_i + b\ (Phys.Act._i) + c\ (Food._i) + d\ (Envir._i) + e\ (UrbanForm_i) + e_i$$

We estimate various forms of this model with different variables for Physical Activity, Food, Environment, and Urban Form. The four urban form discrete (dummy) variables are:

- low density *rural* neighbourhoods (n_1=14);
- outer *fringe* (ex-Greenbelt) neighbourhoods (n_2=10);
- inner *low-mixed land use* neighbourhoods (n_3=21); and
- inner *high-mixed land use* neighbourhoods (n_4=14).

where the discriminants were based on: availability (i.e. per 1,000 population) of a grocery/specialty food store, restaurant and bank and distance <1,500m to the nearest grocery store. This attempted to mirror mixed land use analysis (as in Frank et al., 2004).

Models#1-3 (which omit urban form) show that the transit ridership and active transport commuting (%TR&AT) is always significantly negative in impact on neighbourhood obesity rates. TR&AT dominates over other physical activity variables (e.g. daily activity that is somewhat moderate or high intensity; or leisure time active).

Food variables (e.g. fruit & vegetable consumption, degree of convenience stores & fast-food outlets) have expected signs (in *Model#1*) but are not (generally) statistically significant.

Only *Model#3* (our most stripped-down model) has the availability of convenience stores and fast food outlets (i.e. 'bad food') positively related to obesity rates. This is not a robust finding.

Table 2. Regression Results - Ottawa Neighbourhoods

Dependent Variable - Obesity Rate

(standard errors in brackets - ** significant at 5%)

Explanatory Variable	Model#1	Model#2	Model#3	Model#4	Model#5
Transit & Active Transport	-.4966** (.1306)	-.5774** (.1266)	-.5090** (.1279)	-.5478** (.1905)	-.4450** (.1738)
Convenience & Fast-Food	.2119 (.1335)	.2020 (.1271)	.2751** (.1278)	-.1655 (.1294)	
Daily Activity (Moderate/High)	-.1639 (.1242)				
Fruit & Vegetable (5-10/day)	-.1100 (.1190)				
Low Birth Weight		.2879** (.1236)		.2183 (.1344)	.2691** (.1291)
Smoking in Home				.3196** (.1283)	.3249** (.1290)
Urban Form Dummies					
Rural– Low Density				.0773 (.3092)	.2051 (.2944)
Outer Fringe				.5708** (.2690)	.5865** (.2704)
Inner Low-Mixed-Use				-.2321 (.1905)	-.2886 (.1864)
Inner High-Mixed-Use				-.1310 (.2916)	-.1911 (.2895)
Observations	59	59	59	59	59
R^2	0.26	0.29	0.22	0.42	0.40
F	4.76	7.63	8.10	4.60	4.96

Source: original based on ONS ‘profiles’. All variables (except urban form dummies) are normalized form (% standard deviation from mean).

Environmental (health) variables (e.g. low birth weight incidence per 100 births; smoking in the home) have a positive impact on neighbourhood obesity rates. This is most clearly seen for the case of smoking in the home when we also have urban form variables (e.g. *Model#4* and *Model#5*). In *Model#2* (without urban form variables), low birth weight has a significantly positive effect on neighbourhood obesity rates and this variable weakens the independent contribution of convenience stores & fast-food outlets.

Of the three models without urban form variables, the percentage of dependent variable variation explained by the explanatory variables is modest (R^2<.30).

The inclusion of the urban form variables (*Model#4* and *Model#5*) improve the overall regression explanatory power (R^2>.40) although only the outer fringe (ex-Greenbelt) dummy, which perhaps most captures the urban sprawl aspect of Ottawa development, is statistically significant (positive). The signs of the other variables have the expected signs (i.e. positive for rural-low density and negative for inner-low mixed land use and inner-high mixed land use.

The addition of the urban form variables eliminates the significance of the convenience stores and fast-food outlet variable. *Model#5* presents a version with urban form dummy variables where both environment (health) variables have positive significant impacts on obesity rates.

Separate regressions for each urban form group (see Table 3) indicate that the negative impact on obesity rates of the transit and active transport share of commuting is strong (and statistically significant) for the inner-high mixed land use and rural-low density groups of neighbourhoods. The sign and parameter estimate is very robust across urban form groups of neighbourhoods.

Smoking in the home has a positive (and significant) impact on obesity rates only for the rural-low density neighbourhood sub-group (although its sign is robust (positive) across urban form sub-groups).

Low birth weight has an insignificant (and not robust sign) impact across urban form sub-groups.

Table 3. Regression Results – Ottawa Neighbourhoods
Dependent Variable – Obesity Rate
(standard errors in brackets - ** significant at 5%)

Explanatory Variable	Model#6	Model#7	Model#8	Model#9
Urban Form Type	Rural-Low Density	Outer Fringe	Inner Low-Mixed-Use	Inner High-Mixed-Use
Transit & Active Transport	-.4989** (.2130)	-.5664 (.7231)	-.6777 (.3356)	-.6349** (.2206)
Low Birth Weight	.1395 (.3374)	-.6327 (.6621)	.3437 (.1691)	.2371 (.2958)
Smoking in Home	.5750** (.2478)	.6875 (.4179)	.0505 (.1960)	.3405 (.3451)
Observations	14	10	21	14
R^2	0.49	0.33	0.28	0.42
F	3.57	1.17	2.37	4.60

Source: Original based on ONS 'profiles'. All variables (except urban form dummies) are normalized form (% standard deviation from mean).

Conclusions

This paper makes an important contribution with Canadian evidence to the body of literature that shows an important multi-directional cause and response relationships between: a) transport systems and behaviours; b) urban design characteristics; and c) individual choices that give rise to obesity. These findings are consistent with similar evidence from the USA, Scandinavia and Australia.

Local neighbourhood level data on obesity rates, urban form, built and social environment amenities and household variables on food choice, physical activity (and commuting mode of transport) and health from the Ottawa Neighbourhood Study demonstrate the important role that transit ridership and active transportation for commuting plays in a healthy lifestyle and reduction in the rate of obesity at the neighbourhood level.

The transit/active transport commuter share is a crucial nexus between physical activity, urban form and local amenities (accessibility of services) that influence individual obesity rates.

Annex – Ottawa Neighbourhood Study Data

Table 1. Ottawa Neighbourhood Correlations

	Obesity	Density	% PSE	% TR& AT	G-DIST	HACSC	% PA-MA	% F&V
Obesity	1	-0.40	-0.47	-0.40	0.22	0.31	-0.25	-0.25
Density			0.18	0.65	-0.40	0.03	0.17	0.03
%PSE			1	0.06	-0.09	-0.50	0.34	0.37
%TR& AT				1	-0.59	0.14	-0.12	0.13
G-DIST					1	-0.02	0.11	-0.12
HACSC						1	-0.34	-0.40
%PA-MA							1	0.07
%F&V								1

Source: original based on ONS 'profiles'. Density is population/km^2; %PSE is percent of adults with CEGEP/College/University Degree; %TR&AT is percent of commuters using Transit or Active Transport; G-DIST is distance (m) to nearest grocery store; HACSC is Hospitalization Rate (Ambulatory Care – Sensitive Conditions) per 100,000 population; %PA-MA is percent with some Moderate-Highly Physical Daily Activity; %F&V is percent consuming 5-10 Fruit/Vegetable Servings daily. Correlations are for the full sample of 91 neighbourhoods.

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Endnotes

[1] This paper was motivated by the author's work on the link between obesity and transport (by Virtuosity Consulting for Transport Canada-Accessible Transport).

[2] 'Obesity' is defined as a significantly higher than normal Body Mass Index (BMI ≥ 30) i.e. weight (kg) divided by the square of height (m). Normal weight is 18.5 ≤ BMI < 25. Overweight (*pre-obesity*) is 25 ≤ BMI < 30.

In this paper we only look at adult obesity (aged 18 years and over)

[3] A resulting irony is that while for most of human history people have been ***paid*** to undertake physical activity (wages for energy expenditure); now people ***pay*** to undertake physical activity (e.g. gym membership).

[4] http://staging.neighbourhoodstudy.ca for further detail on data sources and variables.

[5] Where required to maximize data availability (for key variables), contiguous neighbourhoods with similar socio-economic status were combined, as were very small (land area) neighbourhoods. This resulted in a sizable sample of Ottawa neighbourhoods for this analysis.

All regressions involved dependent variable (obesity rate) and explanatory variables (e.g. transit ridership and active transport commuting share) in normalized form (mean=0; standard deviation=1), with the exception of the urban form dummy variables. Coefficient estimates can therefore be interpreted as elasticities (relative to mean values).