Obesity—a growing issue

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Abstract

Objectives
This article, based on longitudinal data, follows a sample of people who were aged 20 to 56 in 1994/95 to determine the percentage who made the transition from normal to overweight, or from overweight to obese by 2002/03. Characteristics that increased the chances of overweight people becoming obese are examined.

Data sources
The data are from five cycles of the National Population Health Survey, 1994/95 through 2002/03.

Analytical techniques
Cox proportional hazards modelling was used to identify variables associated with an increased or decreased risk of becoming obese; 1,937 men and 1,184 women who were overweight in 1994/95 were selected.

Main results
Close to a third (32%) of people who were aged 20 to 56 and of normal weight in 1994/95 had become overweight by 2002/03. During the same period, almost a quarter of those who had been overweight in 1994/95 had become obese. Among people who were overweight, the risk of obesity was relatively high for younger men and members of low-income households. Overweight men who smoked or who had activity restrictions had a high risk of obesity. Physical activity helped women avoid obesity.

Keywords
body mass index, body weight, longitudinal studies, weight gain

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Obesity is recognized as a major public health problem that rivals smoking as a cause of illness and premature death. Obesity has been linked with type 2 diabetes, cardiovascular disease, hypertension, stroke, gallbladder disease, some forms of cancer, osteoarthritis and psychosocial problems.[1] The impact on life expectancy is considerable: among American non-smokers, obesity at age 40 has been associated with a loss of 7.1 years of life for women and 5.8 years for men.[2] The same American study estimated that even being overweight reduced both male and female non-smokers' life expectancy by more than three years.

Obesity results when people consume far more calories than they use (see *Calculating overweight and obesity*). This imbalance has been attributed to a variety of factors that characterize modern life: fast food, growing portion sizes, a sedentary lifestyle, and suburban designs that tend to discourage walking.[3]

Methods

Data source

This analysis is based on longitudinal data from the first five cycles of the National Population Health Survey (NPHS), 1994/95 through 2002/03. Since 1994/95, the NPHS has collected information about the health of the Canadian population every two years. It covers household and institutional residents in all provinces and territories except members of the regular Armed Forces, people living on Indian reserves or in some remote areas, and civilian residents of military bases. Although residents of health care institutions are part of the survey, they are excluded from this analysis.

In 1994/95, 20,095 individuals were selected for the longitudinal panel. Of these, 17,276 agreed to participate, for a response rate of 86.0%. The response rates for subsequent cycles, based on these 17,276 respondents, were: 92.8% in cycle 2 (1996/97); 88.2% in cycle 3 (1998/99); 84.8% in cycle 4 (2000/01); and 80.6% in cycle 5 (2002/03).

More detailed descriptions of the NPHS design, sample and interview procedures can be found in published reports.[4,5]

Analytical techniques

The proportion of people moving from one weight category to another was calculated using cross-tabulations between 1994/95 and each subsequent wave of the NPHS. Thus, the results show the net change between 1994/95 and 1996/97, 1994/95 and 1998/99, 1994/95 and 2000/01, and 1994/95 and 2002/03. Tests for trends for the proportions presented in Charts 1 to 4 were performed using logistic regressions, with time as the only independent variable.

To identify variables that were associated with an increased or decreased risk of becoming obese, Cox proportional hazards modelling was used. This technique allows for the study of relationships between individual characteristics and an outcome when that outcome can take place over a period of time. The method accounts for the possibility that some events do not occur over the study period, and it minimizes the bias associated with attrition.

For the proportional hazards modelling, respondents who were overweight in 1994/95 (BMI 25.0 to 29.9) and had no missing covariates were selected: 1,937 men and 1,184 women. During the study period, 447 of these men and 402 of the women became obese. After 1994/95, if their BMI in a subsequent cycle placed them in the obese category, this was considered an event. Given that weight gain is a continuous process that was measured only at discrete intervals (the NPHS interviews), many transitions to obesity occurred at the same time, after 2, 4, 6 or 8 years. The proper specification of such a model is with a ties = exact option of SAS, which corresponds to a continuous process (becoming obese) inadequately observed at fixed intervals (the NPHS interviews). To allow the use of survey weights, the model was specified with Proc Logistic, with a cloglog link, which is equivalent to a proportional hazards model, or the procedure Phreg, ties = exact in SAS.[6]

If the BMI value was missing for one or more cycles, but values for subsequent cycles were available, the cases were retained. This creates intervals of varying lengths between observations. To control for the fact that the longer the interval, the more likely a transition is to occur from one BMI category to another, wave length and wave length square were entered as independent variables in the model.

Relationships between the independent variables (age, household income, alcohol consumption, etc.) as of 1994/95 and becoming obese by 2002/03 were examined. The exceptions were leisure-time physical activity and usual daily physical activity; associations between values for these variables at each cycle and becoming obese were examined.

The analysis pertains to the 10 provinces, excluding the territories. All the analyses were weighted using the longitudinal weights constructed to represent the total population of the provinces in 1994.

The bootstrap method was used to account for the complex survey design in the calculation of confidence intervals and in the assessment of statistical significance.[7-9] The significance level was set at $p < 0.05$.

Limitations

This analysis is based on personal or telephone interviews. As with every survey, some non-response occurred. If the non-response was not random, bias could have been introduced in the analysis.

The data are self- or proxy-reported; they have not been validated against an independent source or with direct measures. It is possible that respondents provided what they considered socially acceptable answers about issues like weight, smoking or drinking.

Other errors might have occurred during data collection and capture. Interviewers might have misunderstood some instructions, and errors might have been introduced in data processing. However, considerable effort was made to ensure that such errors were kept to a minimum.

Information on nutrition was not available for this analysis.

The analysis in this report uses longitudinal data to follow a large sample of people over eight years to determine what percentage of them made the transition from normal to overweight, and the percentage who shifted from overweight to obese. Because the analysis is based on self-reported information (as opposed to direct measurements of height and weight), the actual extent of overweight and obesity is somewhat underestimated (see "Adult obesity" in this issue). However, the focus of this analysis is the likelihood of moving from one weight category to another, not the prevalence of excess weight. Characteristics that increased the chances of overweight people becoming obese are examined—information that can help target public health programs to prevent new cases of obesity. Once gained, excess weight may be hard to shed, so interventions that emphasize prevention may be more effective than weight reduction efforts.[10]

This study is based on the first five cycles of the National Population Health Survey (NPHS), which interviewed the same individuals every two years from 1994/95 to 2002/03 (see *Methods* and *Definitions*). Because patterns of weight gain differ by sex, separate analyses were conducted for men and women.

Steady gains

Among people whose weight was in the normal range in 1994/95 (based on self-reported height and weight), a shift into the overweight range by 2002/03 was relatively common (Chart 1). At the end of the eight years, about one-third of them (32%) had become overweight. Weight gain is usually a slow process; very few people (2%) whose weight was in the normal range in 1994/95 had become obese by 2002/03 (data not shown).

Once people are overweight, they tend to continue to gain weight. Almost a quarter of those who were overweight in 1994/95 had become obese by 2002/03 (Chart 2). Just 10% who were overweight in 1994/95 had moved into the normal weight range by 2002/03 (data not shown).

Chart 1
Percentage in normal weight range in 1994/95 who became overweight, household population aged 20 to 56 in 1994/95, Canada excluding territories, 1996/97 to 2002/03
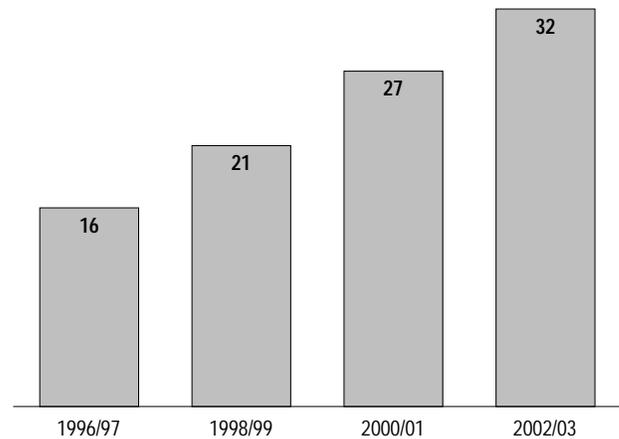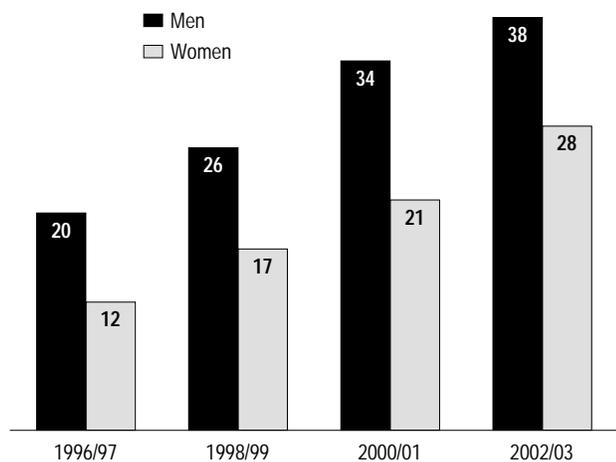

Data source: 1994/95 to 2002/03 National Population Health Survey, longitudinal file
Note: The slope of the increase is significantly different from 0 ($p < 0.05$).

Chart 2
Percentage overweight in 1994/95 who became obese, household population aged 20 to 56 in 1994/95, Canada excluding territories, 1996/97 to 2002/03
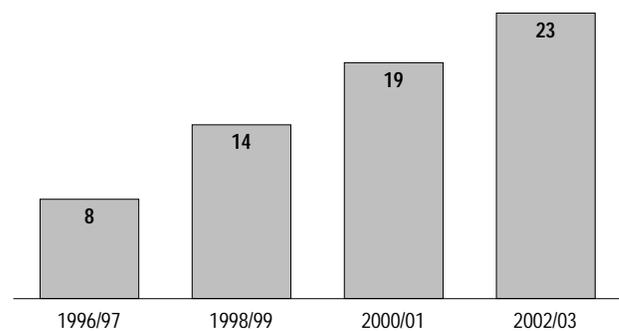
Data source: 1994/95 to 2002/03 National Population Health Survey, longitudinal file
Note: The slope of the increase is significantly different from 0 ($p < 0.05$).

Chart 3
Percentage in normal weight range in 1994/95 who became overweight, by sex, household population aged 20 to 56 in 1994/95, Canada excluding territories, 1996/97 to 2002/03
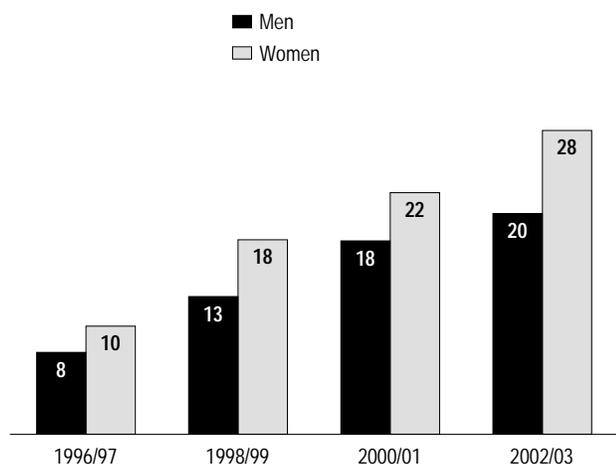
■ Men
□ Women

Data source: 1994/95 to 2002/03 National Population Health Survey, longitudinal file
Note: *The slope of the increase is significantly different from 0 (p < 0.05).*

Chart 4
Percentage overweight in 1994/95 who became obese, by sex, household population aged 20 to 56 in 1994/95, Canada excluding territories, 1996/97 to 2002/03

■ Men
□ Women

Data source: 1994/95 to 2002/03 National Population Health Survey, longitudinal file
Note: *The slope of the increase is significantly different from 0 (p < 0.05).*

Patterns differ for men and women

Men were more likely than women to make the transition from normal to overweight (Chart 3). By 2002/03, 38% of the men whose weight was in the normal range in 1994/95 had become overweight, compared with 28% of the women.

However, the likelihood of going from overweight to obese was greater for women (Chart 4). At the end of the eight years, 28% of women and 20% of men who were overweight at the outset had become obese.

The shift to obesity occurs in the context of a variety of demographic, socio-economic, lifestyle and health variables. Moreover, these factors are often related to each other. For instance, an older person with an activity restriction may be sedentary, and people in low-income households may be more likely to smoke than those in more affluent households. When such potentially confounding effects were taken into account, along with the extent of overweight in 1994/95, several factors emerged as being related to an overweight individual's chances of becoming obese.

Calculating overweight and obesity

Overweight and obesity are based on *body mass index* (BMI), which is calculated by dividing weight in kilograms by height in metres squared. For example, the BMI of an individual 1.7 metres tall (5 feet 7 inches) weighing 70 kilograms (154 pounds) would be:

$$70 \div 1.7^2 = 24.2$$

If this person weighed 80 kilograms (176 pounds), his or her BMI would be:

$$80 \div 1.7^2 = 27.7$$

The BMI categories used for this article are: underweight (less than 18.5); normal weight (18.5 to 24.9); overweight (25.0 to 29.9); and obese (30.0 or more).

Younger men more likely to become obese

Young adults, especially men, had an elevated risk of obesity (Table 1). During the eight-year period, overweight men in their twenties and thirties were more likely than those in their fifties to become obese. For overweight women in their twenties, the risk of becoming obese was high compared with that for women in their fifties, but failed to reach statistical significance (p=0.07).

Lower income, higher risk

Members of the highest income quintile households were less likely to become obese than were those in the lowest income category. Among overweight men, the risk of becoming obese was about 40% less for those in the two highest household income quintiles than for those in the lowest quintile. Overweight women in the middle and upper-middle income quintiles also had a significantly lower risk of obesity, again around 40%, compared with women in the lowest quintile.

Table 1

Adjusted hazards ratios for overweight men and women aged 20 to 56 becoming obese, by selected characteristics, household population, Canada excluding territories, 1994/95 to 2002/03

	Men		Women			Men		Women	
	Adjusted hazards ratio	95% confidence interval	Adjusted hazards ratio	95% confidence interval		Adjusted hazards ratio	95% confidence interval	Adjusted hazards ratio	95% confidence interval
Body mass index in 1994/95	2.05*	1.85, 2.28	1.90*	1.70, 2.12	**Leisure-time physical activity‡**				
Age group					Sedentary†	1.00	…	1.00	…
20 to 29	2.48*	1.54, 4.00	1.61	0.97, 2.68	Light	1.08	0.74, 1.58	0.89	0.59, 1.34
30 to 39	1.60*	1.06, 2.41	1.17	0.75, 1.83	Moderate	1.07	0.76, 1.50	0.73	0.51, 1.06
40 to 49	1.33	0.88, 2.00	1.17	0.75, 1.83	Intense	1.06	0.77, 1.45	0.92	0.55, 1.55
50 to 56†	1.00	…	1.00	…	**Usual daily physical activity‡**				
Household income quintile					Sit†	1.00	…	1.00	…
Lowest†	1.00	…	1.00	…	Stand or walk	0.80	0.55, 1.16	0.72*	0.52, 1.00
Lower-middle	0.77	0.49, 1.23	0.79	0.52, 1.20	Lift light loads	1.02	0.68, 1.52	0.72	0.48, 1.08
Middle	0.67	0.41, 1.09	0.60*	0.37, 0.97	Heavy work	0.75	0.47, 1.17	0.77	0.26, 2.21
Upper-middle	0.60*	0.37, 0.97	0.60*	0.38, 0.92	**Self-perceived health**				
Highest	0.54*	0.33, 0.85	0.63	0.39, 1.01	Excellent/Very good†	1.00	…	1.00	…
Marital status					Good	1.30	0.97, 1.74	0.75	0.54, 1.05
Single†	1.00	…	1.00	…	Fair/Poor	1.04	0.58, 1.88	0.66	0.37, 1.19
Married/Common-law	1.18	0.82, 1.71	1.19	0.75, 1.91	**Activity restriction**				
Separated/Divorced/Widowed	0.84	0.47, 1.51	0.86	0.50, 1.48	No†	1.00	…	1.00	…
Alcohol consumption					Yes	1.44*	1.02, 2.03	1.41	0.97, 2.07
Never†	1.00	…	1.00	…	**Region**				
Regular	0.64	0.38, 1.10	0.65	0.37, 1.15	Atlantic	0.85	0.59, 1.24	1.00	0.67, 1.50
Occasional	0.56	0.29, 1.08	0.54*	0.30, 0.97	Quebec	1.04	0.70, 1.54	1.13	0.77, 1.67
Former	1.20	0.64, 2.25	0.64	0.34, 1.23	Ontario†	1.00	…	1.00	…
Smoking					Prairies	1.05	0.73, 1.51	1.09	0.73, 1.62
Never†	1.00	…	1.00	…	British Columbia	1.02	0.71, 1.48	1.15	0.67, 1.96
Daily	1.49*	1.06, 2.08	1.13	0.80, 1.60					
Occasional	1.33	0.75, 2.34	0.56	0.26, 1.20					
Former	1.26	0.91, 1.76	0.93	0.67, 1.30					

Data source: *1994/95 to 2002/03 National Population Health Survey, longitudinal file*
Notes: *The models are based on records for 1,937 men and 1,184 women who were aged 20 to 56 and overweight in 1994/95. Because of rounding, a hazards ratio with 1.00 as the upper confidence limit is significant.*
† Reference group
‡ Measured at each survey cycle
* Significantly different from estimate for reference group (p < 0.05)

Definitions

Except for the two physical activity measures, the independent variables used in this analysis pertain to respondents' characteristics in 1994/95.

Respondents aged 20 to 56 in 1994/95 were selected. By the fifth cycle of the National Population Health Survey (2002/03), they were aged 28 to 64. Pregnant women were excluded.

Household income quintiles were determined based on household income adjusted to account for household size (household income / square root of household size):

Quintile	Household income
Lowest	Less than $12,500
Lower-middle	$12,500 to $20,207
Middle	$20,208 to $27,500
Upper-middle	$27,501 to $40,414
Highest	More than $40,414

Three *marital status* categories were specified: never married; married, common-law or living with partner; and separated, divorced or widowed.

Alcohol consumption refers to four types of drinkers: regular, occasional, former, and never. Respondents were told that "drink" meant one bottle or can of beer or a glass of draft; one glass of wine or a wine cooler; or one straight or mixed drink with 1.5 ounces of hard liquor. "Regular" means the respondent reported drinking more than once a month in the year before the survey interview, and "occasional," less than once a month during that time. Respondents who had not had a drink in the past 12 months but had had an alcoholic drink sometime before that were classified as "former" drinkers. Those in the "never" category reported never having had a drink.

Smoking was classified as: never, daily, occasional, and former.

Respondents' level of physical activity at each survey cycle was calculated (time-varying covariate). Level of *leisure-time physical activity* was based on a combination of energy expenditure during a given activity and the frequency with which respondents engaged in that activity. Energy expenditure (EE) is kilocalories expended per kilogram of body weight per day (KKD). An EE less than 1.5 KKD is considered low; 1.5 to 2.9 KKD, moderate; and 3 or more KKD, high. The frequency of physical activity was grouped in two categories, based on the number of times respondents participated in each activity for at least 15 minutes: regular (at least 12 times a month) or irregular (11 times or fewer per month). Four physical activity categories were defined:

- *Intense:* high energy expenditure (at least 3 KKD) during regular physical activity
- *Moderate*: moderate energy expenditure (1.5 to 2.9 KKD) during regular physical activity
- *Light*: light energy expenditure (less than 1.5 KKD) during regular physical activity
- *Sedentary:* irregular physical activity, independent of energy expenditure

Usual daily physical activity was based on respondents' usual daily activities and work habits over the previous three months:

- Usually sit and don't walk around very much
- Stand or walk quite a lot
- Lift or carry light loads
- Do heavy work or carry very heavy loads

Self-perceived health was measured on a five-category scale: poor, fair, good, very good or excellent. For this analysis, three categories were specified: excellent or very good, good, and fair or poor.

Respondents were considered to have an *activity restriction* if they reported being limited in the kind or amount of activities they could do at home, at work, in school or in other activities, or indicated they had a long-term disability or handicap.

The provinces were grouped into five *regions*: Atlantic (Newfoundland, New Brunswick, Nova Scotia, Prince Edward Island), Quebec, Ontario, Prairies (Saskatchewan, Manitoba, Alberta), and British Columbia.

The relationship between household income and obesity may reflect the cost of food, as foods high in fat and sugar are often less expensive. Low-income families must balance grocery expenditures with spending on other necessities such as housing and clothing.[11] As well, food costs have been shown to be higher in low-income neighborhoods, and travelling to shop in areas where prices are better may not be feasible.[12]

Occasional drinking

The risk of becoming obese was almost 50% lower for overweight women who reported occasional drinking, compared with those who never drank. While a similar pattern was observed for men, the association did not reach statistical significance ($p=0.08$).

An association between alcohol consumption and a slight weight loss for women has been reported in other studies.[13,14] Also, people who drink only occasionally may practise health-conscious behaviours, especially with regard to their diet, that reduce their risk of becoming obese.

High risk for male smokers

Overweight men who smoked daily in 1994/95 were almost 50% more likely than those who had never smoked to have become obese by 2002/03. This is contrary to cross-sectional studies that have found that smokers are less likely than never-smokers to be obese. However, those studies also showed that former smokers are more likely to be obese than people who have never smoked.[15] Further analysis of the NPHS data indicated that these results reflected, in part, a weight gain among people who quit smoking after 1994/95 (data not shown).

Activity

It is no surprise that overweight people who were restricted in their daily activities—at home, at work or at school—were at increased risk of becoming obese. While the association was statistically significant only for men, an indication of a similar relationship was present for women (p=0.07). Because of their physical restrictions, many of these people may be relatively inactive, which increases their risk of gaining weight.

Physical activity, in fact, seemed to offer overweight women some protection against obesity. Those whose daily activities involved a lot of walking or standing were less likely to become obese than were overweight women who tended to sit most of the day. Even when the effects of the other variables were considered, this association remained statistically significant. As well, overweight women whose leisure time entailed moderate physical activity were at less risk of becoming obese than were those who were sedentary. However, when the other variables were taken into account, this relationship was not significant (p=0.10). No statistically significant association between physical activity, as measured

in the survey, and obesity was observed for overweight men.

Region not a factor

Despite geographic differences in the prevalence of obesity, no association was found between region of residence and the risk of becoming obese. Thus, an overweight individual's chances of becoming obese are influenced by factors such as age, income, smoking and physical activity, and not by the simple fact of residing in a specific part of the country.

Concluding remarks

Between 1994/95 and 2002/03, a third of people who started out in the normal weight range had become overweight, and almost a quarter of those who were overweight had become obese.

Not surprisingly, being overweight is an important predictor of obesity; in fact, it is an intermediate step. But even when the extent of overweight in 1994/95 was taken into account, several other factors were independently associated with becoming obese. Among people who were overweight, the risk of obesity was relatively high for younger men and for members of low-income households. Overweight men who smoked were at risk of becoming obese, while occasional drinking was associated with a reduced risk of obesity among overweight women. Overweight men with activity restrictions were more likely to become obese than were those who did not have such restrictions. Physical activity offered overweight women some protection against obesity.

Although this study does not include children, it has been shown that parental obesity significantly increases the risk for children.[16] Therefore, identifying groups of adults who are likely to gain weight and targeting them for intervention may be an indirect way of preventing their children from becoming obese.

Once weight is gained, it may be hard to lose. Greater knowledge of the dynamics behind the trend toward obesity among Canadians is key to effective public health interventions. ●

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References ● ● ● ● ● ● ● ● ● ● ● ● ● ● ●

1   Canadian Institute for Health Information. *Improving the Health of Canadians*. Ottawa: Canadian Institute for Health Information, 2004.

2   Peeters A, Barendregt JJ, Willekens F, et al. Obesity in adulthood and its consequence for life expectancy: A life-table analysis. *Annals of Internal Medicine* 2003; 138(1): 24-33.

3   Raine KD. *Overweight and Obesity in Canada, A Population Health Perspective*. Ottawa: Canadian Population Health Initiative, Canadian Institute for Health Information, 2004.

4   Swain L, Catlin G, Beaudet MP. The National Population Health Survey—its longitudinal nature. *Health Reports* (Statistics Canada, Catalogue 82-003) 1999; 10(4): 69-82.

5   Tambay J-L, Catlin G. Sample design of the National Population Health Survey. *Health Reports* (Statistics Canada, Catalogue 82-003) 1995; 7(1): 29-38.

6   Allison PD. *Survival Analysis Using the SAS System: A Practical Guide*. Cary, NC: SAS Institute, 1995.

7   Rao JNK, Wu CFJ, Yue K. Some recent work on resampling methods for complex surveys. *Survey Methodology* (Statistics Canada, Catalogue 12-001) 1992; 18(2): 209-17.

8   Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques. *Statistical Methods in Medical Research* 1996; 5: 281-310.

9   Yeo D, Mantel H, Liu TP. Bootstrap variance estimation for the National Population Health Survey. *Proceedings of the Annual Meeting of the American Statistical Association: Survey Research Methods Section, August 1999*. Baltimore, Maryland: American Statistical Association, 1999.

10 Groupe de travail sur la problématique du poids. *Les problèmes reliés au poids au Québec: un appel à la mobilisation*. Montréal: Association pour la Santé publique du Québec, 2003.

11 Ontario Prevention Clearinghouse and the Health Communications Unit (1999). In the news this week! Poverty and health – in global arena (WTO), national (child poverty), provincial (budget cuts) and local (Toronto). *OHPE Bulletin* 1999; 133(1): 5-7. Available at www.ohpe.ca/ebulletin/ViewFeatures.cfm?ISSUE_ID=133&startrow=191.

12 Travers KD. The social organization of nutritional inequities. *Social Science and Medicine* 1996; 43(4): 543-53.

13 Kahn HS, Tatham LM, Rodriguez C, et al. Stable behaviors associated with adults' 10-year changes of body mass index and the likelihood of gain at the waist. *American Journal of Public Health* 1997; 87(5): 747-54.

14 Prentice AM. Alcohol and obesity. *International Journal of Obesity and Related Metabolic Disorders* 1995; 19(Suppl 5): S44-50.

15 Ostbye T, Pomerleau J, Speechley M, et al. Correlates of body mass index in the 1990 Ontario Health Survey. *Canadian Medical Association Journal* 1995; 152: 1811-7.

16 Carrière G. Parent and child factors associated with youth obesity. *Health Reports* (Statistics Canada, Catalogue 82-003) 2003; 14(suppl): 29-39.