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

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Abstract
Objective: Under-reporting is a key issue when dealing with nutrition surveys. This paper estimates under-reporting of energy in the Canadian Community Health Survey (CCHS), identifies characteristics of under-reporters and assesses the impact of under-reporting on data analysis. Methods: Total energy expenditure based on equations from the Institute of Medicine is compared to energy intake. Confidence intervals inspired by the Goldberg cut-offs are used to identify under-reporters. Results: In CCHS, under-reporting of energy is estimated at 9.6%. Age, sex, being overweight or obese and physical activity are associated with under-reporting. Identifying under-reporters results in a positive association between energy intake and being obese.

Key Words: energy under-reporting; nutrition; energy intake; energy expenditure

1. Introduction

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. 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. Finally, we address the implications of under-reporting by identifying "plausible" respondents.

2. Methodology

2.1 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 18.5 kg/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]

2.2 Predicting energy requirements

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).[14] These equations were used to estimate the energy requirements of CCHS respondents.

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 PAL. MET describes the intensity of an activity compared with resting metabolic rate (RMR); PAL represents the ratio between TEE and basal energy expenditure (BEE).

All individual leisure-time physical activities were recalculated in PAL and individuals were reclassified according to the IOM methodology[14] into four categories: sedentary, low active, active, and very active. CCHS was classifying individuals into 3 categories: inactive, moderately active, and active. In the end, the inactive group was split into sedentary and low active people, the low active group remained low active and the active group was split into low active, active and very active. Almost three quarters of the population were classified as low active and another 16% as sedentary.

2.3 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 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 the next section.

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-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.

2.4 Identifying plausible respondents

Identifying plausible respondents requires establishing lower and upper cut-offs for their total predicted energy expenditure; that is, a range for the amount of energy they could be expected to expend to remain at their measured weight.

Every CCHS respondent was identified as a plausible respondent, an under-reporter or an over-reporter, based on a comparison of their total predicted energy expenditure with their reported energy intake. Goldberg et al.[15] were the first to suggest such an approach, by creating a confidence interval for PAL based on coefficients of variation (CV) of subjects' energy intake (CV_{wEI}), the accuracy of the measurement of their basal metabolic rate (CV_{wB}), and the total variation in physical activity level (CV_{tP}). Black[16] developed a practical guide for using the cut-offs, and explained the method's limitations. McCrory et al. went further with a direct comparison of total predicted energy expenditure and measured energy intake. In an initial study,[17] the model of total energy expenditure used a limited database of only 93 individuals, whereas a second[18] used the IOM equations, which were developed with information from more than 700 individuals. Both cases assumed the "low active" physical activity category for all individuals. In the report, *What America Drinks*,[19] McCrory's method was modified to produce larger intervals for plausible intakes by assuming four different levels of physical activity for every individual.

For the present analysis, McCrory's intervals for the four levels of physical activity were applied to CCHS respondents according to the amount of activity each of them reported. That is, the interval applied to CCHS respondents depended on whether they were sedentary, low active, active or very active.

The confidence interval for the ratio of measured energy intake (rEI) to the predicted energy expenditure requirement (pEER) was constructed from the standard deviation (SD), defined as follows:

$$SD = \sqrt{CV_{rEI}^2 / d + CV_{pEER}^2 + CV_{mTEE}^2}$$

where CV_{rEI} represents the intraindividual variation of energy intake;
d the number of days of recall;
CV_{pEER} , the error in predicted energy expenditure requirements; and
CV_{mTEE} , the day-today variation and the measurement error for total energy expenditure based on doubly labelled water.

Black and Cole[20] estimated CV_{mTEE} at 8.2%, which was used in the present study. CV_{rEI} and CV_{pER} came from the CCHS data. CV_{rEI} came from the respondents who provided two dietary recalls, based on the formula:

$$CV_{rEI}^2 = \sqrt{\sum_{i=1}^{n} (CV_i^2)/n}$$

where CV_i is the CV calculated for every individual. CV_{pEER} was obtained by dividing the average standard error of individual predictions for a group by the average prediction of energy expenditure for that group.

The CCHS obtained two dietary recalls for approximately 30% of the sample, but only the first is used in the subsequent analysis, therefore, *d*=1. The SD values will slightly vary by age and sex from 30% to 38% and an average SD value of 35% is used.[21]

Because the energy intake distribution is skewed, the confidence intervals were constructed in the log scale, and the cut-offs were exponentiated. The confidence interval for the energy intake to energy expenditure requirements ratio (EI:EER) for plausible respondents is

$$EI : EER \in \left[\exp\left(-\left(\alpha * SD\right)\right); \exp\left(\alpha * SD\right)\right]$$

A multiplicative factor 〈 can be applied to the SD to construct the confidence interval. This study uses only the multiplicative factor of 1.

Respondents whose reported energy intake was less than 70% of their predicted energy expenditure were classified as under-reporters; if the figure was more than 142% of their predicted energy expenditure, they were classified as over-reporters. Plausible respondents were those whose energy intake was 70% to 142% of their predicted energy expenditure. The representativeness of this sample of plausible respondents was assessed by comparing their sociodemographic characteristics with those of the total sample.

The bootstrap method, which takes account of the complex survey design,[22-24] of the CCHS was used to estimate confidence intervals of the ratios and regression coefficients. The significance level was set at $p < 0.05$.

2.5 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.[25] 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.[26] 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*.

3. Results

3.1 Group average under-reporting

Overall, the ratio of CCHS respondents' reported energy intake (EI) to their energy expenditure requirements (EERp) predicted by the IOM equations was 0.904 (Table 1). 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-yearolds. As well, the ratios decreased with age, indicating that under-reporting became greater at successively older ages.

Table 1: 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*
Total		0.904	0.890 to 0.917
12 or 13 years old	Males	1.009	0.950 to 1.067
	Females	0.992	0.934 to 1.050
14 to 18 years old	Males	0.977	0.939 to 1.016
	Females	0.949	0.917 to 0.981
19 to 30 years old	Males	0.962*	0.921 to 1.003
	Females	0.866[†]	0.828 to 0.904
31 to 50 years old	Males	0.920	0.877 to 0.962
	Females	0.876	0.842 to 0.910
51 to 70 years old	Males	0.877	0.846 to 0.907
	Females	0.856	0.829 to 0.884
71 years old or older	Males	0.836	0.796 to 0.877
	Females	0.887	0.853 to 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.

With a regression model, the influence of several variables can be examined simultaneously. The regression coefficients represent the change in the ratio associated with the change in a characteristic in relation to the "reference person." For adults, 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; did not work the week before the interview; neither an immigrant nor an Aboriginal person; non-smoker; aged 18 to 30. Models for teenagers are available elsewhere[27].

Regardless of sex, BMI category had a significant and consistent impact on the ratio of energy intake to predicted energy expenditure requirements (Table 2). 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 actually overestimated how much they ate. By contrast, very active women under-reported.

Low fruit and vegetable consumption (fewer than 5 servings a day) was associated with under-reporting for men. Men who were smokers tended to overestimate the amount they consumed.

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.

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.

Table 2: 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

Characteristics	*Men*	*Women*
Intercept	1.065	0.909
Body Mass Index		
Overweight	-0.119 *	-0.138 *
Obese	-0.205 *	-0.191 *
Physical activity		
Sedentary	0.092 *	0.123 *
Active	-0.077	-0.080
Very active	-0.152	-0.395 *
Highest level of education		
Less than secondary	0.033	-0.071 *
Secondary graduation	-0.041	-0.082 *
Some postsecondary	-0.017	-0.074 *
Daily consumption of fruit and vegetables		
Fewer than 5 servings	-0.071 *	-0.001
More than 10 servings	-0.012	-0.009
Self-reported health		
Very good	-0.011	-0.026
Good	-0.004	-0.070 *
Fair	-0.002	-0.064
Poor	0.013	-0.091
Did not work in week before interview	-0.024	0.045 *
Smoker	0.052 *	-0.045
Age group		
31 to 50	-0.041	0.022
51 to 70	-0.048	0.002
71 or older	-0.092 *	0.057 *

* coefficient significantly different from 0 ($p < 0.05$)
Note: The model is also adjusted by alcohol consumption in previous year, the presence or not of at least one chronic condition, household income, immigrant and aboriginal status and province of residence.
Source: 2004 Canadian Community Health Survey – Nutrition.

3.2 Plausible respondent characteristics

If an analysis uses only data for plausible respondents, the cost in terms of sample size may be high. Based on the confidence interval of 70% to 142% around the ratio of reported energy intake to predicted energy expenditure, 9,196 (57%) of CCHS respondents were identified as plausible respondents; 5,388 (33%) as under-reporters; and 1,606 (10%) as over-reporters.

The characteristics of plausible respondents did not differ significantly from those of the total population. However, significant differences between plausible respondents and under- and over-reporters emerged in relation to BMI, physical activity, highest level of education in the household, and province. These differences persisted in a logistic regression model (data not shown).

3.2.1 Association between reported energy intake and weight

The biological relationship between energy intake and weight is obvious: if weight is to be maintained, long-term energy expenditure must match long-term energy intake. The higher the weight, the higher the energy expenditure, and the greater the energy intake. Thus, in theory, the regression coefficients between weight and predicted energy expenditure requirements, and between weight and energy intake should be the same.

Table 3 shows the slope of weight in the model of total predicted energy *expenditure*. Because predicted energy expenditure depends on body weight, the relationship would be expected to be strong. In fact, this is borne out, with the R^2 ranging from 0.51 to 0.77 (data not shown).

Table 3: Slope of weight variable in modelling predicted energy expenditure requirements or energy intake for all respondents and for plausible respondents, by age group and sex, household population aged 12 or older, Canada excluding territories, 2004

Age group and sex		*Predicted EER model*	*Energy intake model*	
			All respondents	*Plausible respondents*
12 or 13 years old	Males	27.01	2.34*	19.97*
	Females	18.52	-13.13*	6.13*
14 to 18 years old	Males	24.94	-1.43*	20.43*
	Females	17.84	-6.63*	7.97*
19 to 30 years old	Males	16.24	-9.25*	12.58
	Females	13.88	2.58*	11.14
31 to 50 years old	Males	17.20	4.01*	12.22*
	Females	13.15	1.23*	9.58
51 to 70 years old	Males	16.16	-1.87*	9.57*
	Females	13.15	-2.30*	7.19*
71 years old or older	Males	16.99	5.20*	19.53
	Females	13.43	-2.82*	9.95*

* significantly different from slope estimate of predicted energy expenditure model ($p < 0.05$).
Note: Ratio of energy intake (EI) to energy expenditure (EER) of plausible respondents is between 0.70 and 1.42.
Source: 2004 Canadian Community Health Survey – Nutrition.

Table 3 also shows the slope of weight in the model of energy *intake* for all respondents and for plausible respondents. For all respondents, not only are all the slopes significantly different from the slope for total energy expenditure, but for 7 of the 12 age/ sex groups, the slope is negative, indicating that the higher their measured weight, the lower their reported energy intake. In these models, R^2 never exceeds 0.04 (data not shown).

By contrast, for plausible respondents, the slope of weight is always positive. All slopes are closer to the theoretical biological relationship (the higher the weight, the greater the energy intake), and there is no significant difference from the energy expenditure model for 4 of the 12 age/sex groups. Therefore, when based on plausible respondents, the quality of the energy intake model improves, with the R^2 ranging from 0.02 to 0.24 (data not shown).

3.2.2 Impact on reporting of nutrient intake

A comparison of the average reported consumption of a nutrient for all respondents with that for plausible respondents provides an estimate of the extent to which consumption of that nutrient is under-reported. For example, based on the reported calorie intake of all respondents versus plausible respondents, the average rate of energy under-reporting is 8.1%, which is close to the 9.6% estimated in for the average ratio. Under-reporting of fat and sugar consumption amounts to 9.3% and 9.6%, respectively, an indication that unhealthy food items are probably under-reported in greater amount. However, percent of energy coming from fats averages 3%. These variables might be more suitable choices for analysis. On average, vitamins and minerals are slightly less under-reported than energy. Details are available elsewhere[21].

The ratio of reported energy intake to energy expenditure (EI:EER) is higher for plausible respondents (0.98) than for all respondents (0.90). Regardless of age and sex, the ratios for plausible respondents are higher, ranging from 0.96 to 1.02, compared with 0.84 to 1.01 for the total population. Even among obese people, who tend to under-report, the ratio is 0.96 for those identified as plausible respondents, compared with 0.79 for all respondents.

3.2.3 Impact on modelling obesity

The substantial under-reporting of food and beverage consumption in the CCHS has implications for analysis of the data. For example, the relationship between energy intake (calories consumed) and obesity among people aged 18 or older differs depending on whether the results are based on all respondents or on plausible respondents. Based on all respondents, no significant association emerges between calorie consumption and obesity (adjusted odds ratio of 0.99 for men and 1.00 for women for a change of 100 kcal). However, the use of only plausible respondents yields a positive and significant association between obesity and calories consumed for both sexes (adjusted odds ratio of 1.10 for men, 1.16 for women for a change of 100 kcal).

4. 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. This suggests a link between smoking and a poorer quality diet, which has frequently been found in other research.[28-32]

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.

The main strength of this study is the large sample size. Even excluding under- and over-reporters, the number of plausible respondents is large enough and representative enough to permit a detailed analysis. As well, the availability of measured height and weight data obviated the need to account for the response bias associated with self-reports of these variables. Finally, the analysis incorporates a physical activity variable and considers several levels of activity when predicting energy expenditure requirements.

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.

It would have been possible to assume, as was done by McCrory *et al.*[17] and Huang *et al.*,[18] that all respondents were "low active." Doing so, the EI:EER ratio for the population aged 12 or older would be 0.895. It would also result in a slightly smaller sample of plausible respondents (56%), but 96% of CCHS respondents would still be classified in the same category (under-reporter, over-reporter or plausible respondent) as in the present study. The difference lies in the representativeness of the sample, which would be slightly less if a single physical activity level had been used.

The confidence intervals in this study were exponentiated, whereas McCrory *et al.*[17] and Huang *et al.*,[18] used a ±35% confidence interval. Application of the latter to the CCHS data would shift the confidence interval toward more under-reporters and fewer over-reporters, although 92% of respondents would still be classified in the same category as in the present study. The difference is in the level of correction of the energy intake to energy expenditure ratio (EI:EER). Instead of increasing the average EI:EER ratio for plausible respondents to 0.98, as is the case when using the log scale, a symmetrical confidence interval yields an average EI:EER ratio of 0.94.

Another option for estimating physical activity would have been to use the method employed in *What America Drinks*,[19] whereby the lower confidence interval limit is set based on the assumption of a sedentary level of physical activity, and the upper confidence interval limit is set assuming a very active level of physical activity. The result is that a much larger proportion of the CCHS sample—74%—would be considered to be plausible respondents, including every plausible respondent identified in the present study. The drawback is that this method is less effective in correcting the distortion in the biological relationship between energy intake and body weight, and the relationship between energy intake and obesity in the logistic model is weaker.

Another alternative is the Goldberg cutoffs for physical activity level (PAL) using the ratio of energy intake and predicted basal metabolic rates from the Schofield equations.[33] 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. In terms of plausible respondents using the same SD, with a basic comparative PAL of 1.55 and a multiplicative factor of 1, yields a slightly smaller sample of plausible respondents (54%) than in the present study. While the classification of respondents as under- and over-reporters and plausible respondents is the same for 90% of the sample, the representativeness of the plausible respondents is not as good.

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.

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.

5. Conclusion

It is essential to consider under-reporting in analyses of data from nutrition surveys, especially when examining relationships between diet and variables that are highly correlated with under-reporting, such as body mass index. This study shows that just over half of respondents to the Canadian Community Health Survey reported food and beverage consumption that was "plausible," given their height, weight, and level of physical activity. Fully a third were "under-reporters," in that what they reported that they ate and drank could not sustain their measured weight. Under-reporting was particularly common among people who were obese, and as a consequence, under-reporting tends to distort analyses of the relationship between energy intake and obesity.

This study confirms the findings of others, specifically McCrory *et al.*[17] and Huang *et al.*,[18] on the impact of under-reporting on the biological relationship between energy intake and weight, as well as on models related to body mass index. And because of the large CCHS sample, these results can be confirmed for specific age and sex groups.

The technique employed in the present study has numerous applications. It can be used to analyze models related to body mass index and to estimate the level of under-reporting of nutrients, certain foods, and food groups. The results show that some foods are particularly susceptible to under-reporting. CCHS users should be aware of possible under-reporting bias and also of the strength and limitations of this particular technique to correct for it. More details are available in two papers[21, 27].

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