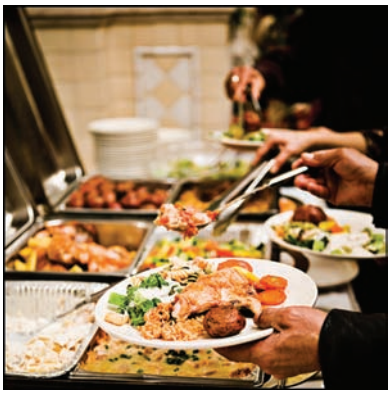
Component of Statistics Canada Catalogue no. 82-003-X
Health Reports

Article

Under-reporting of energy intake in the Canadian Community Health Survey



by Didier Garriguet

October, 2008

Statistics Canada Statistique Canada

Canada

Under-reporting of energy intake in the Canadian Community Health Survey

by Didier Garriguet

Abstract

Background
Under-reporting of food consumption is a recurrent challenge for nutrition surveys. Past research suggests that under-reporting tends to be most pronounced among overweight and obese people.

Data and methods
Data from 16,190 respondents to the 2004 Canadian Community Health Survey (CCHS 2.2)—Nutrition were used to estimate under-reporting of food intake for the population aged 12 or older in the 10 provinces. Multiple linear regression models were used to assess the impact of different characteristics on under-reporting.

Results
Average under-reporting of energy intake was estimated at 10%. Under-reporting was greater among people who were overweight or obese, those who were physically active, adults compared with teenagers, and women compared with men.

Interpretation
Under-reporting of energy intake is not random and varies by key health determinants. Awareness of the characteristics associated with under-reporting is important for users of nutrition data from the CCHS 2.2.

Keywords
Caloric intake, diet, food habits, energy expenditure, energy metabolism, nutrition surveys, twenty-four hour recall

Author
Didier Garriguet (1-613-951-7187; didier.garriguet@statcan.gc.ca) is with the Health Information and Research Division at Statistics Canada, Ottawa, Onto,K1A 0T6.

Data collection is particularly challenging in nutrition surveys. The majority of studies based on data from such surveys have revealed a problem with under-reporting[1-6]; that is, respondents tend to report that they ate and drank less than they actually did.

Body mass index, in particular, has been linked to under-reporting of food consumption (energy intake).[1,3-6] And while there are no clear conclusions with respect to age and sex, under-reporting tends to be more common among women and older people.[2-4,6] Health, socio-economic and psychological characteristics have also been linked to under-reporting.[1,3,5,6]

In 2004, Statistics Canada conducted the Canadian Community Health Survey (CCHS) — Nutrition, the first national survey of the eating habits of Canadians since the early 1970s. As has been the case for similar surveys, the 2004 CCHS was susceptible to under-reporting.

This article quantifies under-reporting of energy intake in the CCHS at the group level. It also compares modelled total energy expenditure of CCHS respondents to their reported energy intake to determine if groups identified in the literature as being more likely to under-report are the same for the Canadian population. This information is valuable to researchers using the CCHS, who should be aware of its potential limitations.

Methodology

Data source

The 2004 CCHS was designed to collect information about the food and nutrient intake of the household population at the national and provincial levels. It excludes members of the regular Canadian Forces, residents of the three territories, people on Indian reserves, in institutions and in some remote areas, as well as all residents (military and civilian) of Canadian Forces bases. Detailed descriptions of the design, sample and interview procedures are available in a published report.[7]

A total of 35,107 people completed an initial 24-hour dietary recall; a subsample of 10,786 completed a second recall three to ten days later. Response rates were 76.5% and 72.8%, respectively. Only the first 24-hour recall was used for this analysis.

All CCHS respondents aged 2 or older were supposed to be measured and weighed, but for various reasons, height and weight data were not collected for around 40% of them. To adjust for this non-response, another survey weight was created, based on respondent classes with similar demographic and socio-economic characteristics. Because of the bias that has been observed between the two types of data,[8,9] measured height and weight are preferable to self-reported height and weight. Therefore, respondents with measured height and weight data (with the appropriate survey weight) were used for this analysis.

This study was restricted to respondents aged 12 or older who answered the leisure-time physical activity questions. Women who were pregnant or breastfeeding, people of very low weight (body mass index less than 18.5kg/m^2), and respondents with no or invalid dietary intakes were excluded. A total of 16,190 respondents were included in the study.

The CCHS used a 24-hour dietary recall to estimate Canadians' energy intake. To help respondents remember what and how much they ate and drank the previous day, a five-step method, known as the Automated Multiple Pass Method (AMPM),[10,11] was employed. The five steps are:

- A quick list (participants listed all the beverages and food consumed);
- A series of questions on specific categories of foods and certain frequently forgotten foods;
- Questions about the time and occasion of consumption;
- A series of questions to collect more detailed information on the foods and beverages, and quantities; and
- A final review.

The energy and nutrient composition of the food reported during this recall came from Health Canada's Canadian Nutrient File (2001b Supplement).[12]

Total energy expenditure

For people who maintain their weight, usual energy intake (calories consumed) equals energy expenditure (calories expended). If intake exceeds expenditure, they gain weight; if intake is less than expenditure, they lose weight. The same is true for a population. In a population with a stable body mass, energy intake and expenditure are virtually equal. A comparison of the average energy intake of a surveyed population with its average energy expenditure yields an estimate of the accuracy of the estimate of energy intake.

With data from the 2004 CCHS, it is possible to estimate respondents' energy intake, but not their energy expenditure. The most widely accepted method of estimating energy expenditure is a doubly labelled water study. This involves administering two forms of isotopes of water to an individual and measuring the rate of disappearance in the urine or in the blood over a given period. These rates are then used to calculate the rate of carbon dioxide (CO_2) production, which, combined with the individual's diet, makes it possible to calculate energy expenditure.[13]

With a number of doubly labelled water studies, the Institute of Medicine (IOM) modelled total energy expenditure (TEE) or estimated energy requirements (EER), based on age, sex, weight, height and physical activity level (PAL) (Table 1). These equations were used to estimate the energy requirements of CCHS respondents.

Predicting energy requirements

With the IOM equations, energy requirements can be predicted if age, sex, height, weight, and physical activity level are known. While age, sex, height and weight are readily available in the CCHS, the physical activity data pertain only to leisure time; information was not collected about activity related to work or transportation. Moreover, daily energy expenditure in the CCHS was measured in Metabolic Equivalents (MET), expressed as kilocalories per kilogram per day, whereas the IOM measures energy expenditure by Physical Activity Level (PAL). MET describes the intensity of an activity compared with resting metabolic rate (RMR); PAL represents the ratio between total energy expenditure (TEE) and basal energy expenditure (BEE).

Using the methodology of the IOM,[14] each physical activity reported in MET values can also be reported in change in physical activity level (ΔPAL), based on the increase in TEE arising from the practice of that activity.

The following formulas were used to determine ΔPAL using MET values for each physical activity that CCHS respondents reported having participated in during the previous three months:

$$\Delta PAL = (MET - 1) * N_{times} * Minutes * 1.34 / 1{,}440 \quad \text{(for men)}$$

and

$$\Delta PAL = (MET - 1) * N_{times} * Minutes * 1.42 / 1{,}440 \quad \text{(for women)}$$

where N_{times} represents the number of times an activity was practiced, and Minutes represents the average duration (13, 23, 45 or 60 minutes) of the activity, based on whether it was practiced for less than 15 minutes, between 15 and 30 minutes, between 30 and 60 minutes, or more than 60 minutes.

To assess the full impact of an activity on total energy expenditure (TEE), additional energy spent in relation to the activity must be taken into account. First, 15% of the energy expended from a physical activity must be added to energy expenditure to account for excess post-exercise oxygen consumption (EPOC).

Second, the increased energy expenditure associated with the physical activity will require an increase in energy intake (if the individual is to maintain his or her weight). Consequently, the thermic effect of food (TEF), which dissipates an estimated 10% of the energy consumed, must also be taken into account.

A final adjustment accounts for the use of basal energy expenditure (BEE) instead of resting metabolic rate (RMR). A MET of 1.0 extrapolated to 24 hours

Table 1
Estimated energy requirements (EER) based on Institute of Medicine (IOM) equations, by body mass index, age and sex

Body mass index (BMI), age and sex	Institute of Medicine equation for estimated energy requirement
BMI between 18.5 kg/m2 and 25 kg/m^2	
Ages 9 to 18	
Male	EER = 113.5 - 61.9*age (years) + PAL * (26.7 * weight (kg) + 903 * height (m)), where PAL = 1 if sedentary, 1.13 if low active, 1.26 if active, and 1.42 if very active.
Female	EER = 160.3 - 30.8*age (years) + PAL * (10 * weight (kg) + 934 * height (m)), where PAL = 1 if sedentary, 1.16 if low active, 1.31 if active, and 1.56 if very active.
Ages 19 or older	
Male	EER = 661.8 - 9.53*age (years) + PAL*(15.91* weight (kg) + 539.6* height (m)), where PAL = 1 if sedentary, 1.11 if low active, 1.25 if active, and 1.48 if very active.
Female	EER = 354.1 - 6.91*age (years) + PAL*(9.36* weight (kg) + 726* height (m)), where PAL = 1 if sedentary, 1.12 if low active, 1.27 if active, and 1.45 if very active.
BMI more than 25 kg/m^2	
Ages 9 to 18	
Male	EER = -114.1-50.9*age (years) + PAL * (19.5*weight (kg) + 1161.4*height (m)), where PAL = 1 if sedentary, 1.12 if low active, 1.24 if active, and 1.45 if very active.
Female	EER = 389.2 - 41.2*age (years) + PAL * (15 * weight (kg) + 701.6 * height (m)), where PAL = 1 if sedentary, 1.18 if low active, 1.35 if active, and 1.60 if very active.
Ages 19 or older	
Male	EER = 1085.6 - 10.08*age (years) + PAL*(13.7* weight (kg) + 416* height (m)), where PAL = 1 if sedentary, 1.12 if low active, 1.29 if active and 1.59 if very active.
Female	EER = 447.6 - 7.95*age (years) + PAL*(11.4* weight (kg) + 619* height (m)), where PAL = 1 if sedentary, 1.16 if low active, 1.27 if active and 1.44 if very active.

Note: PAL is physical activity level.
Source: Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: National Academy Press, 2005.[14]

will be 5% higher than the BEE for a reference 70 kg man and 10% higher for a 57 kg reference woman. These adjustments are represented by the factors of 1.34 for men (1.15 (EPOC) ÷ 0.9 (TEF) ÷ 0.95) and 1.42 for women (1.15 (EPOC) ÷ 0.9 (TEF) ÷ 0.91).

Since MET is a daily measurement, a factor of 1,440 converts this increase in energy expenditure into a measure per minute. For example, swimming has a MET value of 3.0 kcal/kg/hour. For a man, swimming an hour a day over three months amounts to an increase in physical activity of (3.0 MET - 1) * 90 days * 60 minutes * 1.34 / 1,440 = 10.05, or a daily increase of 0.112, representing an increase in total energy expenditure of 189 kcal a day.

Once all individual leisure-time physical activities have been expressed in ΔPAL for three months, values are summed and divided by 90 days to represent the daily increase in energy expenditure resulting from physical activity.

According to the IOM methodology, a person involved in only sedentary pursuits will have a physical activity level of 1.39. The final PAL for one person is obtained by adding the sum of ΔPAL to the base PAL of 1.39. The IOM divides physical activity levels into four categories: sedentary (PAL 1.0 to less than 1.4), low active (PAL 1.4 to less than 1.6), active (PAL 1.6 to less than 1.9), and very active (PAL 1.9 to less than 2.5).

Respondents to the 2004 CCHS were placed in three categories based on their energy expenditure calculated in MET: inactive, moderately active, and active. Table 2 compares the PAL and MET classifications of respondents for whom the information needed to predict energy requirements was available.

With these variables and the IOM equations described above, it is possible to predict the energy requirements of these CCHS respondents.

Measuring under-reporting of energy intake

Two methods can be used to measure the extent to which energy intake (that is, food consumption) is under-reported. The first method, which is employed in this study, involves a macro-estimation that uses only the ratio of measured energy intake to energy requirements predicted with the IOM equations: a ratio less than 1 indicates under-reporting; a ratio greater than 1, over-reporting. (The second method involves classifying respondents according to whether their food intake is deemed to be under-reported, over-reported or plausible. This method is presented in a separate paper.[15])

To assess the effect of energy under-reporting on a group average, the ratio of the average energy intake of a group is divided by the average energy expenditure predicted for that group. To assess the effect of energy under-

Table 2
Physical Activity Level (PAL) versus Metabolic Equivalents (MET), household population aged 12 or older, Canada excluding territories, 2004

Physical activity category (in PAL)	Physical activity category (in MET)		
	Inactive	Moderately active	Active
Sedentary	2,637	0	0
Low active	5,537	3,975	2,460
Active	0	0	1,412
Very active	0	0	169

Source: 2004 Canadian Community Health Survey – Nutrition.

reporting while simultaneously taking multiple groups into account, individual ratios of energy intake to predicted energy expenditure are modelled in a multiple linear regression.

The covariates that were included in the multiple linear regressions were chosen based on the literature and on factors known to influence the quantity or quality of food consumed. These covariates were divided into three categories: risk factors (body mass index, leisure-time physical activity, alcohol consumption, fruit and vegetable consumption, and smoking status), health status (self-reported health and the presence of chronic conditions), and socio-demographic characteristics (sex, age, household education and income, employment status, immigrant status, Aboriginal status, and province of residence).

The risk factors were included because poor food choices are associated with under-reporting energy intake; specifically, people tend to under-report unhealthy items and over-report healthy items. The variables that were chosen generally reflect healthy lifestyles or the quality of food choices.

Since poor health can affect appetite, the two health status variables were included to control for factors that might affect the quantity of food consumed.

The socio-demographic variables were included because the literature has shown that some of them are related to under-reporting. As well, because population subgroups are often defined by these variables (for example, seniors, Aboriginal people, immigrants), it is important to know how under-reporting is associated with these characteristics. Also, some of these characteristics (for example, low household income) are related to poorer quality diets.

The bootstrap method, which takes account of the complex survey design,[16-18] of the CCHS was used to estimate confidence intervals of the ratios and regression coefficients. The significance level was set at $p < 0.05$.

Definitions

Body mass index (BMI) is calculated by dividing weight in kilograms by height in metres squared. In this analysis, the BMI categories for adults were defined according to Health Canada's guidelines.[19] People whose BMI was between 18.5 kg/m^2 and 24.99 kg/m^2 were normal weight; between 25 kg/m^2 and 29.99 kg/m^2 , overweight; and more than 30 kg/m^2 , obese. For adolescents aged 12 to 17, the categories defined by Cole et al.[20] were used.

Leisure-time physical activity level refers to the four PAL categories: sedentary, low active, active, and very active.

Alcohol consumption refers to the 12 months before the CCHS interview.

Fruit and vegetable consumption is based on the reported usual frequency of consumption, not the 24-hour recall. It represents the number of times per day respondents consumed fruit and vegetables, not the amount of food consumed.

Smokers are those who smoke daily and occasionally.

The socio-demographic variables are: *sex* and *age* for adults, based on the IOM dietary reference groups; *highest level of education in the household* (less than secondary graduation, secondary graduation, some postsecondary, postsecondary graduation); household income from all sources, accounting for household size (low, low/average, average, average/high, and high); *employment status* the week before the interview; and *immigrant* and *Aboriginal* status.

The variables related to health status are *self-reported health* (excellent, very good, good, fair and poor) and the presence of at least one *chronic condition*.

Results

Overall, the ratio of CCHS respondents' reported energy intake (EI) to their energy expenditure requirements (EER) predicted by the IOM equations was 0.904 (Table 3). In other words, Canadians aged 12 or older reported that they consumed about 10% fewer calories than they actually required, given their height, weight and level of physical activity. Ratios tended to be lower for females, although the difference was significantly different from men only among 19- to 30-year-olds. As well, the ratios decreased with age, indicating that under-reporting became greater at successively older ages.

With a regression model, the influence of several variables can be examined simultaneously. Separate models were constructed for adolescents (12 to 17) and for adults (18 or older). The regression coefficients represent the change in the ratio associated with the change in a characteristic in relation to the "reference person." For adults,

Table 3
Ratio of energy intake estimate to predicted energy expenditure requirements, by age group and sex, household population aged 12 or older, Canada excluding territories, 2004

Age group and sex	Ratio	95% confidence interval	
		from	to
Total	0.904	0.890	0.917
12 or 13			
Male	1.009	0.950	1.067
Female	0.992	0.934	1.050
14 to 18			
Male	0.977	0.939	1.016
Female	0.949	0.917	0.981
19 to 30			
Male	0.962*	0.921	1.003
Female	0.866†	0.828	0.904
31 to 50			
Male	0.920	0.877	0.962
Female	0.876	0.842	0.910
51 to 70			
Male	0.877	0.846	0.907
Female	0.856	0.829	0.884
71 or older			
Male	0.836	0.796	0.877
Female	0.887	0.853	0.921

* significantly different from estimate for females in same age group ($p < 0.05$)
† significantly different from estimate for previous age group of same sex ($p < 0.05$)
Source: 2004 Canadian Community Health Survey – Nutrition.

Table 4
Linear regression coefficients of ratio of reported energy intake in relation to predicted energy expenditure requirements, by sex, household population aged 18 or older, Canada excluding territories, 2004

	Men			Women		
		95% confidence interval			95% confidence interval	
Characteristics	beta coefficient	from	to	beta coefficient	from	to
Intercept	1.065	0.958	1.171	0.909	0.829	0.990
Body mass index						
Overweight (25 kg/m^2≤ BMI<30 kg/m^2)	-0.119*	-0.171	-0.068	-0.138*	-0.177	-0.098
Obese (≥30 kg/m^2)	-0.205*	-0.258	-0.152	-0.191*	-0.231	-0.150
Physical activity						
Sedentary	0.092*	0.015	0.169	0.123*	0.080	0.165
Active	-0.077	-0.161	0.007	-0.080	-0.173	0.013
Very active	-0.152	-0.312	0.009	-0.395*	-0.752	-0.038
Consumed alcohol in previous year	0.043	-0.023	0.108	0.040	-0.003	0.084
Has at least one chronic condition	-0.046	-0.096	0.004	0.026	-0.014	0.067
Highest level of education in household						
Less than secondary graduation	0.033	-0.044	0.110	-0.071*	-0.121	-0.022
Secondary graduation	-0.041	-0.102	0.021	-0.082*	-0.125	-0.038
Some postsecondary	-0.017	-0.082	0.048	-0.074*	-0.130	-0.017
Daily consumption of fruit and vegetables						
Fewer than 5 servings	-0.071*	-0.118	-0.024	-0.001	-0.038	0.037
More than 10 servings	-0.012	-0.207	0.182	-0.009	-0.201	0.182
Self-reported health						
Very good	-0.011	-0.066	0.043	-0.026	-0.084	0.032
Good	-0.004	-0.066	0.058	-0.070*	-0.127	-0.013
Fair	-0.002	-0.088	0.085	-0.064	-0.137	0.009
Poor	0.013	-0.120	0.146	-0.091	-0.212	0.031
Household income						
Low	-0.071	-0.174	0.032	-0.025	-0.110	0.061
Low/Average	0.016	-0.116	0.149	-0.031	-0.088	0.025
Average	-0.041	-0.108	0.026	-0.016	-0.066	0.035
Average/High	0.005	-0.043	0.053	0.003	-0.042	0.047
Did not work in week before interview	-0.024	-0.071	0.023	0.045*	0.004	0.086
Immigrant	-0.045	-0.100	0.010	0.013	-0.033	0.059
Smoker	0.052*	0.001	0.103	-0.045	-0.081	-0.009
Aboriginal person	0.054	-0.051	0.158	0.056	-0.025	0.137
Province						
Newfoundland and Labrador	0.031	-0.047	0.109	-0.026	-0.089	0.036
Prince Edward Island	0.003	-0.077	0.084	-0.012	-0.063	0.040
Nova Scotia	0.029	-0.045	0.103	0.030	-0.030	0.090
New Brunswick	0.050	-0.034	0.134	-0.053*	-0.104	-0.001
Quebec	0.078*	0.013	0.142	0.117*	0.066	0.168
Manitoba	-0.014	-0.074	0.046	0.023	-0.030	0.075
Saskatchewan	0.026	-0.059	0.112	0.014	-0.044	0.073
Alberta	-0.004	-0.069	0.062	-0.001	-0.053	0.051
British Columbia	0.116*	0.044	0.189	0.063*	0.010	0.117
Age group						
31 to 50	-0.041	-0.099	0.017	0.022	-0.027	0.071
51 to 70	-0.048	-0.109	0.014	0.002	-0.050	0.054
71 or older	-0.092*	-0.169	-0.016	0.057*	0.000	0.113

* coefficient significantly different from 0 ($p < 0.05$)

Note: The reference person has a normal BMI, is low active, lives in a household where at least one member is a postsecondar graduate, has 5 to 10 servings of fruit and vegetables each day, is in excellent health, lives in a household in the highest income category, worked the week before the interview, is not an immigrant or an Aboriginal person, does not smoke, lives in Ontario, and is aged 18 to 30.

Source: 2004 Canadian Community Health Survey – Nutrition.

Table 5
Linear regression coefficients of ratio of energy intake in relation to predicted energy expenditure requirements, by sex, household population aged 12 to 17, Canada excluding territories, 2004

	Boys			Girls		
		95% confidence interval			95% confidence interval	
Characteristics	beta coefficient	from	to	beta coefficient	from	to
Intercept	1.167	1.065	1.268	1.120	1.037	1.202
Body mass index						
Overweight (25 kg/m^2 ≤ BMI<30 kg/m^2)	-0.108*	-0.181	-0.035	-0.277*	-0.341	-0.212
Obese (≥30 kg/m^2)	-0.309*	-0.384	-0.234	-0.364*	-0.462	-0.267
Physical activity						
Sedentary	0.168	-0.041	0.377	0.288*	0.145	0.431
Active	-0.127*	-0.190	-0.064	-0.146*	-0.211	-0.081
Very active	-0.109	-0.244	0.027	-0.208*	-0.409	-0.007
Consumed alcohol in previous year	-0.082*	-0.145	-0.020	-0.039	-0.099	0.020
Has at least one chronic condition	0.033	-0.037	0.104	0.033	-0.040	0.106
Highest level of education in household						
Less than secondary graduation	-0.062	-0.257	0.133	-0.013	-0.118	0.091
Secondary graduation	-0.094*	-0.170	-0.017	-0.029	-0.114	0.057
Some postsecondary	-0.155*	-0.241	-0.068	-0.029	-0.119	0.061
Daily consumption of fruit and vegetables						
Fewer than 5 servings	-0.079*	-0.152	-0.006	-0.058*	-0.115	-0.001
More than 10 servings	0.053	-0.216	0.322	0.097	-0.184	0.378
Self-reported health						
Very good	-0.043	-0.110	0.023	-0.037	-0.116	0.043
Good	-0.057	-0.152	0.039	-0.047	-0.133	0.039
Fair	-0.108	-0.243	0.027	-0.052	-0.184	0.080
Poor	-0.289*	-0.522	-0.056	-0.025	-0.367	0.318
Household income						
Low	-0.196	-0.406	0.014	0.094	-0.133	0.321
Low/Average	0.021	-0.156	0.198	0.064	-0.045	0.174
Average	-0.002	-0.095	0.091	0.050	-0.051	0.152
Average/High	-0.029	-0.101	0.043	0.086*	0.004	0.168
Immigrant	0.080	-0.049	0.209	-0.114	-0.256	0.028
Smoker	0.109*	0.004	0.213	-0.006	-0.092	0.080
Aboriginal person	0.088	-0.194	0.371	0.041	-0.134	0.217
Province						
Newfoundland and Labrador	0.027	-0.090	0.144	-0.038	-0.151	0.074
Prince Edward Island	0.033	-0.087	0.152	-0.008	-0.150	0.133
Nova Scotia	-0.031	-0.172	0.111	-0.033	-0.156	0.091
New Brunswick	0.103	-0.043	0.249	0.015	-0.064	0.095
Quebec	0.183*	0.092	0.274	0.049	-0.048	0.146
Manitoba	0.088	-0.006	0.182	0.015	-0.077	0.107
Saskatchewan	0.140*	0.029	0.251	0.052	-0.067	0.170
Alberta	0.017	-0.077	0.112	-0.085*	-0.169	-0.001
British Columbia	0.028	-0.073	0.128	-0.055	-0.132	0.023

* coefficient significantly different from 0 ($p < 0.05$)
Note: The reference person has a normal BMI, is low active, lives in a household where at least one member is a postsecondary graduate, has 5 to 10 servings of fruit and vegetables each day, is in excellent health, lives in a household in the highest income category, is not an immigrant or an Aboriginal person, does not smoke, and lives in Ontario.
Source: 2004 Canadian Community Health Survey – Nutrition.

the reference person had the following characteristics: BMI in the normal range; low active; lived in Ontario in a household in the highest income category where at least one member was a postsecondary graduate; consumed 5 to 10 servings of fruit and vegetables a day; excellent health; worked the week before the interview; neither an immigrant nor an Aboriginal person; non-smoker; aged 18 to 30. The reference person for adolescents had the same characteristics, except for age and employment the week before the interview.

Regardless of age group and sex, BMI category had a significant and consistent impact on the ratio of energy intake to predicted energy expenditure requirements (Tables 4 and 5). People who were overweight or obese under-reported their energy intake, compared with the reference person (of normal weight).

Leisure-time physical activity was also significantly related to reporting energy intake, but the direction of the estimate depended on the level of activity. Among those who were sedentary, adults of both sexes and girls aged 12 to 17 actually overestimated how much they ate. By contrast, active adolescents of both sexes and very active adult women and adolescent girls under-reported.

Low fruit and vegetable consumption (fewer than 5 servings a day) was associated with under-reporting for all groups except adult women. Similarly, male adolescents who had consumed alcohol in the past year under-reported their energy intake. By contrast, men and male adolescents who were smokers tended to overestimate the amount they consumed.

Under-reporting of energy intake was greater among women who were in good health and among male adolescents who were in poor health. Having a chronic condition was not linked to energy reporting.

While household income had almost no association with the reporting of energy intake, differences emerged by level of education in the household. Among women, all levels of household education below postsecondary graduation were associated with under-reporting. Under-reporting was also statistically significant among adolescent boys in households where the highest level of education was secondary graduation or some postsecondary.

Immigrant and Aboriginal status did not influence the reporting of energy intake. Nor was age group among adults a significant factor—the major difference was between adolescents and adults.

Finally, adults in Quebec and British Columbia over-reported how much they consumed, while women in New Brunswick under-reported. Among adolescents, males in Quebec and Saskatchewan over-reported their consumption, and females in Alberta under-reported.

Discussion

Under-reporting in the nutrition component of the 2004 CCHS amounted to about 10% of total energy intake for the population aged 12 or older. However, the extent of under-reporting varied with a number of factors, notably, body mass index, physical activity, lifestyle factors, and level of household education.

The results of the present analysis confirm what has been observed in other research. A review article that examined 25 studies[6] found BMI categories to be closely linked to energy under-reporting. Other studies have also generally shown that women and older individuals were more likely to under-report. In the present study, too, women tended to under-report energy intake more than men did, but age differences were greater between adolescents and adults than between adult age groups.

Physical activity was linked to energy reporting in this study. A number of earlier analyses did not take physical activity into account when calculating energy requirements.

The CCHS data show that smoking was associated with over-reporting energy intake among males of all ages. This suggests a link between smoking and a poorer quality diet, which has frequently been found in other research.[21-25]

The results for socio-demographic factors have been less consistent from study to study, although lower levels of education have been associated with under-reporting energy intake. Results from the CCHS show that level of household education was significantly linked to under-reporting among adult women and male adolescents.

Limitations

The major limitation of the present study is that the measure of under-reporting of energy intake is highly dependent on the quality of the estimate of energy expenditure. However, information about energy expenditure from the 2004 CCHS is incomplete, as the survey collected data only about leisure-time physical activity.

This analysis used the base 1.39 physical activity level for all respondents, but other assumptions could have been made. For example, if it had been assumed that all respondents were "low active" (the most frequently reported physical activity category), the EI:EER ratio for the population aged 12 or older would be 0.895. Even so, this would not change the relationship between under-reporting and the characteristics shown to be associated with it, especially overweight and obesity.

Assuming a "sedentary" physical activity level for all respondents would yield an estimated EI:EER ratio of 1.003 for the population aged 12 or older. But a substantial number of people would have higher energy requirements based on their leisure-time physical activity. And contrary to the assumption of low physical activity for all respondents, where misclassification can occur in both directions, assuming sedentary physical activity can lead to misclassification in only one direction,

and the true EI:EER ratio would necessarily be below 1.

Another option would have been to use the ratio between energy intake and either basal metabolic rate (BMR) or basal energy expenditure (BEE). These ratios would represent an average physical activity level in the population. To estimate under-reporting, it would still be necessary to estimate physical activity. However, instead of using categories, a continuous variable would have to be used, which would be more sensitive to misreporting than a categorical variable.

Although the IOM equations are the best currently available, the database is not a representative sample of either the Canadian or American population. As well, the model used to derive the EER leads to a prediction with a confidence interval, but in the present study, EER was used as a constant in the calculation of the ratios.

Because this analysis is based on only the first 24-hour recall of energy intake, day-to-day variations are not taken into account. However, the usual intake of a population is typically benchmarked on the average of the first 24-hour recall for that population. Consequently, daily intake can be used to assess energy under-reporting if the analysis is restricted to group or multiple group averages.

The regression results are multiple group comparisons and have been used to identify characteristics that are associated with under-reporting; they are not meant as predictive equations for individual under-reporting.

Another limitation of the study is that it was not possible to account for psychological factors associated with eating, such as social desirability, self-image and weight, and the fear of being negatively evaluated, all of which have been linked to energy under-reporting.[5,6] Nor is it known if CCHS respondents were on a diet or were limiting their food intake when they were interviewed. Reports of energy intake are always subject to the possibility of under- or overeating on a particular day.

Conclusion

The results of the present study are important for users of the CCHS nutrition data, who, before undertaking an analysis, should be aware that subgroups have variable degrees of energy under-reporting. It is helpful not only to determine the extent of under-reporting, but also to identify groups whose energy intake is under-reported, over-reported, or plausible. Identifying these respondents is the topic of another article.[15]

References

1. Johnson RK, Soultanakis RP, Matthews DE. 1998. Literacy and body fatness are associated with under-reporting of energy intake in US low income women using the multiple-pass 24-hour recall, a doubly labelled water study. *Journal of the American Dietetic Association* 1998; 98(10): 1136-40.
2. Jonnalagadda S., Mitchell DC, Smiciklas-Wright H, et al. Accuracy of energy intake data estimated by a multi-pass 24-hour dietary recall technique. *Journal of the American Dietetic Association* 2000; 100(3): 303-8.
3. Johansson G., Wikman A, Ahren AM, et al. Under-reporting of energy intake in repeated 24-hour recalls related to gender, age, weight status, day of interview, educational level, reported food intake, smoking habits and area of living. *Public Health Nutrition* 2001; 4(4): 919-27.
4. Pikholz C, Swinburn B, Metcalf P. Under-reporting of energy intake in the 1997 National Nutrition Survey. *Journal of the New Zealand Medical Association* 2004; 117(1202): 1-11.
5. Tooze JA, Subar AF, Thompson FE, et al. Psychosocial predictors of energy under-reporting in a large doubly labeled water study. *American Journal of Clinical Nutrition* 2004; 79: 795-804
6. Lingstone BE, Black AE. Markers of the validity of reported energy intake. *Journal of Nutrition* 2003; 133: 895S-920S.
7. Béland Y, Dale V, Dufour J, Hamel M. The Canadian Community Health Survey: Building on the success from the past. *Proceedings of the American Statistical Association Joint Statistical Meeting, Section on Survey Research Methods, August 2005*. Minneapolis: American Statistical Association, 2005.
8. Tjepkema M. Adult obesity. *Health Reports* (Statistics Canada, Catalogue 82-003) 2006; 17(3): 9-25.
9. Shields M. Overweight and obesity among children and youth. *Health Reports* (Statistics Canada, Catalogue 82-003) 2006; 17(3): 27-42.
10. Moshfegh AJ, Borrud L, Perloff B, et al. Improved method for the 24-hour dietary recall for use in national surveys. *The FASEB Journal: Official Publication of the Federation of American Societies for Experiment Biology* 1999; 13: A603 (abstract).
11. Moshfegh AJ, Raper N, Ingwersen L, et al. An improved approach to 24-hour dietary recall methodology. *Annals of Nutrition and Metabolism* 2001; 45(Supplement):156 (abstract).
12. Health Canada. *Canadian Nutrient File, 2005 Version*. Available at http: // www.hc-sc.gc.ca/fn-an/nutrition/fiche-nutridata/index_e.html.
13. Speakman JR. *Doubly Labeled Water: Theory and Practice*. London: Chapman & Hall, 1997.
14. Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids*. Washington, DC: National Academy Press, 2005.

15. Garriguet D. Impact of identifying plausible respondents on the under-reporting of energy intake in the Canadian Community Health Survey. *Health Reports* (Statistics Canada, Catalogue 82-003) 2008; 19(4): **xx-xx**.
16. 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.
17. Rust KF, Rao JNK. Variance estimation for complex surveys using replication techniques, *Statistical Methods in Medical Research* 1996; 5(3): 281-310.
18. 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.* American Statistical Association: Baltimore, August 1999.
19. Health Canada. *Canadian Guidelines for Body Weight Classification in Adults* (Catalogue H49-179/2003E). Ottawa: Health Canada, 2003.
20. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal* 2000; 32 (7244): 1240-3.
21. Larkin FA, Basiotis PP, Riddick HA, et al. Dietary patterns of women smokers and non-smokers. *Journal of the American Dietetic Association* 1990; 90(2): 230-7.
22. Dallongeville J, Marecaux N, Fruchart JC, Amouyel P. Cigarette smoking is associated with unhealthy patterns of nutrient intake: a meta-analysis. *Journal of Nutrition* 1998; 128(9): 1450-7.
23. Palaniappan U, Jacobs Starckey L, O'Loughlin J, Gray-Donald K. Fruit and vegetable consumption is lower and saturated fat intake is higher among Canadians reporting smoking. *Journal of Nutrition* 2001; 131(7): 1952-8.
24. Subar AF, Harlan LC, Mattson ME. Food and nutrient intake differences between smokers and non-smokers in the US. *American Journal of Public Health*, 1990; 80(11): 1323-9.
25. Guenther PM, Reedy J, Krebs-Smith SM, et al. *Development and Evalutation of the Healthy Eating Index-2005: Technical Report*. Washington, DC: Center for Nutrition Policy and Promotion, U.S. Department of Agriculture, 2007. Available at http://www.cnpp.usda.gov/HealthyEatingIndex.htm.