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# Mediterranean dietary components and body mass index in adults: The Peel Nutrition and Heart Health Survey 

Mamdouh M Shubair, R Stephen McColl and Rhona M Hanning


#### Abstract

Diet is a lifestyle factor that contributes to the risk of overweight/obesity and cardiovascular disease. The objective of this study was to examine the hypothesis that a Mediterranean-type dietary pattern $(M)$ is associated with healthy body weights in a large suburban municipality in Ontario. A random cross-sectional sample of 759 adults, 18 to 65 years of age, participated in a telephone survey, which included questions on the frequency of consumption of 60 food categories. Principal components analysis showed that food categories aggregated into six loworder dietary factors and two high-order dietary patterns. The $M$ pattern reflected higher consumption of fruits and vegetables, olive oil and garlic, and fish and shellfish. The non-M pattern reflected high fat/nutrient poor foods, meats and poultry, and foods high in added sugars. The $M$-score was inversely related to body mass index (BMI) ( $p=0.027$ ). After adjustment for gender, education, income and marital status, a higher $M$-score predicted a lower BMI in the 40 to 49 year age group. Heart health promotion strategies aimed at preventing adult obesity should emphasize components of a Mediterranean-type diet pattern.


Key words: body mass index, cardiovascular health promotion, dietary patterns,
Mediterranean diet, obesity

## Introduction

Adult overweight and obesity are significant public health problems as established risk factors for diseases such as type II diabetes mellitus and cardiovascular disease (CVD). Clearly, overweight/obesity is associated with a chronic excess of dietary energy intake in relation to energy expenditure (in physical activity, for example). Yet there is a paucity of research examining the effect of food consumption patterns on the prevalence of overweight/obesity in a diverse urbanized population in English Canada.

In 1997, a heart health survey identified overweight and obesity ( $\mathrm{BMI}>25 \mathrm{~kg} / \mathrm{m}^{2}$ ) in 43 percent of the adult population of Peel region, a large suburban municipality in the Province of Ontario. ${ }^{1}$ The present study was
designed with the primary objective of describing dietary intake patterns in a random sample of adults residing in the Peel region. A second objective was to identify whether these dietary patterns were independent predictors of body mass index (BMI).

A prudent dietary pattern that has been linked to reduced CVD morbidity and mortality in a significant number of studies is the Mediterranean diet. ${ }^{2-7}$ A Mediterranean diet varies regionally and has traditionally been described as being high in olive oil; rich in vegetables, fruits, legumes and whole grains; moderate in milk products, fish and poultry; low in red meats and sweets, with moderate wine consumption at meals. ${ }^{8}$ Hence the diet has a high monounsaturated
to saturated fatty acid ratio and is high in fiber and flavinoids. ${ }^{4}$ Diet patterns with many of the components of a Mediterranean diet have been associated with lower BMI in Europe. ${ }^{9,10}$ The present study was based on the hypothesis that similar dietary patterns to those described in a Mediterranean diet construct would be associated with healthy body weights in the Peel region. The identification of healthful and less healthful dietary patterns existent in the Peel region will be helpful in designing and implementing community-based heart health interventions relevant to the population's eating habits.

## Methods

## Study design

The Peel Nutrition and Heart Health Survey (PNAHHS) was a cross-sectional, self-reported telephone survey of adult men and women, 18 to 65 years of age, randomly selected from the Regional Municipality of Peel. A computer-assisted telephone interviewing (CATI) system randomly generated telephone numbers from the region's telephone exchange. Stratified random sampling was conducted according to the population in each geographic locality within the region: Mississauga $=65$ percent, Brampton $=30$ percent, and Caledon $=5$ percent. For each household contacted, one eligible adult was selected for interview following verbal consent. The telephone survey was administered by six trained interviewers from a CATI lab at the University of Waterloo Survey Research Centre (UW-SRC) and was conducted from July to September, 2001. The study was

[^1]approved by the Human Research Ethics Committee (HREC) at the University of Waterloo.

## Population

Telephone interviews were completed by 920 subjects. This represents an overall response rate of 51.6 percent from the number of random digit phone numbers dialed that were known to be eligible households ( $\mathrm{n}=1,782$ ). In regard to the number of calls, the study protocol specified no more than six call attempts to each phone number before being replaced with another number. Hence the number of call attempts made to complete the 920 interviews was a minimum of one and a maximum of six. Of the 920 subjects, 161 individuals were excluded a priori because they were adopting either a lowcalorie or "crash" diet, or were on particular therapeutic diets (such as low-salt or low-fat diets). Consequently, data from 759 eligible subjects were used for subsequent statistical analysis. The excluded cases ( $\mathrm{n}=161$ ) were compared with the non-excluded ( $\mathrm{n}=759$ ) using unpaired t-tests for age, weight and height, and a chi-square test for gender. These tests revealed that those excluded were older than the non-excluded subjects by a mean of 6.5 years ( $p<0.0001$ ) and their self-reported weights were higher by a mean of 5.5 kilograms ( $p<0.0001$ ).

## Measures

## Socio-demographics and self-reported weight and height

The PNAHHS elicited respondents' self-report of their current weight and height measures, which were used to derive BMI (weight [kg])/ height $[\mathrm{m}]^{2}$ ). Age, gender, education attainment, annual household income, marital status and ethnicity/place of birth were also queried in the PNAHHS.

The self-reported weight, height and sociodemographic background questions were originally derived from the 1996 Canada Census questionnaire and the 1996/97 National Population Health Survey (NPHS) questionnaire. For the present study, the age variable was collected on a continuous ratio scale (in years). Potential contacts were excluded a priori from being interviewed if
their age did not fall within the desired age range ( $18-65$ years). Gender was defined as a binary variable (male/female). Education attainment was defined as follows: uncompleted high school, completed high school/ grade 12 , some community college or some university education, completed a university undergraduate degree and education beyond a university undergraduate degree. The household income variable, relative to the year ending December 31, 2001, was recoded into a smaller set of categories. These income categories were derived from the 1996/1997 NPHS: low income ( $\leq \$ 39,999$ ), middle income ( $\$ 40,000-\$ 69,999$ ), high income ( $\$ 70,000$ - $\$ 99,999$ ) and above high income ( $\geq \$ 100,000$ ).

Marital status is a nominal variable originally collected on six categories in the 1996 Canada Census questionnaire. For the present analyses, marital status was defined as a dummy variable: currently married and currently not married. The "currently married" category was derived by collapsing together the categories "married or common law partner" and "living with a partner." The category "currently not married" was derived by collapsing together the categories "widowed", "divorced", "separated" and "never married".

## Food frequency questionnaire

The food frequency questionnaire (FFQ) was based on a list of food items that were developed and validated previously for the studies of Willett and colleagues. ${ }^{11}$ However, the list was adapted and peer reviewed, including input from public health staff and dietitians at the Regional Municipality of Peel Health Department ( $n=5$ ), faculty professors and graduate students affiliated with the Department of Health Studies and Gerontology at the University of Waterloo ( $\mathrm{n}=19$ ) and previous studies, ${ }^{12-17}$ to better reflect the multicultural Canadian context and to account for possible ambiguities or inconsistencies in the prudent pattern construct delineated by Hu et al. ${ }^{11}$ In the end, the questionnaire inquired about 60 food categories (Table 1). A food category might represent many similar foods. For example, the interviewer's script would ask "Over the past month, how often on average did you eat
processed meats such as hot dogs, salami, corned beef, bologna, wieners or sausages, bacon, ham, luncheon meats or other processed deli-style or canned meats?"

The qualitative FFQ instrument was not designed to capture a comprehensive pattern of all food consumption behaviours. Since it was mainly designed to capture and empirically evaluate the prudent Mediterranean diet pattern construct (or food components/ dimensions thereof), food categories included elements that were consistent with a Mediterranean pattern (e.g. olive oil and wine) or clearly not consistent (e.g. lard/shortening). In addition, choices encompassed a range of foods that would be typical of a North American diet. Thus, high-fat snack foods-high in saturated and trans fat-would fall into the "not consistent" category. Some foods (e.g. liquid cooking oils high in polyunsaturated fats) are considered part of a healthy diet but not a traditional Mediterranean diet. These were included to ensure the representation of key food components that might be relevant to healthy body weights in the Peel region.

The majority of the FFQ items in the PNAHHS were structured on a seven-point response scale. Subjects were asked to report their dietary intake for specific foods over the past month, using seven response categories: more than once per day; every day/ seven days per week; five to six days per week; two to four days per week; one day per week; less than one day per week; and never. For each response, a numeric ordinal food score was assigned, with "more than once per day" having a score of six and "never" having a score of zero.

In the present study, portion sizes were not explicitly assessed. However, if a respondent asked a telephone interviewer about a portion or serving size for any particular food item(s), the interviewer was trained to respond with the Canada's Food Guide to Healthy Eating's standard or usual serving for that item.

## Assessment of dietary patterns

Principal components factorial analysis (PCA) was used to derive the factorial structure of the qualitative FFQ items, as has been

TABLE 1

## Food items/categories used in the dietary pattern analysis

## Green leafy vegetables

Orange and dark yellow vegetables
Cabbage-type vegetables
Beans
Other vegetables
Non-citrus fruits
Citrus fruits
Melons
Berries
Exotic fruits
Tomatoes
French fries
Frozen potato products
Baked, boiled, mashed or roasted potatoes
Cooked breakfast cereals
Products made of white flour
Whole wheat foods
White rice, pasta, spaghetti, macaroni, noodles, polenta
Brown rice, whole wheat pasta, other grains
Split peas, chickpeas or hummus, dried beans, lentils
White fish
Dark fish
Shellfish or other sea foods
Chicken or turkey
Duck or goose
Eggs with yolks
Egg whites
Foods made with ground meats
Organ meats

## Processed meats

Beef, pork, lamb
Veal, goat, rabbit
Chocolate bars, chocolate pieces, cookies,
brownies, doughnuts, cake, pie, coffee cake,
sweet roll, pastry
Peanut butter
Nuts, including peanuts, pistachios, almonds, hazelnuts, pecans, cashews, chestnuts, walnuts, pine nuts

Snacks such as potato chips, corn
chips, popcorn, nachos, tortilla chips
Low-fat milk such as 2\% milk, 1\% milk, skim milk
Low-fat dairy products such as low-fat/non-fat ice cream, frozen yoghurt, ice milk, sherbet
Plain or sweetened yoghurt
Homogenized milk
Regular or rich ice cream
Cottage cheese or ricotta cheese
Cream in coffee or tea
Whipping cream, sour cream, cream cheese
Other cheese such as cheddar cheese, mozzarella cheese, brie, feta cheese, goat cheese
Soy products such as soybeans, tofu, miso, tempeh, soy milk, soy cheese, soy flakes, soy flour
Wine including red wine, white wine, rose/blush wine
Natural or $100 \%$ fruit juices such as apple juice, orange juice, grapefruit juice, other
Regular soft drinks or fruit flavoured drinks
Diet soft drinks
Spicy condiments such as chilli sauce, salsa, mustard, pepper, chutney, steak sauce, soy sauce, Worcestershire sauce, wasabi
Sweet condiments such as jam, jelly, corn or maple syrup, honey or molasses
Gravy, hollandaise or cheese sauce Fresh garlic
Butter or margarine
Olive oil, including frying or grilling with olive oil, salad dressings made with olive oil, other foods eaten with olive oil

Liquid cooking oils other than olive oil, such as canola, peanut, corn, safflower, soybean
Lard or shortening
described by others. ${ }^{18-22}$ Essentially, PCA is used to explain the interrelationships among a set of variables (e.g. food items) by aggregating together highly correlated items that load on a few conceptually meaningful factors (behavioural dimensions, components, patterns). These factorial dimensions tend to explain most of the variance in the individual food items so that food items are reduced into a more parsimonious set of factors which retain most of the explained variance in the original data. ${ }^{18-20}$

Orthogonal rotation was used to maximize the independence of the PCA-derived dietary factors. In the PNAHHS questionnaire, 60 food items/categories were loaded into the PCA. The PCA was intended to be conceptually agnostic since the qualitative FFQ did not assemble the food items into predefined food groupings, as was done previously. ${ }^{11,23}$ Instead, all 60 items were included in the PCA without a priori aggregation in order to be objective in the assessment of the dietary factorial structure.

It was specified a priori that only food items with a beta ( $\beta$ ) loading cut-off point of $\geq$ 0.30 would be retained in the PCA. All 60 food items met this criterion. The initial orthogonal PCA output revealed the presence of 19 possible dietary factors on which all the 60 dietary items were loaded. In determining the number of informative (i.e. meaningful) dietary factors to retain, objective scree test criterion and the percentage of variance explained by each factor criterion were considered. ${ }^{18}$ The PCA retained six meaningful low-order dietary factors (described in the results) as the slope of the scree plot started to flatten out at the sixth component (factor). The term "low-order" denotes that these factors were derived from the 60 food items. Using the factor score coefficients generated from the PCA, a weighted summative food score for each of the six low-order dietary factors was calculated. Each individual dietary item was multiplied by its respective weighted factor score coefficient and the product was summed to obtain a food score for a particular dietary factor. ${ }^{18}$

A second PCA was performed and revealed two high-order dietary patterns (described in the results). A composite food score (Mscore; non-M score) was computed for each of the high-order dietary patterns.

## Statistical analysis

Data were analyzed using SPSS 10.1 for Windows. One-way analysis of variance (ANOVA) was carried out to examine the mean differences in the M-score among the four age groups. We used the Tukey Honestly Significant Difference (HSD) method as a post-hoc test for multiple comparisons among the age groups. A probability value of $p \leq 0.05$ was considered statistically significant.

Multiple regression analysis was used to examine whether the derived PCA food score ( M -score) would serve as an independent predictor of BMI after adjusting for other sociodemographic variables in the model: age, gender, education, household income and marital status. The effect of age was controlled for by stratification in subsequent multiple regression analysis. In all multivariate analyses, BMI was included as a continuous variable to reflect the continuum of risk. ${ }^{24}$ For example, even small changes in the overall distribution of body weights of individuals will yield greater health benefits for the population as a whole, relative to a strictly high-risk approach. ${ }^{25}$

## Results

## Socio-demographic characteristics

Baseline characteristics of the 759 eligible subjects who participated in the survey are presented in Table 2. The mean age of subjects was $39.0 \pm 13.0$ years. The sample consisted predominantly of females (65 percent), and two thirds of subjects had completed high school or had some college/university education.

## Body mass index

The mean and standard deviation (SD) values for BMI are illustrated in Table 3. BMI was derived for 746 subjects. The BMI categories were based on the World Health Organization (WHO) standard BMI categories, ${ }^{26-28}$ which have been adopted recently by Health Canada.

TABLE 2
Sociodemographic characteristics of the study sample ( $\mathrm{n}=759$ )

| Variable | Categories | Number of subjects | Percent |
| :---: | :---: | :---: | :---: |
| Gender | Male | 265 | 34.9 |
|  | Female | 494 | 65.1 |
| Age group | 18-29 years | 218 | 28.7 |
|  | 30-39 years | 192 | 25.3 |
|  | 40-49 years | 178 | 23.5 |
|  | 50-65 years | 171 | 22.5 |
| Age-gender | Males (18-29) | 99 | 13 |
|  | Females (18-29) | 119 | 15.7 |
|  | Males (30-39) | 63 | 8.3 |
|  | Females (30-39) | 129 | 17 |
|  | Males (40-49) | 43 | 5.7 |
|  | Females (40-49) | 135 | 17.8 |
|  | Males (50-65) | 60 | 7.9 |
|  | Females (50-65) | 111 | 14.6 |
| Education level | Uncompleted high school (< 12 years education) | 41 | 5.5 |
|  | Completed high school/grade 12 | 231 | 30.9 |
|  | Some college/some university | 263 | 35.2 |
|  | Completed undergraduate degree | 161 | 21.5 |
|  | Beyond undergraduate degree | 52 | 7.0 |
| Annual household income | Less than or equal to $\$ 39,999$ | 122 | 22.6 |
|  | \$40,000-\$69,999 | 166 | 30.7 |
|  | \$70,000-\$99,999 | 130 | 24.1 |
|  | \$100,000 or greater | 122 | 22.6 |
| Marital status | Unmarried | 291 | 39.0 |
|  | Married | 455 | 61.0 |

## Principal components analysis

## Identification of the low-order dietary factors

From the PCA, six low-order dietary factors were identified by aggregation of particular food items (Table 4). The six low-order factors were the fruits and vegetables factor; the meats and poultry factor; the high-saturated/ trans fat/nutrient poor foods factor; the olive oil and garlic factor; the fish and shellfish factor; and the foods high in added sugars factor.

The labels assigned to each of the six dietary factors are rather arbitrary; however, they do reflect the dietary quality of the majority of the food items that loaded on each of these six factors.

## Derivation of the high-order dietary patterns

Two high-order dietary patterns were derived from a second PCA. The first pattern was principally characterized by higher consumption of fruits and vegetables, olive oil
and garlic, and fish and shellfish. It was called the M-pattern due to its similarity to the Mediterranean diet construct. The nonM pattern was characterized by higher consumption of meats and poultry, highsaturated/trans fat/nutrient-poor foods, and foods high in added sugars.

## Diet patterns and BMI

The relationship between the M-score and BMI was tested after adjusting for the sociodemographic variables in multiple regression analysis. The results showed that the overall model was significant ( $\mathrm{R}^{2}=6.7 \% ; p<0.001$ ). The M-score was independently and inversely associated with BMI $(\beta=-0.186, p=0.027)$.

## Sub-analysis by age group

A stratified analysis by age group was carried out by dividing the sample into four age groups, as outlined in Table 2. For each age category, BMI was regressed on the M-score adjusting for gender, education, household income and marital status. The Mscore was an independent predictor of BMI only in those aged 40-49 ( $\beta=-0.237$, $p=0.011$ ). The M -score approached significance in the 30-39 year age group ( $\beta=-0.157, p=0.056$ ), while it was not significantly associated with BMI in the $18-29$ year age group ( $p=0.999$ ), and the $50-65$ year age group ( $p=0.564$ ).

## Discussion

In the present study, we tested the hypothesis that dietary patterns similar to those described in the Mediterranean diet construct would be associated with healthy body
weights in the Peel region. Using PCA performed on FFQ data, two major dietary patterns emerged. The first pattern was labelled the M pattern. The M pattern was characterized by frequent consumption of healthful food components (fruits and vegetables; olive oil and garlic; fish and shellfish) and included some of the key components of a traditional Mediterranean pattern. The second pattern, the non-M pattern, was loaded with less healthful foods (foods high in saturated/trans fats; meats and poultry; added sugars). These two dietary patterns jointly explained 50.6 percent of the variance in the FFQ: The M pattern explained 26.8 percent, while the non-M pattern explained 23.8 percent of the variance.

It was interesting that some of the components of the traditional Mediterranean diet (e.g. legumes and wine) did not load onto any of the six low order dietary factors to describe a significant part of the diet pattern. In the Peel region, these foods did not constitute distinct or stand alone items that would necessarily feature in patterns that were identifiably healthful (M-pattern) or less healthful.

Previous studies have reported diet patterns similar to the M pattern and non-M pattern. For example, using a semi-quantitative FFQ of 131 items, Hu et al. ${ }^{11}$ identified two major dietary patterns by PCA. The results supported the authors' hypothesis that a diet pattern labelled the "prudent pattern", much similar in its food components to the Mediterranean dietary pattern, was associated with a more favourable cardiovascular (CV) risk profile. A less healthful eating pattern, the "Western pattern", was associated with a less

TABLE 3
BMI mean, standard deviation and categories

| BMI | Weight status | Number of <br> subjects $^{\mathbf{a}}$ | Percent |
| :--- | :--- | :---: | :---: |
| Mean $\pm$ SD | $24.8 \pm 5.0$ | $\mathrm{~N} / \mathrm{A}$ | $\mathrm{N} / \mathrm{A}$ |
| BMI categories | Underweight $\left(<18.5 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 35 | 4.7 |
|  | Normal weight $\left(18.5-24.9 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 412 | 55.2 |
|  | Overweight $\left(25.0-29.9 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 205 | 27.5 |
|  | Class I obese $\left(30.0-34.9 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 67 | 9.0 |
|  | Class II obese $\left(30.0-34.9 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 20 | 2.7 |
|  | Class III obese $\left(\geq 40 \mathrm{~kg} / \mathrm{m}^{2}\right)$ | 7 | 0.9 |

a BMI values were available for 746 subjects. There were 13 individuals who had missing values for weight and/or height.
favourable CV risk. Gray-Donald, O'Loughlin, Richard and Paradis ${ }^{12}$ examined food patterning of an adapted questionnaire (the eating patterns FFQ) ${ }^{13}$ in a low-income, low-education adult population in the St-Henri district of Montreal, Canada. The PCA results of the adapted FFQ revealed five dietary factors which explained 40 percent of the variance in the 38 FFQ items. These factors were the following: avoid fat (e.g. use bread, rolls or muffins without butter or margarine); junk food (e.g. french fries, chocolate or candy, bacon or sausages); high-fat traditional (e.g. fried fish or fish sticks, homogenized milk); low-fat substitutes for high-fat foods (e.g. use lowcalorie mayonnaise, low-fat cheese, skim or $1 \%$ milk); and modify meat to reduce fat (e.g. red meat with all visible fat trimmed, use ex-tra-lean ground beef).

A previous heart health survey showed that 43 percent of the Peel region adult population were overweight/obese. ${ }^{1}$ In the present study, 40 percent of subjects were overweight/obese (BMI $\geq 25$ ), and 13 percent were at significant health risk due to obesity (BMI $\geq 30$ ). Using the overall sample ( $\mathrm{n}=759$ ), the independent effect of the prudent M-score on BMI measured on a continuous metric scale was investigated after adjusting simultaneously for antecedent socio-demographic factors (age, gender, education level, annual household income, and marital status) in multiple regression analysis. There was a significant modest inverse association between BMI and the Mscore ( $p=0.027$ ). This finding has potential public health implications as small significant reductions in body weight status were observed across the whole BMI spectrum in relation to the prudent M -score.

The reduced prevalence of overweight/ obesity associated with the M pattern in our study is noteworthy given that this is the first study which has examined such a relationship in English Canada. Several previous studies reported associations between healthful and less healthful dietary patterns and BMI. For example, Slattery, Boucher, Caan, Potter and $\mathrm{Ma}^{23}$ identified two generic diet patterns related to BMI. The prudent pattern, characterized by high consumption of fruits and vegetables, frequent consumption of poultry and fish and low consumption of

TABLE 4
Six low-order dietary factors identified by PCA
$\left.\begin{array}{lll}\hline \text { Factor } & & \begin{array}{c}\text { Factor score } \\ \text { Beta factor } \\ \text { loading }\end{array}\end{array} \begin{array}{c}\text { coefficient for food } \\ \text { item/category }\end{array}\right]$
a The orthogonal PCA was based on a sample of 759 subjects.
b The label for each dietary factor was based on its high beta factor loadings for individual food categories.
eggs, red and processed meats, was significantly associated with lower BMI. Higher BMI was associated with the Western pattern, which was characterized by high intake of red and processed meats, french fries, eggs, high-fat dairy products, refined grains, sweets and desserts. Schulze, Hoffmann, Kroke and Boeing ${ }^{9}$ assessed food intake patterns in a large cohort of European men and women ( $\mathrm{n}=22,354$ ) using PCA performed on FFQ data. They found that factor scores, reflecting dietary components/patterns, were significantly related to BMI, education level, physical activity and smoking status. The diet patterns accounted for 31 percent of the variance explained in energy and macronutrient intake.

In the present study, the association of the M-score to BMI was examined further after stratifying by age in multivariate regression analyses. There was significant evidence of an age-modifying effect on the predictive validity of the M -score in determining BMI that was most apparent in the 40-49 year olds and approached significance in the 30-39 year olds. This finding has potential public health implications. It suggests that intervention strategies in the Peel region, designed to promote healthful eating patterns (including components of a Mediterraneantype diet pattern) and to prevent obesity, would be relevant to those 50 years of age and younger. It is widely recognized that overweight and obesity are difficult to treat and that the focus should be on prevention. The present study adds to the literature supporting the promotion of fruits and vegetables and fish as part of a healthy diet. Moreover, olive oil, which is a key component of a Mediterranean diet, was identified with these healthful foods.

The overall variance in BMI explained by diet pattern may not seem particularly large ( $\mathrm{R}^{2}=6.7 \%$ ). However, body weight status is influenced by genetic, metabolic, physiologic, sociodemographic, cultural, psychosocial and lifestyle behavioural determinants. There is growing scientific evidence, for example from genetic epidemiology studies of twins reared apart, indicating that the magnitude of the genetic contribution of obesity accounts for as much as 60 to 70 percent of the variation in BMI. ${ }^{29-32}$ By contrast,
adoption studies have shown a low to moderate genetic contribution, of the order of 30 percent or less. ${ }^{33,34}$ It is unlikely that the rapid increase in the prevalence of overweight and obesity in most industrialized countries over past decades is due to changes in population genetics. ${ }^{35}$ This suggests that environmental factors (primarily dietary and physical activity patterns) play a significant role as determinants of weight status. These extraneous factors include individual lifestyle behaviours (e.g. smoking, physical activity, alcohol consumption and stress), psychosocial factors (e.g. self-perception of weight; knowledge, attitudes and beliefs about nutrition and physical activity; self-efficacy and intentions for behaviour change). In addition, there are possibly early-life historical effects as postulated in Barker's fetal origins hypothesis, ${ }^{36}$ which argues that adult chronic disease (obesity, insulin resistance, CVD) develop as a consequence of early biological and environmental influences on intrauterine fetal growth.

It is conceivable that individuals who were cognizant of their unhealthy weight status (BMI $\geq 25$ ) at the time of the study interview might have underreported their weights. ${ }^{37-39}$ Some might have provided socially desirable responses on the FFQ which did not reflect their actual intake patterns. For example, they might have reported more frequent consumption of the healthful food components (e.g. fruits and vegetables, fish and shellfish) or underreported energy-dense/nutrient-poor foods. Such a self-reporting bias has been observed in other studies of obese, but not normal weight, individuals. ${ }^{40-44}$

The possibility of response bias in the current study sample can not be ruled out. Males were undersampled in the present study (35 percent of respondents were males). This inadvertent undersampling was attributed to non-participation (response) bias by males, who were less likely to answer the telephone or to provide consent for study participation.

Finally, assessment of dietary patterns in the present study was carried out using a qualitative FFQ which elicited information about the average weekly frequency of consumption of particular foods or food items over
the past month. It was not possible to assess seasonal variability in food intake, ${ }^{45-48}$ given that interviews were conducted during the mid-summer to early fall season (JulySeptember, 2001). In that sense, the qualitative FFQ employed in the present study was not intended to capture a comprehensive pattern of all food consumption behaviours in the target population of the Peel region.

## Conclusions and public health recommendations

The application of epidemiologic methods to nutrition is fraught with complications because of the highly intercorrelated nature of dietary exposures. ${ }^{19,49}$ Because a better understanding of the dietary consumption patterns was needed to effectively guide the development of preventive behavioural interventions in the Peel region, it was important to examine dietary exposures within the framework of total dietary patterns in the present study. It has revealed that certain segments of the diverse urbanized population in the Peel region adopt particular components of the prudent Mediterranean diet as part of their dietary habits. This is also the first research study which examined food consumption patterns and their relationship to BMI as an indicator of adult body weight status in a diverse urbanized population in English Canada. Findings from the present study revealed that there was significant influence of particular components of the Mediterranean diet pattern on reduced prevalence of overweight and obesity, especially in the 40-49 year age group.

The prospect of designing nutrition-tailored intervention strategies aimed at promoting and emphasizing the heart-healthy benefits of the key components of the Mediterranean diet pattern should be clearly communicated to the public. Such nutrition education and intervention strategies should focus on delineating the health risks associated with overweight and obesity, in order to maintain a healthy weight status and improve overall health of the population. For example, nutrition strategies could be designed to modify the unhealthful or less healthful dietary patterns identified in the present study (the non-M pattern, characterized by high con-
sumption of saturated/trans fat/nutrientpoor foods, foods high in added sugars, and red meats). In addition to targeting the unhealthful eating habits, parallel interventions should be aimed at the upstream public health policy level and at the downstream treatment interventions level. ${ }^{24}$

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# Screening mammography participation and invitational strategy: The Quebec Breast Cancer Screening Program, 1998-2000 

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#### Abstract

In the Quebec Breast Cancer Screening Program, a personalized letter signed by a regional program physician is sent to every woman in the province 50 to 69 years of age, inviting her to have a screening mammogram. A reminder letter is also frequently sent. The aim of this study was to evaluate the influence of this screening invitational strategy on rates of participation. The population studied comprised 684,028 women in Quebec aged 50-69. The baseline (expected) monthly mammography screening rate was estimated from the rate of screening mammograms recorded between the date a woman became eligible for screening and the mailing date of her personalized invitational letter; the observed monthly mammography screening rate was calculated after the mailing of the letter. Compared to baseline (expected) screening rates, observed rates were substantially increased ( $p<.05$ ). The ratios of observed to expected rates were respectively 3.05 and 2.23 in the second and fourth months, respectively, after the letter mailing, coinciding with the mailing of the initial and reminder letters. In the twelve months after the mailing, the ratio of observed to expected rates was 1.68 ( $95 \%$ CI: 1.67-1.69). Twelve months following the mailing, 30 percent of the women who were letter recipients had undergone a screening mammography, compared to an expected cumulative probability of 20 percent for women not receiving a letter. The strength of this effect was similar to one seen in randomised controlled trials.


Key words: breast cancer, invitational, mammography, participation, strategy

## Introduction

Mammography screening can reduce breast cancer mortality among women aged 50 to 69 years of age. ${ }^{1}$ However, mammography screening programs need to achieve a participation rate of at least 70 percent if expected reductions in mortality are to be obtained. In Canada, provincial participation rates in screening programs ranged from 13.1 percent to 54.1 percent in 1999-2000, ${ }^{2}$ but some women have mammograms regardless of such programs. In Quebec in 2002, the
participation rate in the Breast Cancer Screening Program (Programme québecois de dépistage du cancer du sein - PQDCS) was 45.1 percent, but the proportion of women aged 50-69 who had had a mammogram within or outside the program in the previous two years had reached 63.0 percent.

Various strategies can be used to improve the participation rates of women in screening programs. A meta-analysis of strategies invoked to increase participation was published in 2001 in The Cochran Library. ${ }^{3}$ The
authors compiled randomised trials comparing women exposed to various invitation strategies to women not targeted by any special intervention. The meta-analysis demonstrated that a personalized invitational letter can increase participation rates of screening mammograms during the twelve months subsequent to the letter mailing.

In the PQDCS, inaugurated in May 1998, a personalized letter signed by a regional program physician is sent to each woman between 50 and 69 years of age, inviting her to undergo a screening mammogram. This first letter is followed by a reminder letter two months later if no screening mammogram has taken place. The Centre de coordination des services régionaux (CCSR) is responsible to each Quebec health region for sending the letters, using a file produced and updated every six months by the Régie de l'Assurance Maladie du Québec (RAMQ), which identifies all women aged 50 to 69 eligible for the program. The letters are either in French or English, depending on each woman's preferred language of communication with the RAMQ.

Due to the time and costs involved in the PQDCS's invitation strategy, an assessment of its effect on participation rates was needed. Thus, the objective of the current study was to assess any associations between the personalized invitational letter signed by a regional program physician and screening mammogram participation rates during the first two years of the Quebec program.

[^2]FIGURE 1
Screening mammography program cohort follow-up: May 1998 - June 30, 2000


## Methods

## Studied population

The current study included 684,028 women in Quebec, 50 to 69 years of age, who were eligible to have a screening mammogram between May 1998-the implementation date of the PQDCS—and the end of June 2000. Since the PQDCS was implemented gradually across the province, only women from regions where the PQDCS was implemented before June 30, 1999 were included in the study in order to ensure a potential follow-up of at least twelve months.

## Sources of data and variables

Data used in the current study were retrieved from the information system of the PQDCS. On June 30, 2000, three files were extracted: the file produced by the RAMQ of women eligible for the PQDCS, the follow-up file used by the CCSR detailing mailing activities, and the PQDCS mammography file containing screening data.

The main variables are the following: the identification number assigned to each woman, her date of birth, her region of residence, the date of the implementation of the PQDCS in each region, the date of mailing of the initial invitational letter and the date of the mammography screening (if applicable).

## Statistical analysis

The influence of the invitational letter on participation was assessed by comparing the rate of screening mammograms following the mailing of the letter (observed rate) to the baseline rate of screening mammograms seen in this population before invitational letters were sent (expected rate).

The observed rates of screening mammograms were calculated for 438,066 women in the twelve month period, occurring sometime between May 1998 and June 2000, following the mailing of their invitational letters. The observed rate equals the number of women who had undergone a screening mammogram during a given period divided by the women's cohort's total amount of person-time during the same period. A woman's person-time is the amount of time elapsed between the date

FIGURE 2
Rate of screening mammography after eligibility to the PQDCS but before mailing of invitational letters

of mailing of her invitational letter and the earliest occurring of one of the following events:

- The woman had a screening mammogram (event of interest)
- The woman reached 70 years of age (censored)
- Twelve months elapsed after the mailing of the woman's invitational letter (censored)
- June 30, 2000: the follow-up end date for all women studied (censored)

The expected rate of screening mammograms was calculated in the cohort, based on the baseline rate, which included the 684,028 women eligible to have screening mammograms between May 1998 and June 2000. The expected rate is the number of women who had undergone a screening mammography before the mailing of their personalized invitational letters, divided by the cohort's total accumulated person-time. A woman's persontime is measured from the date of her inclusion in the program (either the implementation date of the PQDCS in her region of residence or the date she reached 50 years of age) until the earliest occurring of one of the following events:

- The woman had a screening mammogram (event of interest)
- The woman's invitational letter was mailed by the CCSR (censored)
- The woman reached 70 years of age (censored)
- June 30, 2000: the follow-up end date for all women (censored)

Figure 1 presents the follow-up of the women in the cohort.

The LIFETEST procedure from SAS software was used to calculate mammographic rates. The Cox proportional hazards model was used to calculate the ratio of observed to expected rates, adjusting for age and region.

The cumulative probability of having a screening mammogram was also calculated. KaplanMeier survival analysis was used to calculate the observed cumulative probability of a screening mammogram in the 12 -month period following the mailing of an invitational letter. The expected cumulative probability was estimated using baseline rates.

Finally, the cumulative probability of receiving an invitational letter was calculated. The Kaplan-Meier survival analysis was used to calculate the observed cumulative probability of receiving an invitational letter in the 24-month period beginning when a woman became eligible to participate in the PQDCS.

TABLE 1
Ratio and confidence intervals of crude screening mammography rates by region and age group

|  | After mailing of letters |  | After eligibility for PQDCS but before mailing of letters |
| :--- | :--- | :--- | :--- | :--- |\(\left.\quad \begin{array}{c}Ratio of crude <br>

screening\end{array}\right)\)

* Included regions are those where the PQDCS was implemented before June $30^{\text {th }}, 1999$.


## Results

The cumulative probability of receiving an invitational letter reached 83.9 percent 24 months after women became eligible to participate in the PQDCS. This probability was 81.5 , 83.6, 83.8 and 88.3 percent for women aged 50-54, 55-59, 60-64 and 65-69, respectively. It should be noted that a percentage of women did not receive an invitational letter within 24 months of their eligibility due to varying administrative practices between provincial health regions.

The PQDCS was implemented gradually in each region. Therefore, the rate of screening mammography after the beginning of the program, but prior to the mailing of invitational letters, progressively increased during the first four months of implementation, then stabilized (Figure 2). The baseline or expected rate of screening mammography used in this analysis is the weighted mean of monthly mammographic rates from the fifth to the twentieth month following implementation of the program in a region. Overall, the baseline or expected monthly rate of mammography was 2.04 per 100 women.

When compared to expected rates of screening mammography, observed rates were substantially increased following the mailing of the invitational letters (Figure 3). Two peaks are observed: in the second and fourth months after the mailing, and ratios of observed to expected rates were 3.05 and 2.23 , respectively. Moreover, observed rates of mammography still showed increases compared to expected rates up to the tenth month following the mailing.

Table 1 presents the amount of person-time (in months) and the number of women who had a screening mammogram before and after the mailing of invitational letters, along with the ratio of observed to expected crude mammography rates. The ratio of crude rates of screening mammography during the twelve months following the mailing of the letters of invitation is 1.68 . This ratio varies with age, from 1.52 for women aged $55-59$ to 1.93 for women between 65 and 69 years of age. The ratio of crude rates also varies from one region to another, from a minimum of 1.38 for the region of Montréal-Centre to a maximum at 3.57 for the Outaouais region.

FIGURE 3 Observed and expected rates of screening mammography up to 12 months after the invitational letter


From the Cox model, ratios of observed to expected rates of screening mammography within the twelve months following the mailing of personalized invitational letters, with and without adjustment for age and region, were respectively 1.78 (CI 95\%: 1.76-1.80) and 2.10 (CI 95\%: 2.07-2.12).

The observed cumulative probability of screening mammography reached 30.2 percent twelve months after the invitational letters were sent. The expected probability of mammography without letters was estimated at 20.3 percent (Figure 4). The ratio of the observed to the expected cumulative probability was 1.49 (Table 2). The ratios of observed to expected cumulative probability by age group varied from 1.40 to 1.75 , with the maximum being observed among women aged 65-69. The ratios also varied from one region to another, with a minimum of 1.30 for the Laurentides region and a maximum of 3.03 for the Outaouais region.

The odds ratio is often used to measure associations. In this analysis, the observed cumulative odds of screening mammography was 0.433 (0.302/0.698) after the mailing, compared to an expected cumulative odds of 0.255 (0.203/0.797); this results in an odds ratio of 1.70.

Due to the great number of women studied, all comparisons made between cumulative probabilities and those made between
observed and expected ratios of rates within age groups and regions were statistically significant ( $p<0.05$ ).

## Discussion

Most of the randomised trials and two metaanalyses had showed that personalized invitational letters increased participation in screening mammography. ${ }^{3-14}$ In the present study of a population-based breast cancer screening program, the mailing of personalized invitational letters signed by a regional program physician was associated with an increase in participation as great as the one observed in the randomised trials. For example, in our study, the crude ratio of observed to expected cumulative odds of screening mammograms at twelve months following the mailing of the letters was 1.70 , which is comparable to the odds ratio of 1.66 (CI $95 \%$ : 1.43-1.92) obtained in the Cochrane metaanalysis of Bonfill et al. ${ }^{3}$

The baseline rate of mammography seen in this population of women before the mailing of letters was used as the expected rate. This monthly expected rate of 2.04 per 100 women calculated for the purposes of this analysis also corresponds to the estimated rate of screening mammograms used by the medical services registry of the Régie de l'Assurance Maladie du Québec (RAMQ) before the implementation of the PQDCS. ${ }^{15}$

TABLE 2
Ratio of observed to expected cumulative probability of screening mammography, 12 months after mailing of invitational letters, by region and age group

| Age group/Region | Cumulative probability of mammography at twelve months (\%) |  | Ratio of cumulative percentages |
| :---: | :---: | :---: | :---: |
|  | Observed (0) | Expected (E) | (0/E) |
| Total | 30.2 | 20.3 | 1.49 |
| Age group (years) |  |  |  |
| 50-54 | 33.1 | 21.4 | 1.55 |
| 55-59 | 30.3 | 21.7 | 1.40 |
| 60-64 | 30.7 | 18.9 | 1.62 |
| 65-69 | 26.9 | 15.4 | 1.75 |
| Region* |  |  |  |
| 03 Québec | 35.2 | 21.9 | 1.61 |
| 04 Mauricie et Centre-du-Québec | 34.5 | 21.0 | 1.64 |
| 05 Estrie | 43.7 | 23.8 | 1.84 |
| 06 Montréal-Centre | 22.9 | 17.3 | 1.32 |
| 07 Outaouais | 33.9 | 11.2 | 3.03 |
| 08 Abitibi-Témiscamingue | 39.2 | 23.5 | 1.67 |
| 12 Chaudière-Appalaches | 41.4 | 25.7 | 1.61 |
| 13 Laval | 29.2 | 21.7 | 1.35 |
| 14 Lanaudière | 33.4 | 23.9 | 1.40 |
| 15 Laurentides | 23.1 | 17.8 | 1.30 |
| 16 Montérégie | 32.7 | 21.5 | 1.52 |

* Included regions are those where the PQDCS was implemented before June $30^{\text {th }}, 1999$.

The increase in observed screening mammogram rates was seen to extend for a period of at least 10 months. However, this increase appeared to be greatest shortly after the mailing, showing peaks in the second and fourth months. The first peak may be related primarily to the mailing of the initial invitational letter, while the second peak may be at least partly related to the mailing of the reminder letter, which was often sent two months after the initial one.

The increase in rates of screening mammography subsequent to the invitational letters varied with age and region of residence. In the present study, the largest increase in mammography rates was found in women aged 65-69. In the study of Turnbull et al, ${ }^{7}$ older women responded with a higher frequency than younger ones to the invitational letter, while in a study by Irwig et al., ${ }^{6}$ response
rates of older women were similar to those of younger ones.

The strength of the letters' effect may be explained to some extent by slight differences in women's age distributions between regions. However, factors other than age can modify the effect of letters. Wording and format of letters are known to affect response; ${ }^{16}$ in this study, wording of the letters varied from one region to another. Promotion of the then-new program also varied somewhat between regions. As well, physicians can have a substantial influence on the likelihood of a woman having a screening mammogram; ${ }^{15}$ regional variation of physicians' support for the PQDCS may also partly explain regional response rate differences.

Any interpretations of our results should take into consideration the strengths and limitations of our method. One of its advantages is the exhaustiveness of information obtained on the mailing of initial invitational letters since all women eligible for a screening mammogram in Quebec are included in our cohort and no invitational letters were sent outside the provincial screening program. Information on screening mammograms also was largely complete.

Secondly, the accreditation of the examination facility is a PQDCS program requirement and our data include all instances of screening undergone at accredited mammography screening centres. It is likely, however, that

## FIGURE 4

Observed and expected cumulative percentages of women having a screening mammogram up to 12 months after the invitational letter

some women had screening mammography as diagnostic mammograms in non-accredited centres and these examinations would not have been captured in our analysis. However, this effect could have been neutralized by regional co-intervention effects. For example, as they were being implemented, some regional programs incorporated strategies to encourage participation, such as promotional campaigns targeting women and/or family physicians. Thus, these two influences (co-intervention and diagnostic examinations at non-accredited centres) would affect both the baseline and observed rates and, therefore, should have little combined effect on observed associations. Thirdly, overestimation of baseline rates and underestimation of the effect of the letters could be a possibility if some women had been informed of the invitational letters by their friends before actually receiving one of their own. This knowledge may have encouraged some women to have a screening mammogram before their letter was sent.

It should be noted that our results were obtained as the Quebec screening program was first being implemented, when the goal was to increase the number of first mammograms among women who had never participated in a screening program. Since the program has now been in place for several years, the effect of invitational letters on participation, not only for first but also for subsequent screening mammograms, may differ to some extent from that observed in this analysis. Lastly, since all rates of screening mammograms (baseline and observed) were estimated in the same population, any concern about confounding is reduced.

In conclusion, the use of personalized invitational letters signed by a physician increases participation in population-based mammography screening programs. Compared to expected screening rates, observed rates were substantially increased ( $p<.05$ ). The observed effect of invitational letters on screening in the Quebec Breast Cancer Screening Program is as great as that observed in randomised controlled trials. Further research is needed to identify the most effective mix of strategies which will be able to achieve the highest participation rates in population mammography screening and ensure reduced prevalence of breast cancer.

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# An observational study of sun and heat protection during Canada Day outdoor celebrations, 2003 

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#### Abstract

Attendance at summer outdoor mass gatherings may lead to heat- and sun-related illness. The purposes of this study were (1) to estimate the proportion of people in attendance at the 2003 Canada Day celebrations in the National Capital Region who used sun and heat protective items; (2) to identify factors associated with the utilization of these protective items; and (3) to provide research data to public outdoor event organizers when developing evidence-based plans for safer events. A naturalistic observational cross-sectional method was used to gather information at the 2003 Canada Day celebrations in the National Capital Region on attendees' demographics, the sun and heat protective items they used and the protective resources available at the event sites. Of the 398 observed attendees, the proportion using any one of the protective items ranged from 3 percent (an open umbrella) to 51.5 percent (sunglasses). Females were more likely to use protective items more than males, and adults more likely than children. Planners of public outdoor events should consider the factors that influence the utilization of sun and heat protective behaviours and the environmental modifications that would allow participants to make safe choices.


Key words: cross-sectional studies, heat exhaustion, heat stroke, mass gatherings, outdoor events, sunburn, sunstroke

## Introduction

Outdoor mass gatherings in hot weather can lead to large numbers of cases of heat- and sun-related illnesses. For example, heat alerts were issued during the World Youth Day celebrations held in Toronto, Canada from July 23-28, 2002, and the major diagnoses of pilgrims treated at the on-site medical tents were minor injuries related to the considerable distances walked and heat-related illness. ${ }^{1}$ In addition, an increased number of hospital emergency department visits for temperature-related illness was recorded
during the celebrations. ${ }^{1}$ Similarly, at the 1996 Summer Olympic Games in Atlanta, USA, heat-related illnesses were the most common preventable health problem experienced by the spectators and staff treated by physicians at venue medical-assistance sites (12.8 percent of visits). These illnesses also comprised 2 percent of hospital emergency department visits. ${ }^{2}$

In the short term, extended exposure to the heat and sun places people at risk for dehydration, heat cramps, heat exhaustion, heat rash, heat stroke and sunburn. ${ }^{3,4}$ In the long
term, heat illness is associated with cardiovascular disease, renal failure, neurologic coma and death. ${ }^{3,5,6}$ Sun exposure is associated with cataracts, premature aging, changes to skin texture and cancers of the skin, eye and lip. ${ }^{6-10}$

Sun-related illnesses can be prevented by sunscreen with an SPF of 15 or greater; tightly woven dark coloured clothing covering the extremities; hats with wide brims; eyeglasses that block UVA and UVB light; and sun avoidance between 10:00 a.m. and 4:00 p.m. ${ }^{11}$ Heat-related illness is prevented by limiting outdoor activities and staying out of direct sunlight and crowded areas during times of maximal heat; drinking nonalcoholic and non-diuretic fluids; avoiding very cold drinks; cooling the body with water; resting often in shady areas; wearing wide-brimmed hats; using sunscreen that protects against UVA and UVB rays; and wearing lightweight, light-coloured, loosefitting, absorbent clothing. ${ }^{12}$

The Canada Day celebration in the National Capital Region (Ottawa, Ontario and Gatineau, Quebec) is an outdoor mass gathering that occurs annually on July 1 , often a very hot and humid time of year in that region. Approximately 300,000 people attend. The official activities are held in four parks: Parliament Hill (PH), Jacques-Cartier (JC), Confederation (CP) and Major's Hill (MH). Organized events begin at 9:15 a.m. and continue until approximately 11:00 p.m.

[^3]Activities include a parade, musical performances, buskers, games, workshops and a fireworks display. ${ }^{13}$

The purposes of this study were the following:

1. to estimate the proportion of people in attendance at the 2003 Canada Day celebrations in the National Capital Region who used sun and heat protective items;
2. to identify factors associated with the utilization of these protective items; and
3. to provide research data to public outdoor event organizers when developing evidence-based plans for safer events.

## Method

A naturalistic, observational, cross-sectional study was conducted during the 2003 Canada Day celebration in the National Capital Region. The target population was the attendees at the four official sites.

A data collection tool was developed to gather demographic information about the attendees and the sun and heat protection items used by them, such as hats, sunglasses and fluids. Due to the large crowds and limited number of investigators, it was deemed impossible to observe a representative sample of Canada Day participants by circulating through the four official sites. Therefore, information was collected as people entered or exited the sites and was limited to observable characteristics of this mobile population.

To calculate the most conservative sample size necessary, the proportion of the population using each protective item was estimated to be 50 percent. To achieve a 95 percent confidence level, a sample size of 384 was calculated. The number of individuals sampled at each site was proportional to the attendance at that site during the 2001 Canada Day celebrations. ${ }^{14}$

Observation occurred between 1:00 p.m. and 3:00 p.m. at randomly selected entrance gates to all four official sites. Individuals were systematically sampled at site entrances and exits based on time intervals - every 1.5 to 2.0

TABLE 1
Frequency distribution of site, sex and age group ( $\mathrm{N}=398$ )

|  | N | Percentage |
| :--- | ---: | :---: |
| Site |  |  |
| Parliament Hill (PH) | 207 | 52.0 |
| Jacques-Cartier (JC) | 60 | 15.1 |
| Confederation (CP) | 61 | 15.3 |
| Major's Hill (MH) | 70 | 17.6 |
| Sex |  |  |
| Male | 195 | 49.0 |
| Female | 190 | 47.7 |
| $\quad$ Unknown | 13 | 3.3 |
| Age group |  |  |
| $\quad$ Child | 47 | 11.8 |
| Youth | 63 | 15.8 |
| Adult | 286 | 71.9 |
| Unknown | 2 | 0.5 |

minutes (depending on the sample size required at each site). At the appropriate time, the person closest to a pre-determined marker was selected. No interaction was solicited with the individuals being observed.

As this was an observational study, best guess estimates were used to record the gender, age group and ethnicity of Canada Day attendees. The three age-group categories used were children ( $<12$ years), youth (12-18 years) and adults (> 19 years).

A site analysis was conducted at each of the four parks to determine whether resources such as water, first aid and cooling stations, and sunscreen were available. The day's weather information was collected at Ottawa's international airport weather station, located on average 13 kilometres from the sites. ${ }^{15}$

Protective items were combined into three composite variables: 1) the total number of protective items used by each subject; 2) the amount of clothing coverage; 3) whether the subject wore both a head covering with a brim (or carried an open umbrella) and sunglasses. The second composite variable, clothing coverage, was defined and categorized as follows: full coverage - legs covered
to below the knees and a long-sleeved top; partial coverage - legs covered to below the knees and a short-sleeved top, tank top, bikini top or no top - or legs covered to above the knees and a long-sleeved top; minimal coverage - legs covered to above the knees and a short-sleeved top, tank top, bikini top or no top. The third composite variable (hat with a brim and sunglasses) was created by combining items that have been consistently recommended by recognized public health authorities as sun and heat protection factors. ${ }^{11,12}$

The data were entered into an EpiData 2.1b database. Univariate and bivariate analyses were conducted using EpiInfo 6.04d. Odds ratios, 95 percent confidence intervals and $\chi^{2}$ were calculated. Statistical significance was set at 0.05 .

## Environmental conditions

On July 1, 2003, between 1:00 p.m. and 3:00 p.m., the skies over Ottawa and Gatineau were mainly clear. Temperatures ranged between 26.8 and 27.7 degrees Celsius, relative humidity was between 40 and 41 percent, and there was a UV index of 4.0 (moderate). ${ }^{15}$ All four sites had first-aid stations and

TABLE 2
Frequency distribution of use of protective items ( $\mathrm{N}=398$ )

|  | N | Percentage |
| :---: | :---: | :---: |
| Head cover |  |  |
| Yes | 179 | 45.0 |
| No | 216 | 54.3 |
| Unknown | 3 | 0.8 |
| Hat brim |  |  |
| Yes (in front) | 158 | 39.7 |
| No | 210 | 52.8 |
| Unknown | 30 | 7.5 |
| Sunglasses |  |  |
| Yes | 204 | 51.3 |
| No | 186 | 46.7 |
| Unknown | 8 | 2.0 |
| Upper-body covering |  |  |
| Long sleeves | 23 | 5.8 |
| Short or no sleeves | 374 | 94.0 |
| Unknown | 5 | 1.3 |
| Lower-body covering |  |  |
| Above the knee | 271 | 68.1 |
| Below the knee | 126 | 31.7 |
| Unknown | 1 | 0.3 |
| Open umbrella |  |  |
| Yes | 12 | 3.0 |
| No | 383 | 96.2 |
| Unknown | 3 | 0.8 |
| Liquids |  |  |
| Yes | 82 | 20.6 |
| Water | 69 | 17.3 |
| Other* | 12 | 3.0 |
| No | 308 | 77.4 |
| Unknown | 8 | 2.0 |

* Includes juice, carbonated and other liquids. There were no observations of sports drinks, milk, coffee, tea or alcohol.
water for purchase. The visual estimates of shade coverage were 25 to 50 percent at one site (CP) and less than 25 percent at the other three sites. Shade was not easily accessible at MH and PH. Two of the sites (JC, MH) had sprinklers as cooling stations. Water was available at no cost at two sites ( $\mathrm{PH}, \mathrm{MH}$ ). Samples of sunscreen were being handed
out at one site (PH), and bottles of sunscreen were visible at the first-aid station of another site (MH).


## Results

More than 350,000 people attended the 2003 Canada Day celebrations. ${ }^{16}$ Observations were made of 398 individuals (207 at PH, 60 at JC,

61 at CP , and 70 at MH ) between 1:00 p.m. and 3:00 p.m. Demographic information is summarized in Table 1. The majority of individuals sampled appeared to be of European Caucasian origin.

The proportions using sun/heat protective items are given in Table 2. Head coverings were worn by 45.0 percent of individuals and sunglasses by 51.3 percent. The majority of people wore tops with short or no sleeves ( 93.0 percent) and leg coverings that ended above the knee ( 68.1 percent). Only 20.6 percent of people were observed carrying liquids. Of those carrying liquids, 84.1 percent had bottled water.

Although only 4.3 percent of attendees wore full coverage (Table 3), significantly more females did so (7.4 percent) than males (1.5 percent) ( $p=0.002$; Table 4). Clothing coverage varied significantly by age group ( $p=0.045$ ), with a trend for adults ( 5.3 percent) being more likely to have full clothing coverage than children ( 0.0 percent). When stratified by age group, the relationship between coverage and sex remained significant in adults ( $p=0.004$ ), with higher proportions of adult females than adult males having partial or full coverage. Among youth, the relationship between coverage and sex was not significant; however there was a statistically insignificant trend for more females than males to wear full coverage.

There was a positive association between the estimated age group and the number of protective items used (Table 5). More adults than children used 4 to 6 protective items ( 14.3 vs. 8.5 percent). There was a statistically insignificant trend for females to have more protective items than males.

Of the people observed, 20.9 percent were wearing both a hat with a brim (or carrying an open umbrella) and sunglasses (Table 3). Age group was positively associated with use of both these items in combination ( $p=0.004$; Table 6). However, children were significantly more likely to wear head coverings than adults ( $p<0.001$ ), while adults were significantly more likely to wear sunglasses than children ( $p<0.001$ ).

TABLE 3
Frequency distribution of composite variables ( $\mathbf{N}=\mathbf{3 9 8}$ )

|  | N | Percentage |
| :--- | ---: | :---: |
| Total number of protective items used |  |  |
| 0 | 47 | 11.8 |
| 1 | 105 | 26.4 |
| 2 | 119 | 29.9 |
| 3 | 79 | 19.8 |
| 4 | 37 | 9.3 |
| 5 | 10 | 2.5 |
| 6 | 1 | 0.3 |
| Clothing coverage |  |  |
| Minimum | 265 | 66.6 |
| Partial | 114 | 28.6 |
| Full | 17 | 4.3 |
| Unknown | 2 | 0.5 |
| Hat with brim or umbrella and sunglasses |  |  |
| Yes | 83 | 20.9 |
| No | 315 | 79.1 |

There was no significant difference in the use of a hat with a brim (or umbrella) plus sunglasses by sex. However, males (50.3 percent) were significantly more likely than females ( 38.6 percent) to wear head coverings ( $p=0.022$ ). More females ( 57.8 percent) than males ( 48.7 percent) wore sunglasses, but this was not statistically significant.

When stratified by age, male youth were significantly more likely to wear head coverings than female youth ( $p=0.009$ ).

## Discussion

Although the weather was warm, there was a moderate UV index and shade was difficult to access. The use of protective items by people attending the Canada Day celebration was low. None of the items were used by more than 50 percent of the attendees, except for sunglasses.

A significant advantage of this study was its observational design. By their nature, sun and heat protective items (with the exception of sunscreen) should be visible in order to be effective; it is easy to observe whether clothing, hats and sunglasses are being worn.

Observational studies (where participants are not conscious of observation) are the best measure of actual behaviour. Studies involving interaction with the participants run the risk of social desirability bias, as the need for approval is associated with increased frequency of reported protective health behaviours. ${ }^{18}$ This study's design allowed us to collect data rapidly, conveniently and without influencing the subjects.

The findings from two of our composite variables - the number of protective items and the amount of clothing coverage - were very
similar. Both found that very few people utilized protective items and that adults and females were generally more likely to be protected than children and males.

The tendency for older people to take more sun safety precautions than younger people was also found by Purdue in a Canadian telephone survey ${ }^{19}$ and by the American Academy of Dermatology (AAD) in a survey of Americans. ${ }^{20}$ However, the AAD also found that adults reported taking precautions for the children in their care. It is when children get older and begin to assert their independence that they report spending more time in the sun and using sunscreen less often. ${ }^{20}$ This finding is corroborated by a European study in which parents reported that children in the sixth year of life had increased exposure to the sun and decreased use of protective clothing when compared to children in the first year of life. ${ }^{21}$ The results of these studies most likely overestimate sun protection due to social desirability bias inherent in self-report. However, these studies still demonstrate trends for adults, infants and toddlers to report more precautions than do children and youth. This is disconcerting since childhood sunburn places people at the highest risk for skin cancer. ${ }^{11,22}$

In our study, the composite variable based on observable recommended items (wearing a head covering with a brim and sunglasses) showed that age group was positively associated with wearing both of these items in combination. Interestingly, the age trends for hat use and sunglass use were opposed, as were the trends between males and females. Children and males were more likely to wear

TABLE 4
Interaction of clothing coverage with sex and age group ( $\mathbf{N}=398$ )

|  | Minimum |  | Partial |  |  | Full |
| :--- | ---: | :--- | ---: | :--- | ---: | :--- |
|  | $\mathbf{N}$ | Percentage | $\mathbf{N}$ | Percentage | $\mathbf{N}$ | Percentage |
| Sex $\boldsymbol{p}=\mathbf{0 . 0 0 2}$ |  |  |  |  |  |  |
| Male | 143 | 73.3 | 49 | 25.1 | 3 | 1.5 |
| Female | 111 | 59.0 | 63 | 33.5 | 14 | 7.4 |
| Age group $\boldsymbol{p}=\mathbf{0 . 0 4 5}$ |  |  |  |  |  |  |
| $\quad$ Child | 39 | 84.8 | 7 | 15.2 | 0 | 0.0 |
| Youth | 38 | 60.3 | 23 | 36.5 | 2 | 3.2 |
| Adult | 187 | 65.6 | 83 | 29.1 | 15 | 5.3 |

TABLE 5
Interaction of number of protective items with age group ( $\mathrm{N}=398$ )

|  | Number of protective items |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | 0 |  | 1-3 |  | 4-6 |  |
|  | N | Percentage | N | Percentage | N | Percentage |
| Age group ( $p=0.047$ ) |  |  |  |  |  |  |
| Child | 9 | 19.1 | 34 | 72.3 | 4 | 8.5 |
| Youth | 6 | 9.5 | 55 | 87.3 | 2 | 3.2 |
| Adult | 32 | 11.2 | 213 | 74.5 | 41 | 14.3 |

hats, while adults and females were more likely to wear sunglasses. Therefore, combining these two variables did not provide a relevant measure. The clothing coverage and number of protective items composites had similar findings, validating the results from these new composite measures. If looking for a composite measure of observable sun and heat protective items, we would recommend that future studies consider using the number of protective items variable, as it is more inclusive than the clothing coverage variable.

The observational study design has inherent limitations. Firstly, the rapid implementation of the study made it impossible to pilot test the survey tool. Secondly, we were unable to validate ethnicity, to ascertain the use of certain unobservable protective items (e.g. sunscreen) and it was impossible to verify whether bags or coolers contained protective items. Thus, we judge this study's estimates to be conservative; the overall frequency of protective items used may have been higher than recorded results. As well, though individuals were meant to be sampled systematically, selection consistency could sometimes be problematic. It was also difficult to conduct the site evaluations in the large crowds: By collecting the data over two hours, sampling at the four official sites and observing mobile populations, we may have missed certain types of people, protective items or protective resources. Also, categorization of items can be challenging: Items that offer protection from the sun but are risky in the heat were difficult to categorize. For example, wearing tightly woven dark clothing that covers the torso and legs offers sun protection, yet dark and heavy clothing could also lead to heat-related illness.

Our findings could be generalized to phenomena occurring at mass-gathering events elsewhere in Canada attended by all age groups due to the range of demographics of the subjects observed at this Canada Day celebrations' four sites.

In order to be successful, primary prevention initiatives for sun- and heat-related illness need to address priorities of event organisers, the attitudes of the attendees, the availability and cost of sun protection, and fashion trends. ${ }^{23}$ Public health campaigns for outdoor events should focus on improving the adoption of protective behaviours in males and younger individuals. For example, parents could be educated on the importance of sunglasses, even for young children. In addition, event organizers could make environmental changes that would allow individuals to make
healthier choices on site. Such changes include the provision of more shaded areas (e.g., tents and canopies), the distribution of free sunscreen samples by sunscreen companies, providing free water and the presence of vendors of hats and sunglasses. One approach would be to sell novelty items that double as protective items (e.g. festive umbrella hats and sunglasses with maple leaf frames) that would make protective behaviour fun and part of the event. These recommendations are in agreement with those made in the United States following the 1996 Atlanta Summer Olympics. ${ }^{2}$

## Conclusion

Overall, uptake of sun and heat protective behaviours by people attending the 2003 Canada Day celebration in the National Capital Region was quite poor. Females and adults were more likely to be protected than males and children. The current study provides useful data that can be the basis for health promotion campaigns to reduce sun and heat related illness at outdoor mass gatherings. Further and more detailed studies may help improve the planning of large outdoor gatherings, making them safe and healthy events.

TABLE 6
Recommended protective items by age group ( $\mathrm{N}=398$ )

|  | Child |  | Youth |  | Adult |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | N | Percentage | N | Percentage | N | Percentage |
| Hat with brim (or open umbrella) and sunglasses $(\boldsymbol{p}=\mathbf{0 . 0 0 4}$ ) |  |  |  |  |  |  |
| Yes | 2 | 4.3 | 10 | 15.9 | 70 | 24.5 |
| No | 45 | 95.7 | 53 | 84.1 | 216 | 75.5 |
| Wearing head cover$(p<0.001)$ |  |  |  |  |  |  |
| Yes | 33 | 71.7 | 20 | 47.6 | 114 | 40.1 |
| No | 13 | 28.3 | 33 | 52.4 | 170 | 59.9 |
| Wearing sunglasses$(p<0.001)$ |  |  |  |  |  |  |
| Yes | 2 | 4.3 | 20 | 33.3 | 181 | 64.4 |
| No | 45 | 95.8 | 40 | 66.7 | 100 | 35.6 |

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# Validity of a 12-item version of the CES-D used in the National Longitudinal Study of Children and Youth 

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#### Abstract

This validation study assessed the degree of confidence that can be placed on inferences from depressive symptoms among adolescents, based on a 12-item version of the Centre for Epidemiological Studies Depression scale (CES-D). This short version of the scale had been developed for application in the National Longitudinal Study of Children and Youth and we refer to it as the CES-D-12-NLSCY. The major data source for the present validation study was a 2002/2003 survey of 12,990 students in junior and senior high school in the Atlantic provinces of Canada. Receiver operating characteristic curve analyses for two different proxy gold standards yielded adequate areas under the curve (AUCs) of .84 and .80 , allowing us to establish cut points for three categories of depressive symptoms in the general adolescent population: Minimal (CES-D-12-NLSCY total score 0 to 11), Somewhat Elevated (total score 12 to 20) and Very Elevated (total score 21 to 36). The CES-D-12-NLSCY was found to have acceptable internal consistency (Cronbach's alpha .85). All but one of the 12 items of the CES-D-12-NLSCY were found to have acceptable discrimination ability. The prevalence of Minimal, Somewhat and Very Elevated depressive symptoms in the adolescent student population of the Atlantic provinces was estimated to be $72.3,19.5$ and 5.5 percent, respectively. A further 2.6 percent of students who responded to fewer than 11 items of the scale were classified as Indeterminate with regards to depressive symptom category. The major threat to the accuracy of the CES-D-12-NLSCY is its lack of inquiry about irritability, which is a key symptom of depression in youth.


Key words: adolescent, depression, depression scale, measurement, reliability, validity

## Introduction

The Centre for Epidemiological Studies Depression Scale (CES-D) is one of the most commonly used measures of depressive disorders in general population studies. ${ }^{1}$ This 20-item scale was designed specifically for such studies and focusses primarily on the affective component of depression. ${ }^{2-5}$ It was meant to capture elevated depressive symptoms common to more than one diagnostic category and found in persons without a clinical diagnosis. ${ }^{1}$ It was not intended to provide a clinical diagnosis of depression; rather, the CES-D score is thought to inform on the risk of clinical depression. ${ }^{6}$ Clinical populations have been shown to score
significantly higher on the scale than do community populations ${ }^{1,7}$ and CES-D scores have been shown to be correlated with other measures of depression. ${ }^{8,9}$ Despite the wide application of this scale, the ideal cut point score for the identification of adolescent populations at risk for depression has not been established. The adult cut point score of 16 has been applied to adolescents and has yielded prevalence estimates ranging from 24 percent to more than 50 percent, ${ }^{2-5}$ suggesting a high number of false positive cases. Cut point scores between 20 to 24 have yielded prevalence estimates ranging from 9 to 31 percent. ${ }^{2,3,5}$ In comparison, prevalence estimates of depression among adolescents using the Beck Depression

Inventory have ranged from 22 to 28 percent using adult cut points, and 3 to 4 percent using adolescent-specific cut points. ${ }^{2,9,10}$

The length of the CES-D may be a limitation for the application of this scale in large multidomain population health surveys such as Canada's National Longitudinal Study of Children and Youth (NLSCY). ${ }^{11}$ In fact, the CES-D scale was reduced from 20 to 12 items specifically for the 1996 cycle of the NLSCY. We refer to the short version as the CES-D12 -NLSCY. The reduction was based on data from the Ontario Child Health Study (OCHS), an epidemiological survey on childhood psychiatric disorders in the community. ${ }^{12,13}$ The reduction was accomplished using CES-D item responses in a sample of 1,600 adults who were the primary caregivers of children randomly selected to participate in the OCHS. ${ }^{12,13}$ The 12 items were selected to approximate the four factors of Radloff's ${ }^{1}$ original factor analysis of the full scale. ${ }^{14}$ Further validation procedures of the CES-D-12-NLSCY were not performed at the time the short version was devised nor was the cut point score determined for elevated depressive symptoms in adolescents.

We incorporated the CES-D-12-NLSCY into the 2002/2003 Student Drug Use Survey in the Atlantic Provinces (SDUSAP) in order to examine the association between substance use and depression risk among adolescents. ${ }^{15}$ The present validation study seeks to determine the degree of confidence that can be placed on inferences about depression risk among adolescent students based on their scores on the CES-D-12-NLSCY, capitalizing on data from the 12,990 students who participated in the 2002/2003 SDUSAP.

[^4]
## Methods

## Participants

The present study is based on two sources of data. The primary source of data was the 2002/2003 SDUSAP, an anonymous, standardized and cross-sectional survey of adolescent students in the provinces of Nova Scotia (NS), ${ }^{16}$ New Brunswick (NB), ${ }^{17}$ Prince Edward Island (PE) ${ }^{18}$ and Newfoundland and Labrador (NL) [report not yet released]. The survey was standardized in $1994^{19}$ and implemented in 1996, 1998 and 2002-2003. The sample design of the SDUSAP is a single-stage cluster sample of randomly selected classes stratified by grade (grades 7, 9,10 and 12) and health region or school district. In NS, NB and PE, a total of 10,451 students participated in the 2002 survey, and a total of 2,539 students participated in the survey in 2003 in NL. About 97 percent of students present on the day of the survey participated in the study. The primary source of data for the present study was therefore a sample of 12,990 students in grades $7,9,10$ and 12 in the four Atlantic provinces of Canada. The average age of participants was 14.9 years and 50 percent of respondents were male. The present study is based primarily on the 12,110 students who responded to all 12 items in the CES-D-12NLSCY and who also responded to a question about help obtained for depression.

The second source of data used in the present study was a database of the OCHS noted above. ${ }^{12,13}$ The database was generously provided to us by Michael Boyle, the principal investigator of the OCHS. The methods for the OCHS are described in detail elsewhere. ${ }^{12,13}$ Our interest in these data was solely to establish the internal consistency of the full CES-D and the CES-D-12-NLSCY in the same sample.

## Instrument

The 2002/2003 SDUSAP employed a selfreported questionnaire comprising 100 items requesting information on demographics, social environment, substance use and related problems, gambling, school rules and obtaining help for substance use or depression. The 2002 survey also included, for the first time, a scale on depression risk. The

TABLE 1

## Content analysis of items from the CES-D and CES-D-12-NLSCY matched to DSM-IV symptoms for major depressive disorder

| CES-D | CES-D-12-NLSCY | DSM-IV symptom |
| :---: | :---: | :---: |
| I had crying spells. | I had crying spells. | Depressed mood |
| I felt depressed. | I felt depressed. | Depressed mood |
| I felt sad. | - | Depressed mood |
| I was happy. | I was happy. ${ }^{\text {a }}$ | Depressed mood |
| I felt that I could not shake off the blues even with help from my family or friends. | I felt that I could not shake off the blues even with help from my family or friends. | Depressed mood |
| I felt hopeful about the future. | I felt hopeful about the future. ${ }^{\text {a }}$ | Markedly diminished interest or pleasure |
| I enjoyed life. | I enjoyed life. ${ }^{\text {a }}$ | Markedly diminished interest or pleasure |
| I felt that I was just as good as other people. | - | Feelings of worthlessness or inappropriate guilt |
| I thought my life had been a failure. | - | Feelings of worthlessness or inappropriate guilt |
| I had trouble keeping my mind on what I was doing. | I had trouble keeping my mind on what I was doing. | Diminished concentration, or indecisiveness |
| I did not feel like eating; my appetite was poor. | I did not feel like eating; my appetite was poor. | Significant weight loss or weight gain |
| My sleep was restless. | My sleep was restless. | Sleep disturbance, either insomnia or hypersomnia |
| I felt that everything I did was an effort. | I felt like I was too tired to do things. ${ }^{\text {b }}$ | Fatigue or loss of energy |
| I could not get "going". | - | Fatigue or loss of energy |
| I felt fearful. | - | Anxiety item |
| I felt that people disliked me. | I felt that people disliked me. | Unrelated item |
| I felt lonely. | I felt lonely. | Unrelated item |
| People were unfriendly. | - | Unrelated item |
| I talked less than usual. | - | Unrelated item |
| I was bothered by things that usually don't bother me. | - | Unrelated item |

a These items are reverse-scored.
b For the item assessing low energy or fatigue, the CES-D-12-NLSCY used the wording from the child version of the CES-D ("I felt like I was too tired to do things" ${ }^{40}$ ) rather than the adult version of this item ("could not get going").
depression scale was the CES-D-12- NLSCY, with the four response options "never or rarely", "sometimes", "often" and "always" coded 0 to 3 respectively. The items in the CES-D and the CES-D-12-NLSCY are shown in Table 1. The time frame for the depression items was the seven days prior to the survey. The time frame for items on help sought or
obtained for substance use and for depression was the 12 months prior to the survey.

Since its inception, the SDUSAP has been available in English and French, with the French version being reviewed by bilingual and francophone professionals from the health and education fields in New Brunswick and

Nova Scotia. The French version of the SDUSAP incorporated the French version of the CES-D-12-NLSCY found in the NLSCY, with the exception of one item, which was minimally modified to ensure comprehension by younger students.

## Survey procedures

The SDUSAP questionnaires were administered to classes of students by university students in NS, staff of the regional addictions services office in NB and teachers from participating schools in PE and NL. Surveys were administered in the spring of 2002 or 2003. The person administering the survey read a prepared script of instructions to respondents, requesting of them to not indicate their name or other identifying information on either the questionnaire or their manila envelope. The methods to assess validity and reliability of the overall SDUSAP have been replicated at each implementation of the survey. ${ }^{20-22}$ Approval for the SDUSAP research was obtained from the Dalhousie University Health Sciences Research Ethics Board.

## Statistical analysis

The prevalence estimates, 95 percent confidence intervals (CIs) and comparisons across subgroups were calculated by taking into account the disproportionate stratified cluster sample design. The estimated prevalence of the categories of depression was based on the full sample of 12,990 . A total of 425 records having two or more missing responses to the CES-D-12-NLSCY scale were labeled "Indeterminate" as their depression category. Statistical significance was set at $p<0.05$. We used Stata $7.0^{23}$ for all statistical analyses.

## Construct validity

We examined the content validity of the CES-D-12-NLSCY by comparing the scale items to the diagnostic criteria for major depressive disorder in the Diagnostic and Statistical Manual of Mental Disorders, $4^{\text {th }}$ edition (DSM-IV). ${ }^{24}$ The DSM-IV criteria state that a diagnosis of major depressive disorder
requires the presence of five out of nine symptoms for a duration of at least two weeks. For adults, one of these symptoms must be either depressed mood or anhedonia; in children and adolescents, irritable mood. The remaining symptoms are significant weight loss or weight gain, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue, feelings of worthlessness or guilt, reduced concentration or increased indecisiveness and suicidal ideation/attempt or recurrent thoughts of death.

We performed a comparison of extreme groups using Kruskal-Wallis one-way analysis of variance to compare the CES-D-12NLSCY scores with the response to an item asking "In the past 12 months, have you used any services or received help because you felt depressed?", with answer options "Yes", "No" and "I did not feel depressed".

## Criterion validity

We performed receiver operating characteristic (ROC) curve analysis to determine cut point demarcating levels of depressive symptomatology. We used as a proxy gold standard of depression an item asking "In the past 12 months, have you used any services or received help because you felt depressed?", with answer options "Yes", "No" and "I have not felt depressed." We dichotomized these three answer options in two ways. First, we identified the cut point for the response "I have not felt depressed" versus the remaining two options. We reasoned that the response of not having felt depressed was analogous to Minimal depressive symptoms. Second, we identified the cut point for a "Yes" response (having used services or received help for depression) versus the remainder ("No" and "I have not felt depressed"). We reasoned that having received such help was analogous to Very Elevated depressive symptoms. Finally, we reasoned that the total scores between these two cut points constituted a category analogous to Somewhat Elevated depressive symptoms. Thus, our regrouping of the three answer options to the help-fordepression item resulted in the identification of two cut points demarcating three
categories of elevated depressive symptoms (Minimal, Somewhat Elevated and Very Elevated) from the CES-D-12-NSLCY total scores.

The CES-D-12-NLSCY is considered to be a screening tool to identify the risk of depression in the general adolescent population. From a public health perspective, it can be argued that a cut point for Very Elevated depressive symptoms should be chosen to maximize specificity in order to guard against an inflated estimate of the prevalence of clinical depression. We reasoned that under these circumstances a screening instrument applied to an undifferentiated population should ensure a high level of specificity ( 95 percent).

## Discrimination ability

We examined the ability of items in the CES-D-12-NLSCY to discriminate among the various categories of depressive symptoms by calculating the proportions of students classified into the three categories of depressive symptoms, within the group of students who responded "often" or "always" to a given item, for each of the 12 items.

## Internal consistency

We calculated Cronbach's alphas for the CES-D-12-NLSCY based on the SDUSAP data. We used the OCHS data to compare alphas of both the 20 - and 12 -item versions of the CES-D.

## Results

## Content validity

Table 1 shows how the CES-D and CES-D12 -NLSCY items correspond to each other and to the DSM-IV symptoms of major depressive disorder. The CES-D-12-NLSCY covers six of the nine possible symptoms of depression. The scale is most heavily loaded with affective symptoms of depression: Six items focus on depressed mood or anhedonia. Almost all the somatic symptoms are represented. The DSM-IV symptoms not included in the CES-D-12-NLSCY are
irritability, feelings of worthlessness/guilt, suicidal ideation and psychomotor retardation/agitation. The emphasis of the CES-D-12-NLSCY on depressed mood is consistent with the construct of depression as defined in the DSM-IV and captures depressive symptoms in an omnibus sense. The major limitation identified in the content of the CES-D-12-NLSCY is that no item captures irritability, which is a key symptom of depression in youth.

## Extreme groups

The SDUSAP included the following question: "In the past 12 months, have you used any services or received help because you felt depressed?" About 4.9 percent ( $\mathrm{CI}=4.4-5.3$ ) of students responded "Yes", 42.4 percent (CI $=41.3-43.5$ ) responded "No" and 52.8 percent $(\mathrm{CI}=51.6-53.9)$ responded "I have not felt depressed." The mean CES-D-12-NLSCY scores for these answer groups were 16.0 (SD $=7.4, \mathrm{CI}=15.4-16.6), 12.0(\mathrm{SD}=6.2, \mathrm{CI}=$ $11.8-12.1)$ and $5.5(\mathrm{SD}=3.5, \mathrm{CI}=5.5-5.6)$, respectively. The Kruskal-Wallis one-way analysis of variance by ranks revealed that the CES-D-12-NLSCY scores of these three groups were significantly different (average rank sums $9,519.5 ; 8,104.3$; and $41,776.0$, respectively), $\left[\chi^{2}(2, \mathrm{~N}=12,110)=4,186.1\right.$, $p<.001]$. The highest total scores on the CES-D-12-NLSCY were found among adolescents who reported having received help for depression.

## Criterion validity

## Receiver operating characteristic curves

Figure 1 shows the trade-off between sensitivity and specificity of all possible cut points in the CES-D-12-NLSCY total scores, based on the two proxy gold standards derived from the item on help obtained for depression. The ROC curve for the CES-D-12NLSCY total scores using the first proxy gold standard ("I have not felt depressed" versus the remainder) resulted in an AUC equal to 0.84 (CI =.83-.84). Our requirement of 95 percent specificity resulted in a cut point score of 12. CES-D-12-NLSCY total scores of 0 to 11 inclusive were then categorized as

TABLE 2

## Discrimination analysis, as percentages of students responding "often" or "always" to items in the CES-D-12-NLSCY

|  | Depressive symptoms category |  |
| :--- | :---: | :---: | :---: |

a These items have been reverse-scored.

Minimal depressive symptoms. The ROC curve for the CES-D-12-NLSCY total scores using the second proxy gold standard ("Yes" versus the remainder) yielded an AUC of .80 ( $\mathrm{CI}=.78-.82$ ). Our requirement of 95 percent specificity resulted in a cut point score of 21 for Very Elevated depressive symptoms. CES-D-12-NLSCY scores of 21 or greater were then categorized as having Very Elevated depressive symptoms. It should be noted that our decision rule limits to 5 percent the false labelling of students as having Very Elevated depressive symptoms, but does so at the expense of our identifying only about a quarter ( 26.6 percent sensitivity) of students who said they received help for depression as having Very Elevated depressive symptoms.

## Discrimination

Table 2 shows the proportions of students classified into the three categories of depressive symptoms, from among the students who responded "often" or "always" to a given item. For 11 of the 12 items, of the students endorsing "often" or "always", large proportions ( 60 to 92 percent) were classified as having Very Elevated depressive symptoms. Relatively smaller proportions (20 to 59 percent) were classified as having Somewhat Elevated depressive symptoms. Small proportions ( $<1$ to 12 percent) were classified as having Minimal depressive symptoms. Only one item ("I felt hopeful about the future") showed poor discrimination ability among the three categories of depressive symptoms. In particular, among the

FIGURE 1

## Receiver operating characteristic curves for the CES-D-12-NLSCY total scores using as a proxy gold standard "I have not felt depressed"


students who endorsed "often" or "always" to the item "I felt hopeful about the future," 78,70 and 44 percent were classified as having Very Elevated, Somewhat Elevated and Minimal depressive symptoms, respectively, representing a markedly different pattern than was observed for the remaining 11 items. Furthermore, for this item, students were about equally likely to endorse each of the four response options ("always" $=21$ percent , "often" $=28$ percent, "sometimes" $=29$ percent, "never/rarely" $=23$ percent). In contrast, for the remaining 11 items, the majority of students responded "never" or "sometimes" and a minority responded "often" or "always" .

## Internal consistency

Based on the SDUSAP data, the Cronbach's alpha for the CES-D-12-NLSCY was 0.85 . The alpha coefficients were 0.79 for males and 0.88 for females. Based on data from the OCHS, the Cronbach's alphas were 0.89 and 0.85 for the 20 - and 12 -item versions of the CES-D, respectively.

## Prevalence

The prevalence of Minimal, Somewhat Elevated and Very Elevated depressive symptoms in the adolescent student population of the Atlantic provinces of Canada was
estimated to be 72.3 percent $(\mathrm{CI}=71.3-73.3)$, 19.5 percent ( $\mathrm{CI}=18.7-20.3$ ) and 5.5 percent (CI $=5.0-6.0$ ) respectively. A further 2.6 percent of students who responded to fewer than 11 items were considered Indeterminate as to their depressive symptoms. The prevalence of Very and Somewhat Elevated depressive symptoms was significantly higher among females ( 8.6 and 24.7 percent, respectively)
than among males ( 2.6 and 14.5 percent, respectively, $p<.001$ ).

## Discussion

Our examination of the CES-D-12-NLSCY revealed that the scale has acceptable validity and reliability for our intended purposes. In particular, the purpose of the Student Drug Use Survey in the Atlantic Provinces is to allow the provinces to develop policy and programming on addictions-related health in the adolescent student population based on sound epidemiologic information. ${ }^{16}$ The priority was to ensure that the total count of adolescents meeting a definition of elevated depressive symptoms was approximately correct; mis-classification in such a survey is not as important as it would be in a classical screening program. The Cronbach alpha of the CES-D-12-NLSCY is consistent with those in the literature; these have ranged from 0.85 to 0.97 when the CES-D was administered to adolescents. ${ }^{7,9,25-27}$ The major threat to the accuracy of the CES-D-12NLSCY is that the scale does not inquire about irritability, which is a key symptom of depression in youth. This deficiency can be expected to result in a systematic underestimation of the prevalence of depression risk among adolescents. Future applications

FIGURE 2
Receiver operating characteristic curves for the CES-D-12-NLSCY total scores using as a proxy gold standard "Yes, I received help because I felt depressed"

of the CES-D-12-NLSCY should correct this shortcoming of the scale.

Our literature review led us to conclude that the most comparable study of depressive symptoms in the general adolescent population was from the National Longitudinal Study of Adolescent Health, ${ }^{3}$ where the 20-item CES-D was used to describe the prevalence of depressive symptoms among American adolescents. Despite the widescale application of the CES-D, the ideal cut point score for the identification of adolescent populations at risk for depression remains unknown. As in our study, Rushton and colleagues ${ }^{3}$ had to make a decision as to the most appropriate cutoff scores for the CES-D. Recognizing that the adult CES-D cutoff score of 16 leads to an overestimation of the prevalence of adolescent depression, the authors used a cutoff score of 24 , as recommended by Roberts et al. ${ }^{9}$ Rushton and colleagues ${ }^{3}$ then used the CES-D cutoff of 16 as the lower limit of an intermediate level of depressive symptoms. They estimated a prevalence of 9 percent for "moderate/ severe" depressive symptoms (CES-D scores 24 or greater), 29 percent for "mild" depressive symptoms (CES-D scores of 16 to 23 ), and 72 percent for "minimal" depressive symptoms (CES-D scores of 0 to 15). They found that the vast majority of adolescents initially in the "minimal" depressive symptoms continued to be in that category one year later. However, the one-year outcome of adolescents initially in the "mild" and "moderate/severe" depressive symptoms groups was largely unpredictable. Rushton and colleagues ${ }^{3}$ also found that one of the strongest factors predicting persistent "moderate/severe" depressive symptoms one year later was having received counseling services.

In our study, we determined the cutoff CES-D-12-NLSCY scores based on the criterion of having received help for depression. This criterion is in keeping with the Diagnostic Interview Schedule (DIS) ${ }^{28}$ which requires the meeting of an impairment criterion such as having sought help or taken medication for a diagnosis of major depressive disorder. Thus, our Very Elevated depressive symptoms category is characterized by clinically
significant symptoms. Our estimated point prevalence of 5.5 percent for Very Elevated depressive symptoms among adolescent students is consistent with the estimated prevalence of "moderate/severe" depressive symptoms in the study by Rushton and colleagues. ${ }^{3}$ Furthermore, in both the Rushton ${ }^{3}$ study and our study, the highest risk group is associated - either as an independent risk factor or as an intrinsic function of the definition - with the notion of having received help. It therefore appears that our Very Elevated category is comparable to the "moderate/severe" depressive symptoms category in the Rushton ${ }^{3}$ study.

Our data led us to identify an intermediate category of depressive symptoms, characterized by an adolescent denying he/she had received help for depression but also not rejecting the proposition that he/she had not felt depressed. The prevalence of Somewhat Elevated depressive symptoms overall was 19.5 percent and was particularly high among females (24.7 percent). This intermediate level of elevated depressive symptoms may be akin to a sub-clinical or sub-threshold depressive symptom complex and in many ways appears to be analogous to the group labeled as "mild" depressive symptoms by Rushton and colleagues. ${ }^{3}$ A re-analysis of the American data using the short Canadian version of the CES-D would provide a direct comparison relative to the prevalence and other key determinants of the various depression risk groups in the two populations.

The estimated prevalence of Very Elevated depressive symptoms found in the present study is consistent with findings from the Canadian Community Health Survey (CCHS), which employed a structured interview to identify major depressive disorder in youth. ${ }^{29}$ Based on the CCHS, the prevalence of major depressive disorder among Canadian youth 15 to 24 years of age was estimated to be 6.4 percent ( 8.3 percent for females and 4.5 percent for males). ${ }^{29}$ Our findings are consistent with other published point prevalence estimates of depression of 3 to 7 percent in the general adolescent population. ${ }^{27,30-32}$ Our finding of significantly higher rates of elevated depressive symptoms among females than
males is consistent with estimated annual prevalence rates of depression elsewhere. ${ }^{2,29,32,33}$

The present study fills an important gap in the measurement of depression in the general population in that adolescent-specific cut point scores were identified for a short version of the CES-D scale. We recognize that from a clinical perspective the accepted gold standard for depression is a diagnosis of major depressive disorder based on DSM-IV criteria. The most accurate method of assessing the criterion validity of the CES-D-12NLSCY would entail a two-stage procedure whereby a sample of adolescents would be screened with this tool and then the highscoring respondents as well as a random sample of the low-scoring respondents would be assessed with a structured diagnostic interview. Our single-item criterion of having obtained help for depression is an imperfect standard since adolescents with depression tend to not seek or obtain help for depression. ${ }^{34,35}$ However, we minimized the potential bias of our proxy gold standard by identifying cut points for three incrementally severe levels of depressive symptoms and by requiring a high degree of specificity for those categories.

Ultimately, the accuracy of an instrument to detect depression is most affected, not by the inherent properties of the test, but by the prevalence of the disorder. Fechner-Bates and colleagues ${ }^{6}$ illustrated the problem of mis-classification in the case of depression and the CES-D. Based on a prevalence of depression of 13.5 percent, a sensitivity of 79.5 percent and a specificity of 71.1 percent for the CES-D, the positive predictive value of the CES-D was only 27.9 percent. Given a prevalence of depression of 6 percent among Canadian youth, ${ }^{32}$ and based on a sensitivity of 27 percent and a specificity of 95 percent of our cut points for the CES-D-12-NLSCY, an adolescent with a total score of 21 or greater on the CES-D-12-NLSCY would have only a 26 percent chance of actually having depression.

Despite these measurement issues, the need for monitoring depression risk in the general adolescent population remains highly rele-
vant. Longitudinal studies have consistently shown that an elevated level of depressive symptoms is a strong independent predictor of developing a depressive disorder. ${ }^{36-38}$ Furthermore, an elevated level of symptoms, even without meeting the threshold for a diagnosis of major depressive disorder, is associated with significant psycho-social impairment. ${ }^{39}$ Therefore, in some real sense, adolescents whose scores do not meet the threshold of the very highest risk should not be considered "false positives" and should not be overlooked in population-level interventions. We conclude that the categories of Somewhat Elevated and Very Elevated depressive symptoms based on the CES-D-12-NLSCY can provide insights into, at the very least, the risk of depressive disorder and of psy-cho-social impairment in the general adolescent population.

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# An analysis of the effect of selection bias on the association of hormone replacement therapy and breast cancer risk 

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#### Abstract

A sensitivity analysis was conducted to determine the impact on measures of effect of a suspected differential participation response rate between hormone replacement therapy (HRT) users and nonusers, among controls recruited to a population-based case-control study of breast cancer. The age-specific prevalence of current HRT use among controls was compared to data from the 1996 Canadian National Population Health Survey (NPHS). Control women identified as current HRT users were randomly re-sampled to replicate the prevalence of HRT use reported by the NPHS. Unconditional logistic regression was conducted to estimate odds ratios (OR) and 95 percent confidence intervals (CI) for the use of HRT and breast cancer risk before and after re-sampling. Multivariate adjusted ORs for breast cancer and estrogen-only and estrogen-progestin formulations were 0.76 (0.53-1.10) and 0.94 (95\% CI: 0.64 - 1.38), respectively, using the original case-control controls and 0.99 ( $0.77-1.27$ ) and 1.57 ( $95 \% \mathrm{CI}$ : $1.02-2.40$ ), respectively, following re-sampling of the controls. This sensitivity analysis illustrates the extent to which differential participation rates between HRT users and nonusers may affect estimates of measures of effect.


Key words: breast cancer, bias, Canadian National Population Health Survey, hormone replacement therapy, methods

## Introduction

Results from the Women's Health Initiative $(\mathrm{WHI})^{1}$ randomized controlled trial ( RCT ) have confirmed that estrogen and progestin replacement therapy (EPRT) increases the risk of breast cancer incidence over the long term. ${ }^{1}$ After a mean follow-up of 5.2 years, EPRT users in the WHI trial had a 26 percent increase in the risk of breast cancer compared with the placebo control group (hazard ratio [1.26] and 95 percent confidence interval [1.00-1.59]). Similar results, albeit not statistically significant, were reported by the Heart and Estrogen/Progestin Replacement Study trials (HERS), ${ }^{2}$ a large secondary prevention randomized controlled trial of

EPRT and cardiovascular disease (relative hazard [1.27] and 95 percent confidence interval [0.84-1.94]). On the other hand, after an average of 6.8 years of estrogenalone replacement therapy (ERT), an increase in the risk of breast cancer was not observed among participants of the WHI (0.77 [CI: 0.59-1.01]). ${ }^{3}$

While the majority of results from observational studies have been consistent with those from RCTs and have reported an increase in breast cancer incidence with at least five years of EPRT use, ${ }^{4-10}$ null associations ${ }^{11-15}$ and even a borderline protective effect have been reported. ${ }^{14}$ A few studies have reported a null association between

ERT and breast cancer risk, ${ }^{5,9,16}$ but many have also reported an increase in risk. ${ }^{4,17-22}$ Hence, while it is within the realm of epidemiology to design observational studies that lead to results that are consistent with those of RCTs, some methodological aspects of observational studies warrant scrutiny.

During the past two decades, epidemiologists and investigators from diverse medical sub-specialties have been challenged by the complexity of designing observational studies that minimize the numerous biases that can potentially affect HRT research. ${ }^{23-27}$ Publication of the WHI trial results has renewed interest in debates with respect to the role of observational epidemiology in studying the health effects of pharmacological treatments and these discussions are leading to even more critical reexamination of the HRT evidence from observational research. ${ }^{28-31}$

Confounding of the association between HRT and health outcomes has always been suspected, particularly in studies where the observed effect has been protective. In general, HRT users have been associated with many lifestyle and health habits thought to be protective for chronic diseases. ${ }^{32-36}$ The association between HRT use and breast cancer, however, is complex and potentially confounded by the presence of characteristics and lifestyle habits that may increase or decrease the estimated risk of cancer. ${ }^{37}$ In a recent meta-regression analysis of observational studies, Garbe et al. ${ }^{31}$ identified various study design factors that could, if not accounted for, lead to an increase and

[^5]overestimation of the observed risk of breast cancer with ERT use (e.g. not accounting for the use of mammography, age at menopause and type of menopause). When information pertaining to these factors is measured, this type of confounding may be minimized during multivariate analysis. ${ }^{38}$ On the other hand, multivariate analyses cannot control for recruitment response rates that differ by exposure and disease status. ${ }^{39}$ When differential response rates are present, disease risk may be over- or underestimated.

We illustrate an example from a populationbased case-control study where differential response rates for HRT users and nonusers were suspected among control women and where external population data were used to conduct a sensitivity analysis in an attempt to quantify the impact on measures of effect. The association between HRT and breast cancer incidence is examined in analyses that first use the original case-control control group and then in analyses where the over response of HRT users among controls is adjusted to reflect the estimated prevalence of HRT use in the population.

## Methods

The methods for this case-control study have been described previously. ${ }^{40}$ Hence only the methods relevant to this analysis are presented here. Between 1995 and 1997, a pop-ulation-based case-control study was conducted in Alberta among 1,239 incident, histologically confirmed, in situ and primary cases of invasive breast cancer ( 78.3 percent of all eligible cases). Women less than 80 years of age were identified from the records of the Alberta Cancer Registry. One thousand two hundred and forty-one women ( 56.5 percent of those eligible), free of cancer diagnoses, excluding non-melanoma skin cancer, were identified through random digit dialing and frequency-matched to cases by age ( $\pm 5$ years) and urban/rural residence. Two and a half percent of controls contacted were ineligible because of language and a history of cancer. A woman was considered to be postmenopausal if she, i) had not had a hysterectomy and had reported her age at natural menopause; ii) had not had a hysterectomy and had not had a menstrual period during the year prior to the index date; or iii)
was 55 years of age and older on the index date (see below). A woman who had had a hysterectomy was considered to be postmenopausal if she, i) had reported an absence of periods for at least a year preceding the hysterectomy; ii) had had a bilateral oopherectomy; iii) was 55 years of age or older; or iv) if she had reported being postmenopausal. Women who had started HRT before meeting the above criteria were considered postmenopausal if they were 55 years of age or older; otherwise, they were classified as peri-menopausal. Following the exclusion of women classified as pre- and peri-menopausal women, 1,415 postmenopausal women remained (708 cases and 707 controls). We present results for the association between HRT use and breast cancer among postmenopausal women.

In-person cognitive interviews were conducted to obtain information pertaining to reproductive, medical and family history, personal history of breast disease, mammography history, use of HRT (formulation, dose, mode of delivery and duration), lifetime physical activity, ${ }^{41}$ dietary intake ${ }^{42}$ during the year prior to the index date (the date of breast cancer diagnosis for cases and a comparable date for the controls), anthropometric measurements, weight history, smoking history, alcohol consumption and demographic characteristics.

All sources of estrogens and progestins (oral, transdermal, injections and vaginal creams) were ascertained by interview. Vaginal estrogen creams were not counted in the calculation of HRT exposure due to generally poor compliance with their use, their primarily local rather than systemic effects and their variable absorption. ${ }^{43-45}$ Women who were unsure of whether or not they had used HRT were excluded ( 19 cases and 14 controls). To exclude exposure most likely not causally associated with breast cancer, the reference year for the ascertainment of HRT exposure was established at a point one year prior to the index date for both cases and controls. An a priori decision was made to exclude women who had used HRT only during the year prior to the index date ( 11 cases and 22 controls) and for less than 2 months (16 cases and 16 controls) since these exposures were not considered to be associated with
the incidence of breast cancer. Following these exclusions, 662 cases and 655 controls remained. HRT use of two or more months was classified by type of formulation (estrogen only or estrogen opposed by cyclically or continuously administered progestin), current use (women continuing HRT use up until one year prior to the index date) and recent use (women who were not current users but who were HRT users within five years of the index date).

Data from the 1996 Canadian National Population Health Survey (NPHS), ${ }^{46}$ a health survey with a response rate of 89 percent were used to determine the prevalence of HRT use in Alberta for five-year age categories of women aged 45 and older. Details of the NPHS study methods and national HRT use have been published elsewhere. ${ }^{47}$ Briefly, telephone interviews were conducted to collect information pertaining to demographic, health and determinants of health from a population-based sample. Women were asked "In the past month, did you take hormones for menopause or aging symptoms?" Women were not asked about their menopausal status.

The age-specific prevalence of HRT use, in five-year age categories, was determined among the case-control control women by identifying the number who reported using HRT during the year prior to their index date. The age-specific proportions of HRT users were then compared with the Albertan agespecific proportions from the NPHS for the purpose of determining whether or not the prevalence of HRT use among case-study controls reflected the source population use. For women under the age of 55, comparisons of HRT use were made between NPHS age-specific groups and age-specific groups of controls that included all women (pre-, peri- and postmenopausal), since menopausal status in the NPHS data was not ascertained and because of the unlikelihood of all the women between 45 and 55 years of age being postmenopausal. ${ }^{48}$ For women 55 years of age or older, the comparisons of HRT use were between NPHS age-specific groups and age-specific case-control postmenopausal women, since almost all women in these age categories were postmenopausal. We assumed that virtually
all of the control women over 55 years of age, except those who provided information to indicate otherwise ( $\mathrm{n}=4$ ), were postmenopausal. Where age-specific prevalence discrepancies were found, women were randomly sampled without replacement from age-specific categories of women identified as having used HRT during the year just preceding the index year in order to simulate age-specific proportions of Alberta NPHS HRT use.

## Statistical analysis

Unconditional logistic regression was used to estimate odds ratios (ORs) and 95 percent confidence intervals (CIs). Potential confounding variables identified a priori were assessed by examining their impact on ageadjusted ORs, using the criterion of 10 percent change in age-adjusted ORs as evidence of confounding. Age, type of menopause, age at menopause, gravida, age at first birth, age at menarche, past use of oral contraceptives, family history of breast cancer, number of screening mammograms, past diagnosis of benign breast disease, past breast biopsy, body mass index, weight gain since age 20, smoking, use of alcohol, lifetime total physical activity (LTPA), marital status, ethnic origin, education level, energy intake, and fat intake were considered potential confounding variables. The final model included age at menopause (identified as an important confounder), and family history of breast cancer, weight gain since age 20 (quartiles), type of menopause (natural vs. surgical), education level, and LTPA (MET-hours per week per year in quartiles) to control for residual confounding. ORs were estimated for HRT use and incidence of breast cancer among post-menopausal women using both the original and prevalence adjusted case-control study control groups.

## Results

## HRT use among study controls and source population

The prevalence of HRT use among agespecific categories of case-control controls and women in the Alberta population are presented in Table 1. When women of all

TABLE 1
Proportion of controls and women in Alberta (NPHS*) identified as current HRT users, and absolute number of HRT exposed controls before and after random re-sampling

| Ages group <br> (years) | Case-control study preva- <br> lence of HRT users among <br> control women, Alberta <br> 1995-97 | HRT use in <br> Alberta 1996 <br> (NPHS)** | Number of postmenopausal <br> women using HRT before <br> and after sampling |  |  |
| :--- | :---: | :---: | :---: | :---: | :---: |
|  | Post- <br> All women <br> $(\%)$ | menopausal <br> women (\%) | (\%) | Before | After |
| $45-49$ | 17 | 63 | 13 | 10 | 10 |
| $50-54$ | 35 | 44 | 34 | 28 | 28 |
| $55-59$ | 48 | 52 | 35 | 66 | 33 |
| $60-64$ | 36 | 36 | 25 | 59 | 35 |
| $65-69$ | 30 | 30 | 19 | 41 | 22 |
| $70+$ | 23 | 23 | 7 | 43 | 11 |
| Total |  |  |  | 247 | 139 |

* National Population Health Survey 1996, Statistics Canada 27
** Weighting factor developed by Statistics Canada (WT66) to better represent underlying national population ${ }^{27}$
menopausal status were compared, there was good agreement between the two sources of data in estimates of HRT use for women under 55 years of age. Therefore, we assumed that the prevalence of HRT use among the postmenopausal subset of women was also similar. However, compared with the Alberta population-based survey, greater proportions of the postmenopausal control women 55 years of age or older were using HRT. We therefore took a random sample of the HRT users (during the year prior to the index year) from the five-year age-specific categories among women 55 years of age and older to simulate the source population proportions of HRT use. After sampling, 139 postmenopausal women remained of the original sample of 247 (Table 1).


## Type of HRT regimen

Table 2 (using original controls) and Table 3 (using re-sampled HRT exposed controls) present results for associations between various HRT regimens with and without progestins. Before adjusting for HRT prevalence, the multivariate-adjusted ORs for use of ERT and EPRT at any time prior to the reference dates were 0.76 ( $95 \% \mathrm{CI}$ : 0.53-1.10) and 0.94 ( $95 \%$ CI: 0.64-1.38), respectively. Among
current and recent users, the multivariateadjusted ORs were 0.73 ( $95 \%$ CI: $0.45-1.20$ ) and 0.97 ( $0.65-1.44$ ) for ERT and EPRT, respectively (Table 2). Following re-sampling, there was an increase in ORs to above 1.0 for associations with all regimens except for the ever use of estrogen only (multivariateadjusted $\mathrm{OR}=0.94$ [95\% CI: 0.65-1.37]). Among ever users and current and recent users of EPRT (Table 3), there were significant increases in the risk of breast cancer (multivariate-adjusted $\quad \mathrm{OR}=1.57 \quad[95 \%$ CI: 1.02-2.40)] and OR $=1.77$ [ $95 \%$ CI: $1.13-$ 2.78], respectively). ORs were also elevated for both cyclical and continuous use of progestin, but only cyclical use was associated with a statistically significant increase ( $O R=2.00$ [95\% CI: 1.08-3.69]).

## Discussion

One of the most common and serious threats to validity in case-control studies is a low response rate among cases or controls. ${ }^{49,50}$ In the presence of low response rates, an increase may occur in the likelihood of recruiting subjects who are different from those in the base population, thus increasing the chance of introducing selection bias. In this study, we compared the age-specific

TABLE 2
Age and multivariable-adjusted odds ratios for the HRT formulation and incidence of breast cancer before re-sampling of controls

| HRT | $\begin{gathered} \text { Cases } \\ \mathrm{N}=662 \end{gathered}$ | $\begin{aligned} & \text { Controls } \\ & \mathrm{N}=665 \end{aligned}$ | Age-adjusted |  | Multivariable-adjusted ${ }^{\text {d }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Odds Ratios | 95\% confidence intervals | Odds Ratios | 95\% confidence intervals |
| Type of formulation |  |  |  |  |  |  |
| No Use | 353 | 302 | 1.00 |  | 1.00 |  |
| ERT | 211 | 252 | 0.72 | 0.57-0.92 | 0.76 | 0.53-1.10 |
| EPRT | 98 | 101 | 0.86 | 0.62-1.19 | 0.94 | 0.64-1.38 |
| EPRT (cyclical prog) | 49 | 52 | 0.85 | 0.55-1.31 | 1.03 | 0.61-1.74 |
| EPRT (continuous prog) | 49 | 45 | 0.97 | 0.63-1.51 | 0.99 | 0.59-1.66 |
| Type of formulation among current and recent users |  |  |  |  |  |  |
| No Use | 353 | 302 | 1.00 |  | 1.00 |  |
| ERT | 138 | 166 | 0.73 | 0.55-0.96 | 0.73 | 0.45-1.20 |
| EPRT | 92 | 95 | 0.86 | 0.62-1.21 | 0.97 | 0.65-1.44 |

* Multivariable adjusted for current age, first degree of family history of breast cancer, weight gain since age 20 (quartiles), age at menopause (quartiles), type of menopause (natural vs. surgical), education level (high school or below vs. above) and lifetime total physical activity (MET-hours/week/year in quartiles). 176 cases and 179 controls missing due to missing information on one or more covariates
ERT: estrogen replacement therapy
EPRT: estrogen and progestin replacement therapy; continuous: daily; cyclical $\leq 14$ days
prevalence of HRT use among controls in a case-control study to data from the Albertan component of the NPHS, with the objective of determining the presence of a suspected differential participation response rate. We illustrate a methodological approach to adjust for the presence of a differential participation rate between HRT users and nonusers. The subsequent increase and even change in direction of ORs that we observed in our study following re-ampling was predictable given that the re-sampling decreased the proportion of HRT use among control women to proportions of HRT use observed among Albertan women. However, we also re-examined the association between breast cancer risk and physical activity, the main exposure of interest in the original case-control study. ${ }^{40}$ Physical activity remained protective for breast cancer risk and was consistent with the original analysis, indicating that the re-sampled subgroup of controls did not differ in all measured characteristics from the original controls and that the issue raised here is restricted to the HRT analyses.

The extent to which we have successfully reduced the selection bias associated with participation rate and HRT use among
controls depends on the validity of the assumptions that we have made about the response rates. Since the response rates for cases and controls were 78.3 and 56.5 percent respectively, we assumed that selection bias, if at all present, was lesser in magnitude among the cases than it was among the controls. In addition, although cases were aware of the original research question at the time of recruitment, whether or not a woman had used HRT would likely not have motivated her participation since the main exposure of interest in the study was physical activity, not HRT. Among healthy women, on the other hand, HRT users may have been more likely to participate regardless of the research question, since HRT users have been reported to be more health conscious, better educated and have a higher socioeconomic status. ${ }^{32,33}$ These characteristics have also been reported to be correlated with willingness to participate in research. ${ }^{49,51}$ Indeed, at least one large cohort study has reported a higher participation rate among HRT users compared with nonusers during the recruitment. ${ }^{33}$

In a multi-centre population-based casecontrol study that was designed to investigate the effect of EPRT and ERT on the risk
of breast cancer, Newcomb et al. ${ }^{4}$ reported high response rates among both cases and controls ( 83 and 78 percent, respectively) and statistically significant increases in breast cancer risk associated with the use of both types of hormone. However, response rates were more variable among controls than among cases across the three recruitment centers (Wisconsin, 84 percent; Massachusetts, 70 percent; New Hampshire, 69 percent), as were the estimated relative risks: 1.40 ( $95 \%$ CI: 1.20-1.64) in Wisconsin and only 1.09 ( $95 \% \mathrm{CI}: 0.86-1.38$ ) in Massachusetts. While the authors hypothesized that Massachusetts controls may have been more likely to use hormones than the source population, they did not have external data to confirm this suspicion.

In a case-control study designed to investigate the association between HRT and breast cancer, Moorman et al. ${ }^{52}$ found that respondents who completed full face-to-face interviews were more likely to have used HRT compared with respondents who had only completed partial telephone interviews. ${ }^{53}$ Although the difference in prevalence of HRT use was more extreme among controls, a similar trend was observed among cases. Characteristics of women who completely

TABLE 3
Age and multivariable-adjusted odds ratios for HRT formulation and incidence of breast cancer after re-sampling of controls

| HRT | $\begin{gathered} \text { Cases } \\ \mathrm{N}=662 \end{gathered}$ | $\begin{gathered} \text { Controls } \\ \mathrm{N}=665 \\ \hline \end{gathered}$ | Age-adjusted |  | Multivariable-adjusted ${ }^{\text {d }}$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Odds Ratios | 95\% confidence intervals | Odds Ratios | 95\% confidence intervals |
| Type of formulation |  |  |  |  |  |  |
| No Use | 353 | 302 | 1.00 |  | 1.00 |  |
| ERT only | 211 | 186 | 0.99 | 0.77-1.27 | 0.94 | 0.65-1.37 |
| EPRT | 98 | 66 | 1.39 | 0.97-1.99 | 1.57 | 1.02-2.40 |
| EPRT (cyclical prog) | 49 | 29 | 1.64 | 0.99-2.72 | 2.00 | 1.08-3.69 |
| EPRT (continuous prog) | 49 | 34 | 1.36 | 0.85-2.20 | 1.51 | 0.86-2.64 |
| Type of formulation among current and recent users |  |  |  |  |  |  |
| No Use | 353 | 302 | 1.00 |  | 1.00 |  |
| ERT only | 138 | 100 | 1.31 | 0.96-1.79 | 1.28 | 0.75-2.19 |
| EPRT | 92 | 60 | 1.53 | 1.05-2.23 | 1.77 | 1.13-2.78 |

* Multivariable adjusted for current age, first degree of family history of breast cancer, weight gain since age 20 (quartiles), age at menopause (quartiles), type of menopause (natural vs. surgical), education level (high school or below vs. above) and lifetime total physical activity (MET-hours/week/year in quartiles). 176 cases and 136 controls missing due to missing information on one or more covariates
ERT: estrogen replacement therapy
EPRT: estrogen and progestogin replacement therapy; continuous: daily; cyclical $\leq 14$ days
refused to participate in their study were not available.

We do not have any means of examining whether or not cases who participated in our study were more likely to have used HRT than non-responders. However, we suspect that women with breast cancer are generally more motivated and willing to participate in research than are controls, regardless of previous HRT exposure. ${ }^{49}$ Understanding the nature of factors that motivate cases and controls to participate in case-control studies would be of value in the design of future studies.

This sensitivity analysis is limited by the lack of detailed descriptive information available with respect to patterns of HRT use in the general population and to the existence of some differences in the case-control and NPHS study designs. Some control women were ineligible for our study either because they did not speak English or because they had been diagnosed with cancer other than non-melanoma skin cancer ( 2.5 percent). These women would have been eligible to participate in the NPHS. However, only 4 percent of women 50 years of age and older in the NPHS had been diagnosed with cancer, non-melanoma skin cancer included. In
contrast to the NPHS methods, we did not consider as HRT exposed women who had used only vaginal estrogen creams and rings, and we excluded women who had used HRT for less than 2 months. However, if they had any impact at all, these latter exclusions from exposed categories would have led to an underestimation of the magnitude of difference between the proportions of HRT use in the two studies.

In addition to the NPHS data, only two other studies of HRT use in Canada have been published; they are specific to the provinces of Saskatchewan ${ }^{54}$ and Manitoba ${ }^{55}$ and describe only the prevalence of HRT use. ERT, EPRT and former and long-term hormone users may vary in their motivation to participate in research studies. Therefore, they may also be over- or underrepresented in study populations. Detailed descriptive population statistics would facilitate the identification of similarities in exposure patterns between study populations and their source population.

It is not feasible to investigate all aspects of health risks and benefits associated with HRT use in the framework of randomized controlled trials. Observational studies will, therefore, continue to be heavily relied
upon. ${ }^{56,57}$ It is essential to identify and develop methods which evaluate and (ideally) quantify potential biases affecting observational research. We suggest considering an approach in epidemiologic research which makes use of available populationbased descriptive statistics pertaining to HRT.

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# A comparison of measures of socioeconomic status for adolescents in a Canadian national health survey 

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#### Abstract

The purpose of this study was to explore and compare measures of socioeconomic status (SES) in a national sample of Canadian adolescents. Issues of missing data and interrelationships among the measures were addressed. Measures of SES included household income, parental education, two parental occupation-based measures and four neighbourhood proxy indicators. The proportion of adolescents with missing data was largest for household income (21.1 percent). Data were not missing at random, as adolescents missing household income information were less likely to reside in a high income neighbourhood. Pair-wise Spearman correlations ranged from 0.40-0.79 between neighbourhood SES measures; 0.12-0.37 between household/parental and neighbourhood indicators; and $0.36-0.87$ between household/parental measures. Correlations were lower among rural adolescents, particularly for the neighbourhood SES measures. The results highlight both measurement and conceptual challenges for researchers who wish to gain insight into SES-health relationships for adolescents. In particular, the findings emphasize the importance of incorporating multiple measures of SES and suggest a need to further explore the meaning of socioeconomic position for this population.


Key words: adolescence, correlation, data quality, social class, socioeconomic factors

## Introduction

The need to continue to investigate associations between socioeconomic status (SES) and health outcomes is well recognized, ${ }^{1-5}$ and this requires access to meaningful and reliable measures of SES. Traditional measures of SES used in health and social research (occupation, education and income) may be viewed as relating to two underlying dimensions, a prestige or social status dimension, and a class or economic resource dimension. ${ }^{6,7}$ Different measures of SES may capture these aspects of socioeconomic position in different ways. ${ }^{8}$

The conceptualization and measurement of SES for adolescents is particularly challenging. For example, it is not clear which underlying aspects of socioeconomic position are
most salient for this age group or how these aspects are differentially captured by different SES measures. ${ }^{9}$ Although studies often incorporate household or parental indicators of SES (such as household income, parental education or parental occupational status), there are concerns over the validity of the measurement of parental SES from adolescent reports and about potentially high levels of item-missing data. ${ }^{10-14}$ Other possible indicators include alternative SES measures at the individual level of measurement (such as material deprivation or subjective evaluations of SES), , ${ }^{10,11,13,15,16}$ and measures of SES at the neighbourhood or small-area level, included either as proxies for individual SES, or to examine contextual effects. ${ }^{8}$

In response to the various conceptual and measurement issues that exist in assessing the SES-health relationship, several authors have recommended that studies should incorporate multiple indicators of SES. ${ }^{6,7,17,18}$ There is a paucity of research comparing measures of SES for adolescents. Examining how data quality issues influence different adolescent SES indicators may help researchers to make informed choices among these measures. Understanding the interrelationships among the different measures is also important for interpreting research findings.

The overall purpose of this study was to explore and compare various available measures of SES for adolescents using Canadian national health survey data, in order to highlight important measurement and conceptual issues that require consideration by researchers interested in examining SEShealth relationships in this population. There were two specific objectives. First, we aimed to document the amount of missing data for each of the SES indicators and to explore the potential impact of missing data by examining the characteristics of adolescents with missing information. The second objective was to explore the extent to which different measures of adolescent SES addressed similar aspects of socioeconomic position, by examining their interrelationships.

[^6]
## Methods

## Sample and data source

The study sample consisted of Canadian adolescents 12 to 19 years of age who were participants in the 1996-1997 cross-sectional cycle of the National Population Health Survey (NPHS) ( $\mathrm{N}=6967$ ). ${ }^{19}$ The 1996-1997 NPHS included a sample of household residents in all Canadian provinces, based on a complex sampling design. ${ }^{19}$ There were three main components to the survey: the household-level information component, the general component and the health component. Householdlevel information (such as household income and type of dwelling) was collected for each household in the NPHS sample and this information was added to both the general and health data files. The general component captured basic demographic and limited health information for each individual member of selected households. The health component collected detailed health information for one specific selected member of the household.
One member of each household provided household-level information. In terms of the general component information, sometimes household members were each interviewed individually but more typically one household member (not necessarily the member selected for the health component) provided all of the general information for all other members. ${ }^{19}$ Interviewers were instructed to obtain this information from a knowledgeable household member. ${ }^{20}$ For the health component, interviewers attempted to obtain the information directly from the individual selected. ${ }^{20}$

The adolescents in this study were those who were selected for the health component of the NPHS. Information on other members of the adolescents' households was available from the general file and household-level information was available from either file. A total of 68 adolescents were excluded from the full sample, due to an inability to link their responses to census tabulations at the small-area level, leaving 6,899 adolescent respondents in the analyses presented. Among the 6,899 adolescents included in the study, a small minority (238 or 3.5 percent) had the health file
information provided by a proxy respondent. Information was collected through telephone interviews for 6849 adolescents ( 99.3 percent of the sample), with the remaining interviews conducted in person.

## Measures of SES

Information on total household income from all sources was collected using 11 categories, ranging from no income to $\$ 80,000$ or more per year. This information was used to create a five-category household income variable; categories were roughly based on multiples of low income cut-off values and were adjusted for household size. For example, the middle income category included one- and two-person households with an income of $\$ 15,000$ to $\$ 29,000$ per year, three- and four-person households with an income of $\$ 20,000$ to $\$ 39,000$ per year, and households with five or more persons and an income of $\$ 30,000$ to \$59,000 per year. ${ }^{19}$

General component SES information (education and labour force data) was used to create parental measures of SES for those adolescents who reported that they lived with parents ( $\mathrm{N}=5723$ ). For these adolescents, the highest value of each SES variable among household members 25 years of age or older was considered to represent parental SES. Although the survey did not contain information on the specific relationships among household members, over 99 percent of adolescents who reported that they lived with parents were living in households that included a couple or single parent living with children under 25 years of age, and no others. This suggests that SES values for adults 25 years of age or older in these households can reasonably be assumed to represent parental SES. The choice of the highest value among household adults is consistent with other recent studies that have adopted this approach, rather than focusing solely on paternal or maternal SES. ${ }^{21-23}$

Parental education was measured using five categories that were focussed on educational credentials (rather than years of schooling), ranging from less than secondary school graduation to a university degree. Variables representing parental occupational prestige and a
parental SES index were based on occupation information. These two SES measures were included for adolescents with a household member 25 years of age or older who had worked for pay in the past 12 months.

Parental occupational prestige was measured using the Pineo-Porter-McRoberts occupational prestige scale..$^{24,25}$ This scale has 16 categories and was re-coded so that, like other SES variables in the study, higher scores represented higher prestige. The Blishen SES index, rather than being solely prestige based, also incorporates information regarding the education and income levels associated with a given occupation. ${ }^{26}$ Blishen index scores can range from 17.81 to 101.74 , with higher values indicating higher SES.

Four neighbourhood proxy indicators of SES were created by linking adolescents' postal codes to 1996 census enumeration areas (EAs), ${ }^{27}$ using the Postal Code Conversion File program (PCCF + ).${ }^{28}$ First, a variable representing average household income for all private households within an EA was created, based on public use census data. A second neighbourhood income variable categorized EA-level household income information into quintiles, incorporating adjustments for both household size and geographic area. ${ }^{28}$ Since average income information is suppressed for some EAs, because of small population sizes, imputation from adjacent EAs was used for the income quintiles variable to reduce missing data. ${ }^{28}$ Education information (based on public use census data) was used to create a variable representing, for each EA, the estimated proportion of the population 15 years of age and older who had completed secondary school. Labour force information (also from public use census data) was used to create a fourth neighbourhood SES variable, which reflected the estimated proportion of the population who were employed among those in an EA who were 15 years of age and older and who were eligible for employment. The data used to create the education and employment variables were subject to a random rounding process, in order to protect confidentiality, which introduced some error into the final estimates. ${ }^{27}$

TABLE 1

## Distribution of the sample within demographic categories (weighted ${ }^{\dagger}$ ) (unweighted: total $\mathbf{N}=6899$; urban $\mathbf{N}=4572$; rural $\mathbf{N}=2327$ )

|  | Total |  | Urban |  | Rural |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Percent | 95\% confidence interval | Percent | 95\% confidence interval | Percent | 95\% confidence interval |
| Rural | 24.1 | 21.8-26.3 |  |  |  |  |
| Male | 51.1 | 49.6-52.5 | 51.9 | 50.1-53.7 | 48.4 | 44.1-52.7 |
| Age group |  |  |  |  |  |  |
| 12-14 years | 35.3 | 33.2-37.4 | 34.3 | $31.8-36.8$ | 38.5 | 34.7-42.3 |
| 15-17 years | 39.5 | 37.4-41.5 | 39.9 | 37.3-42.4 | 38.3 | 34.9-41.6 |
| 18-19 years | 25.2 | 23.3-27.2 | 25.9 | 23.5-28.3 | 23.3 | 20.2-26.3 |
| Region |  |  |  |  |  |  |
| East ${ }^{1}$ | 8.7 | 8.0-9.3 | 6.3 | 5.4-7.3 | 16.0 | 13.2-18.9 |
| Quebec | 24.2 | 22.7-25.8 | 23.9 | 21.7-26.2 | 25.3 | 19.5-31.0 |
| Ontario | 36.5 | 35.5-37.5 | 40.2 | 38.6-41.7 | 24.8 | 22.1-27.5 |
| Man./Sask. ${ }^{2}$ | 7.6 | $7.1-8.2$ | 6.0 | $5.2-6.7$ | 12.9 | 10.7-15.1 |
| Alberta/BC ${ }^{3}$ | 23.0 | 21.7-24.3 | 23.7 | 21.9-25.4 | 21.0 | 16.8-25.3 |
| Living with: |  |  |  |  |  |  |
| Parents ${ }^{4}$ | 83.9 | 82.3-85.4 | 83.3 | 81.4-85.2 | 85.7 | 82.7-88.6 |
| Alone ${ }^{5}$ | 3.0 | 2.3-3.7 | 3.2 | 2.4-4.0 | *2.5 | 1.5-3.5 |
| Other ${ }^{6}$ | 13.1 | 11.6-14.6 | 13.5 | 11.7-15.4 | 11.8 | 8.9-14.7 |

${ }^{1}$ East includes the provinces of Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick.
${ }^{2}$ Provinces of Manitoba and Saskatchewan.
${ }^{3}$ Provinces of Alberta and British Columbia.
${ }^{4}$ Adolescents living with one or more parents, with or without siblings.
${ }^{5}$ Adolescents living unattached and alone, unattached with others, or with spouse/partner, with or without own children.
${ }^{6}$ Adolescents with other living arrangements, or living arrangements not stated.

* Proportion should be interpreted with caution due to high sampling variability.
${ }^{\dagger}$ Weighted using NPHS sampling weights.


## Data analysis

All analyses were carried out using SAS (version 8, the SAS Institute Inc., 1999-2001). For each measure of SES, the distribution of the variable and the proportion of adolescents with missing data were examined. To determine whether adolescents missing household income data were different from those with valid data, predictors of missing household income were examined using multivariable logistic regression. Specifically, an indicator of absent household income variable data was regressed on a neighbourhood-level income quintiles variable and on demographic characteristics (region, age group, rural versus urban residence, living arrangements and gender).

Spearman rank correlation coefficients were used to explore the pair-wise relationships
among the SES measures. The aim of the correlation analysis was to explore the strength of the association between measures, rather than to determine whether they were related. For this reason, tests of statistical significance were not used.

We anticipated that both measurement and conceptual issues relevant to indicators of SES for adolescents might differ according to rural versus urban areas of residence. Thus, we explored potential rural-urban differences in all analyses.

Missing data were substantial for some SES measures. For this reason, and because exploring data quality was an aim of this study, the sample was not restricted to adolescents with valid data on all SES variables. Instead,
each analysis included all available observations relevant to it.

Because the NPHS used a complex sampling design to yield a sample that was representative of the Canadian population, sampling weights were incorporated in all analyses. Variance estimates for descriptive and regression analyses were adjusted using bootstrap replicate weights to account for clustering within the sample. ${ }^{19}$ The distribution of sampling weights for the adolescent sample had a wide range and was highly positively skewed, in part because some provinces purchased extra sampling units that led to smaller sampling weights in those provinces, and larger sampling weights in other provinces. The result was that in the weighted logistic regression analysis, indi-
viduals with large sampling weights had the potential to have a large influence on the regression coefficients. To reduce bias, therefore, nine influential outliers were excluded from the final weighted model. All excluded observations had sampling weights exceeding the $90^{\text {th }}$ percentile for the sample. None of the excluded observations was influential in the unweighted analysis, suggesting that the sampling weight was the reason for the large influence.

## Results

## Sample characteristics and distribution of variables

Urban and rural adolescents were similar in terms of gender, age and living arrangements (Table 1). A higher proportion of urban adolescents lived in Ontario as compared with rural adolescents; rural adolescents were more likely than their urban
peers to live in the East and in Manitoba/ Saskatchewan.

The distributions of socioeconomic variables are shown in Table 2 (full sample) and Table 3 (adolescents living with parents). The majority of adolescents with valid household income information had household incomes in the middle and upper-middle categories (Table 2). Since fewer than 5 percent of adolescents were in the lowest household income

TABLE 2

## Distribution of categorical and continuous socioeconomic variables for full sample (weighted ${ }^{\dagger}$ ) (unweighted: total $\mathrm{N}=6899$; urban $\mathrm{N}=4572$; rural $\mathrm{N}=2327$ )

| a) Categorical variables |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | Urban |  | Rural |  |
|  | Percent | 95\% confidence interval | Percent | 95\% confidence interval | Percent | 95\% confidence interval |
| Household income ${ }^{1}(\mathrm{~N}=5189)$ |  |  |  |  |  |  |
| Lowest | 4.3 | 3.3-5.4 | 4.2 | 3.1-5.3 | *4.8 | 2.7-6.8 |
| Lower-middle | 12.5 | 10.6-14.5 | 12.5 | 10.2-14.9 | 12.6 | $9.1-16.2$ |
| Middle | 33.8 | $31.1-36.5$ | 32.4 | 29.5-35.4 | 38.1 | $32.1-44.2$ |
| Upper-middle | 35.0 | 32.4-37.6 | 35.3 | 32.4-38.3 | 33.9 | 28.2-39.7 |
| Highest | 14.3 | 12.5-16.2 | 15.5 | 13.4-17.7 | *10.6 | $6.9-14.2$ |
| Neighbourhood income Quintiles ${ }^{2}$ ( $\mathrm{N}=6866$ ) |  |  |  |  |  |  |
| Lowest | 17.0 | 15.2-18.8 | 17.3 | 15.1-19.5 | 16.2 | 13.1-19.2 |
| Lower-middle | 18.6 | 16.6-20.7 | 18.7 | 16.4-21.0 | 18.5 | 14.6-22.4 |
| Middle | 19.7 | 17.9-21.5 | 18.9 | 16.8-21.1 | 22.1 | 18.2-25.9 |
| Upper-middle | 21.2 | 19.1-23.3 | 22.2 | 19.9-24.5 | 18.1 | 14.0-22.1 |
| Highest | 23.5 | 20.8-26.1 | 22.9 | 20.1-25.7 | 25.2 | 19.3-31.2 |
| b) Continuous variables (at EA level) |  |  |  |  |  |  |
|  | Median | Percentiles $\left(25^{\mathrm{th}} ; 75^{\mathrm{th}}\right)$ | Median | Percentiles $\left(25^{\mathrm{th}} ; 75^{\mathrm{th}}\right)$ | Median | Percentiles $\left(25^{\text {th }} ; 75^{\text {th }}\right)$ |
| Neighbourhood avg income ${ }^{3}$ ( $\mathrm{N}=6615$ ) | 49 | 39; 63 | 53 | 41; 66 | 42 | 36; 50 |
| $\begin{aligned} & \text { Neighbourhood education }{ }^{4} \\ & (\mathrm{~N}=6889) \end{aligned}$ | 0.66 | 0.57; 0.75 | 0.69 | 0.61; 0.77 | 0.56 | 0.48; 0.64 |
| Neighbourhood employment ${ }^{5}$ ( $\mathrm{N}=6889$ ) | 0.91 | 0.87; 0.95 | 0.92 | 0.88; 0.95 | 0.90 | 0.84; 0.95 |

$E A=$ enumeration area.
${ }^{1}$ Categories of household income adequacy, taking household size into account.
${ }^{2}$ Income quintiles at the EA level, adjusted for region and household size.
${ }^{3}$ Average household income at the EA level (no adjustments) (\$1000s, rounded).
${ }^{4}$ At the EA level, proportion of residents over age 15 estimated to have graduated from secondary school.
${ }^{5}$ At the EA level, proportion of residents over age 15 and in the labour force estimated to be employed.

* Proportion should be interpreted with caution due to high sampling variability.
+ Weighted using NPHS sampling weights.

TABLE 3

## Distribution of categorical and continuous parental socioeconomic variables for adolescents living with parents (weighted ${ }^{\dagger}$ ) (unweighted: total $\mathrm{N}=5723$; urban $\mathrm{N}=3751$; rural $\mathrm{N}=1972$ )

| a) Categorical variables |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total |  | Urban |  | Rural |  |
|  | Percent | 95\% confidence interval | Percent | 95\% confidence interval | Percent | 95\% confidence interval |
| Parental education ${ }^{1}$ ( $\mathrm{N}=5601$ ) |  |  |  |  |  |  |
| < Secondary | 10.4 | 8.8-11.9 | 9.1 | 7.3-10.9 | 14.4 | 10.8-18.0 |
| Secondary | 15.2 | 13.2-17.2 | 15.0 | 12.5-17.5 | 15.9 | 13.2-18.5 |
| Some post-secondary ${ }^{2}$ | 21.3 | 19.2-23.5 | 20.2 | 17.7-22.7 | 24.9 | 20.6-29.3 |
| Certificate/diploma ${ }^{3}$ | 29.1 | 26.8-31.3 | 28.2 | 25.7-30.6 | 31.8 | 27.2-36.4 |
| Degree ${ }^{4}$ | 24.1 | 21.9-26.2 | 27.6 | 25.1-30.2 | 13.0 | 10.4-15.6 |
| Parental occupational prestige ${ }^{5}(\mathrm{~N}=5021)$ |  |  |  |  |  |  |
| Lowest ${ }^{6}$ | 8.9 | 7.4-10.3 | 8.2 | 6.6-9.9 | 10.8 | 7.7-13.9 |
| Lower-middle ${ }^{7}$ | 14.5 | 12.6-16.5 | 14.3 | 11.9-16.6 | 15.4 | 12.2-18.6 |
| Upper-middle ${ }^{8}$ | 29.9 | 27.3-32.6 | 27.6 | 24.4-30.8 | 37.3 | 32.4-42.2 |
| Highest ${ }^{9}$ | 46.7 | 44.0-49.4 | 50.0 | 46.9-53.0 | 36.5 | 31.1-42.0 |
| b) Continuous variable |  |  |  |  |  |  |
|  | Median | Percentiles $\left(25^{\mathrm{th}} ; 75^{\mathrm{th}}\right)$ | Median | Percentile $\left(25^{\text {th }} ; 75^{\text {th }}\right)$ | Median | Percentiles $\left(25^{\text {th }} ; 75^{\text {th }}\right)$ |
| Parental Blishen SES Index ${ }^{10}$ $(\mathrm{N}=5021)$ | 48 | 38; 59 | 50 | 39; 59 | 43 | 34; 55 |

1 Highest level of education among household members aged 25 and older.
2 Some post-secondary education with no diploma or degree.
3 Trade school or college certificate or diploma.
4 University degree.
5 Highest occupational prestige for household members aged 25 and older (Pineo-Porter-McRoberts measure).
6 Categories 14-16, unskilled workers.
7 Categories 12-13, semi-skilled workers.
8 Categories 7-11, supervisors, forepersons, and skilled workers.
9 Categories 1-6, professionals, high-level \& middle management, semi-professionals, technicians.
10 Highest Blishen SES Index Score among household members aged 25 and older (nearest integer).
$\dagger$ Weighted using NPHS sampling weights.
category, this category was combined with the lower-middle income category for further analyses. Adolescents in the sample were moderately more likely to live in higher income neighbourhoods relative to private households in the general population, based on the distribution of the neighbourhood income quintiles variable (Table 2). Large urban/rural differences were not apparent in neighbourhood income quintiles, likely because of adjustments for geography made in the creation of this variable. ${ }^{28}$ The median values for average neighbourhood income and for the proportion of the neighbourhood
population with at least a high school education, though, were somewhat higher for urban adolescents, relative to rural adolescents. Similarly, parental education, occupational prestige and Blishen SES index levels tended to be higher for urban adolescents living with their parents, relative to their rural counterparts (Table 3).

## Missing data

Fewer than 5 percent of adolescents were missing data for any one SES variable, with three exceptions. Household income was missing for an estimated 21.1 percent (weighted
proportion) of the full sample ( 95 percent confidence interval, 19.5-22.7 percent). Both parental occupational prestige and Blishen SES index values were missing for an estimated 12.2 percent of adolescents who were reported to be living with parents (95 percent confidence interval, 10.4-14.1 percent). Household income data were not missing completely at random among adolescents in the sample (Table 4). After adjusting for the other predictors in Table 4, adolescents with missing household income information were the following: less likely to be from a high income neighbourhood; less
likely to live in a region outside the Province of Ontario; more likely to be older; and more likely to be living in a rural area (Table 4).

## Relationships among SES measures

For the full sample, overall correlations between household income and the neigh-bourhood-level SES variables ranged from 0.24 to 0.37 (Table 5), with the lowest correlation for the neighbourhood employment rate. Correlations among the neighbourhood SES variables were somewhat higher, ranging from 0.40 to 0.79 , with the lowest correlations again tending to involve the employment rate variable, and the highest correlation between the neighbourhood income quintiles variable and the average neighbourhood income variable. When stratified by rural/urban status, the correlations for the full sample were lower for adolescents living in rural areas, both for household income with the neighbourhood SES variables (urban: 0.25-0.38, rural: 0.18-0.29), and among the different neighbourhoodlevel variables (urban: 0.48-0.84, rural: 0.21-0.77) (Table 5).

For adolescents living with parents, overall correlations among the parental SES variables ranged from 0.50 to 0.87 , with the highest correlation between the occupational prestige variable and the Blishen SES index (Table 6). Correlations between the parental measures and household income were more modest (0.36-0.43). Correlations between the parental SES measures and the neighbourhood-level SES variables were lower still (0.12-0.31), and again, correlations were particularly low for the neigh-bourhood-level employment rate variable. Similar to the full sample correlations, almost all correlations with parental SES measures were lower for adolescents living in rural areas, relative to those living in urban areas.

## Discussion

## Missing data

This study examined various measures of adolescent SES, addressing issues related to missing data and exploring interrelation-

TABLE 4
Predictors of missing values for household income variable - weighted ${ }^{\dagger}$ multivariable results, excluding influential outliers ${ }^{1}$ (unweighted: $\mathrm{N}=6857$ )

|  | Odds ratio | 95\% confidence interval |
| :--- | :---: | :---: |
| Neighbourhood income quintiles <br> (reference $=$ lowest) |  |  |
| $\quad$ Lower-middle | 0.9 | $0.7-1.2$ |
| Middle | 0.8 | $0.6-1.1$ |
| Upper-middle | 0.8 | $0.6-1.1$ |
| $\quad$ Highest | ${ }^{*} 0.7$ | $0.5-0.9$ |
| Region/province (reference = Ontario) |  |  |
| $\quad$ East | ${ }^{* * *} 0.2$ | $0.1-0.3$ |
| $\quad$ Quebec | ${ }^{* * *} 0.1$ | $0.1-0.2$ |
| $\quad$ Manitoba/Saskatchewan | ${ }^{* * *} 0.4$ | $0.3-0.6$ |
| $\quad$ Alberta/British Columbia |  | $0.3-0.5$ |
| Age group (reference =12-14 years) | ${ }^{* * *} 1.8$ |  |
| $\quad$ 15-17 years | ${ }^{* * *} 1.8$ | $1.5-2.2$ |
| $\quad 18-19$ years | ${ }^{*} 1.3$ | $1.4-2.4$ |
| Rural living status (vs. urban) | 1.0 | $1.0-1.6$ |
| Living with parents (vs. other) | 1.1 | $0.7-1.3$ |
| Female (vs. male) |  | $1.0-1.3$ |

$E A=$ enumeration area.
19 influential outliers were excluded.
${ }^{*}=p<0.05 ;{ }^{* *}=p<0.01$; ${ }^{* * *}=p<0.001$.
$\dagger$ Weighted using NPHS sampling weights.
ships among the measures. With respect to missing data, a high proportion of adolescents (over 20 percent) were missing household income information, and the results revealed that income data were not missing completely at random. In particular, adolescents with missing household income data were more likely to be from lower income neighbourhoods and they differed from the remaining sample on other demographic characteristics.

Unless data on a variable can be assumed to be missing completely at random (MCAR, a rarely satisfied assumption that implies that data absence is unrelated to the values on all variables), missing data can lead to biased estimates of statistical parameters, particularly when a large proportion of observations is affected. ${ }^{29}$

There are a number of options when dealing with missing data in survey research. These range from simply restricting the analysis to
observations with complete data on all relevant variables (listwise deletion or complete case analysis), to treating missing data as a separate category or using dummy variables to account for data absence, to imputing or estimating missing data using techniques such as multiple imputation or maximum likelihood-based methods. ${ }^{29,30}$ Each approach, including the conventional method of listwise deletion, carries assumptions about the nature of missing data. Most of the methods (with the exception of the use of dummy variables to account for data absence) are relatively robust if the data can be assumed to be missing at random (MAR), which differs from MCAR and implies that absence can be predicted based on the values of other variables in the dataset. ${ }^{29}$ It is typically not possible, though, to demonstrate that data are MAR (although it may be possible, as demonstrated in the results presented here, to show that data are definitely not MCAR). Thus, the results of analyses

TABLE 5
Correlations among socioeconomic variables - Full sample (weighted ${ }^{\dagger}$ ) (unweighted: total $\mathbf{N}=6899$; urban $N=4572$; rural $\mathbf{N}=2327$ )

| Weighted $\mathrm{r}_{5}(\mathbf{n})^{1}$ |  | Household income ${ }^{2}$ | Neighbourhood income quints ${ }^{3}$ | Neighbourhood avg income ${ }^{4}$ | Neighbourhood education ${ }^{5}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Neighbourhood income quints ${ }^{3}$ | Total | 0.31 (5165) |  |  |  |
|  | Urban | 0.35 (3373) |  |  |  |
|  | Rural | 0.18 (1792) |  |  |  |
| Neighbourhood avg income ${ }^{4}$ | Total | 0.37 (4958) | 0.79 (6615) |  |  |
|  | Urban | 0.38 (3323) | 0.84 (4503) |  |  |
|  | Rural | 0.28 (1635) | 0.77 (2112) |  |  |
| Neighbourhood education ${ }^{5}$ | Total | 0.29 (5181) | 0.54 (6858) | 0.66 (6615) |  |
|  | Urban | 0.30 (3373) | 0.64 (4561) | 0.63 (4503) |  |
|  | Rural | 0.29 (1808) | 0.45 (2297) | 0.60 (2112) |  |
| Neighbourhood employment ${ }^{6}$ | Total | 0.24 (5181) | 0.44 (6858) | 0.56 (6615) | 0.40 (6889) |
|  | Urban | 0.25 (3373) | 0.53 (4561) | 0.59 (4503) | 0.48 (4567) |
|  | Rural | 0.20 (1808) | 0.21 (2297) | 0.46 (2112) | 0.21 (2322) |

Quints = quintiles $E A=$ enumeration area
1 For each pairwise Spearman rank correlation $\left(r_{s}\right)$, the weighted correlation coefficient is shown, followed by the unweighted sample size contributing to the co-efficient (in brackets).
2 Categories of household income adequacy, taking household size into account.
3 Income quintiles at the EA level, adjusted for region and household size.
4 Average household income at the EA level (no adjustments for region or household size).
5 At the EA level, proportion of residents over age 15 estimated to have graduated from secondary school.
6 At the EA level, proportion of residents over age 15 and in labour force estimated to be employed.
† Weighted using NPHS sampling weights.
where a large proportion of cases have itemmissing data should be treated with caution.

The high proportion of adolescents missing household income information in this survey could have implications for analyses that incorporate this variable, either as a predictor of adolescent health or as a covariate. A careful approach to such analyses is required. One option would be to compare multiple methods for handling missing income data; such a sensitivity analysis would provide insight into the robustness of study findings in relation to the method chosen.

## Relationships among SES measures

Correlations among neighbourhood indicators of SES for the total sample ranged from 0.40 to 0.79 . Other studies examining pairwise correlations among area or neighbourhood socioeconomic characteristics have also tended to observe correlations of about
0.50 or above. ${ }^{31-33}$ The correlations between household/parental measures of SES and neighbourhood measures were much lower ( $0.12-0.37$ for the full sample). This is also consistent with previous research ${ }^{21,32-34}$ and is perhaps not surprising, as EAs are formed based on census geography and do not necessarily represent social neighbourhoods or communities.

Although there was considerable variability (range: 0.36 to 0.87 in the full sample), correlations among some household/parental SES indicators for adolescents were relatively modest. Other studies that have examined correlations among various individuallevel SES characteristics have also tended to observe variability, including some weaker relationships, ${ }^{17,32-35}$ suggesting that status incongruence (whereby individuals experience inconsistencies across indicators of status or social position) is not unusual. In fact, such incongruence may itself be associated with health outcomes. ${ }^{36-38}$ The modest correlations observed among some
household/parental SES measures also imply that these measures may have been capturing different underlying characteristics related to the concept of socioeconomic position. This has implications for studies of SES-health relationships, as different measures of SES are likely to be related to health outcomes in different ways for both adults ${ }^{39,40}$ and adolescents. ${ }^{9,41,42}$ This suggests that the choice of an appropriate measure of SES may depend on the setting. For example, while income may be seen as more of an indicator of material resources, occupation and education could reflect both economics and prestige. ${ }^{7}$ This becomes more complex for adolescent populations, where the influence of parental indicators may be more subtle or indirect.

Correlations with both neighbourhood and household/parental SES measures were lower for the neighbourhood employment rate variable, relative to most other SES indicators in this study. This may reflect the lack of variability in the distribution of this

## TABLE 6

## Correlations among socioeconomic variables - Adolescents living with parents (weighted ${ }^{\dagger}$ ) (unweighted: total $\mathbf{N}=5723$; urban $\mathbf{N}=3751$; rural $\mathbf{N}=1972$ )

| Weighted $\mathrm{r}_{\mathbf{s}}(\mathbf{n})^{1}$ |  | Parental education ${ }^{2}$ | Parental occup prestige ${ }^{3}$ | Parental Blishen SES Index ${ }^{4}$ |
| :---: | :---: | :---: | :---: | :---: |
| Parental occupational prestige ${ }^{3}$ | Total | 0.52 (4995) |  |  |
|  | Urban | 0.55 (3232) |  |  |
|  | Rural | 0.38 (1763) |  |  |
| Parental Blishen SES Index ${ }^{4}$ | Total | 0.50 (4995) | 0.87 (5021) |  |
|  | Urban | 0.52 (3232) | 0.87 (3251) |  |
|  | Rural | 0.36 (1763) | 0.87 (1770) |  |
| Household income ${ }^{5}$ | Total | 0.36 (4297) | 0.38 (3926) | 0.43 (3926) |
|  | Urban | 0.38 (2757) | 0.41 (2509) | 0.46 (2509) |
|  | Rural | 0.28 (1540) | 0.28 (1417) | 0.30 (1417) |
| Neighbourhood income quintiles ${ }^{6}$ | Total | 0.23 (5575) | 0.27 (5001) | 0.30 (5001) |
|  | Urban | 0.25 (3659) | 0.31 (3248) | 0.34 (3248) |
|  | Rural | 0.07 (1916) | 0.15 (1753) | 0.16 (1753) |
| Neighbourhood average income ${ }^{7}$ | Total | 0.25 (5373) | 0.27 (4812) | 0.31 (4812) |
|  | Urban | 0.25 (3611) | 0.29 (3204) | 0.32 (3204) |
|  | Rural | 0.12 (1762) | 0.15 (1608) | 0.14 (1608) |
| Neighbourhood education ${ }^{8}$ | Total | 0.30 (5594) | 0.28 (5014) | 0.30 (5014) |
|  | Urban | 0.31 (3659) | 0.29 (3247) | 0.30 (3247) |
|  | Rural | 0.17 (1935) | 0.13 (1767) | 0.17 (1767) |
| Neighbourhood employment ${ }^{9}$ | Total | 0.15 (5594) | 0.13 (5014) | 0.12 (5014) |
|  | Urban | 0.16 (3659) | 0.15 (3247) | 0.17 (3247) |
|  | Rural | 0.08 (1935) | 0.04 (1767) | 0.02 (1767) |

[^7]measure across the study sample. Correlations among measures of SES were also lower for rural adolescents, relative to those living in urban areas. This was particularly evident for the neighbourhood indicators of SES. Since postal codes often map to more than one EA in rural areas, there is likely greater measurement error for the EA-level variables among rural adolescents, which may help to explain these lower correlations. A related issue is that because the
geographic distribution of rural populations may not be related to housing prices to the same degree as urban populations, neighbourhood measures of SES (and specifically area-based income measures) are likely to be poorer proxies for individual SES in rural areas, relative to urban areas. ${ }^{43}$ Further research is needed to determine the implications of this finding for research on the relationship between SES and health for adolescents. There is some evidence that
area-based indices of deprivation may be less strongly associated with morbidity and mortality for rural populations overall. ${ }^{44} \mathrm{~A}$ recent Canadian study, though, found that relationships with SES for various health outcomes were similar for urban and rural populations. ${ }^{43}$ The same study also found that for rural and urban populations, relationships with health were similar for household income and an area-based proxy measure of income. ${ }^{43}$ In the present study,
correlations among SES variables were somewhat lower for rural adolescents, even for household income and parental SES variables, which suggests that additional differences in the measurement or conceptualization of SES may have existed between rural and urban adolescents.

## Limitations

This study uniquely focussed on exploring and comparing eight different indicators of adolescent SES available in a Canadian national health survey. There were several limitations, though, that may have influenced the findings.

First, although the household and parental measures of SES were sometimes based on adolescent reports and sometimes based on adult reports (at the discretion of the respondent and the NPHS interviewer), it was not possible to explore the impact of proxy reporting in an in-depth way. We did repeat the correlation analysis with results restricted to adolescents who were the reporters of SES information, and found no systematic differences (details available upon request), but adolescent and adult reports from the same household were not available for comparison.

Secondly, although this study included a number of different SES measures at the individual and small-area level, we did not incorporate alternative SES indicators, such as material deprivation or adolescents' own evaluations of SES. In particular, adolescents' subjective assessments of their social standing may be independently related to some health outcomes, ${ }^{16}$ suggesting that there may be unique concepts relevant to adolescents that are not captured in traditional SES measures. ${ }^{45}$ Further research designed to provide in-depth insights into the meaning of social status among adolescents (for example, using qualitative methods) may be most informative.

Thirdly, there is little consensus on how SES indicators should be classified (for example, as continuous or categorical variables; and if categorical, how categories should be formed). This is particularly true for SES indicators at the small-area level. In coding SES variables, we aimed to maintain
maximum variability while using categories that were logical conceptually and consistent with previous literature (for example, in developing categories based on attained credentials for parental education), but it is possible that these coding choices had some influence on our findings. Finally, although the sample size for this study was relatively large and allowed for some comparisons across rural versus urban residence, we were not able to examine potential differences across age sub-groups within the sample.

## Conclusion

In presenting findings related to missing data and in highlighting the modest correlations among different SES indicators (particularly between household/parental measures and neighbourhood proxy measures), we have aimed to draw attention to both measurement issues and conceptual issues that present challenges to health researchers who wish to gain insight into SES-health relationships for adolescents. The results highlight the need to incorporate and thoughtfully compare multiple measures of SES when carrying out research with adolescent samples. Incorporating both individual/household and neighbourhoodlevel indicators would also provide an opportunity to examine potential contextual effects, which have been increasingly recognized as important to the study of SES and health. ${ }^{8}$ To fully inform future SES-health research for adolescents, there is a need to further explore the conceptual meaning of socioeconomic position in this population. In particular, research approaches that address dimensions of SES throughout the life course and between generations have been recommended. ${ }^{8,9}$ Issues that should also be considered include status incongruence, rural-urban differences, and potential diferences across health outcomes relating to the underlying dimensions of SES that are most relevant for adolescents.

## Acknowledgements

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## Workshop report:

# Occupational cancer surveillance 

## Jennifer I Payne

Occupational cancer surveillance can be defined as the systematic collection, evaluation and dissemination of data relating to workplace exposures to cancer-causing agents among workers, with the ultimate aim of reducing or preventing excess risk. ${ }^{1}$ However, identifying the risks of cancer associated with occupational carcinogen exposures is complicated by the long latency of the disease and the role of multiple risk factors. ${ }^{2}$ A comparison of aggregate data from the 1980s from provincial cancer registries and provincial workers' compensation boards suggested there is a great deal of inconsistency in data quality across jurisdictions and that the proportion of possible occupational cancers reported to the boards was as low as 10 percent. $^{3}$

Given these challenges, Cancer Care Ontario and the Ontario Workplace Safety \& Insurance Board jointly sponsored a three-year demonstration project in the area of occupational cancer, the Occupational Cancer Research and Surveillance Project (OCP). In this context, approximately 80 people were invited to attend the Occupational Cancer Surveillance Workshop in Toronto on February 1-2, 2005. The project hosted the workshop to get input into developing priorities for Cancer Care Ontario in the area of occupational cancer surveillance.

The workshop agenda called for a full day of discussion around surveillance, with a larger emphasis on carcinogen exposure surveillance and a lesser emphasis on cancer surveillance. The morning consisted of presentations and discussion on exposure surveillance. Dr. Paul Demers of the University of British Columbia gave an overview of CAREX, a tool that is being used to produce crude estimates of the number of workers exposed to a range of carcinogens in both Ontario and British

Columbia. Mr. Bob Kusiak of the Ontario Ministry of Labour outlined how the CIHI Discharge Abstract Database (DAD), which contains data on hospital discharges across Canada (Quebec data not included), can be used for surveillance and research of medical conditions that are potentially associated with occupational exposure (e.g. silicosis). Dr. Willem Sont of Health Canada described the National Dose Registry. This centralized radiation dose exposure database has been linked with other databases to look at a number of health outcomes, including cancer and adverse reproductive outcomes, as a function of occupational radiation exposure. Dr. Jack Siemiatycki of the University of Montreal provided a historical overview of work in the area of expert assessment of occupational exposures in Montreal and the limitations of this approach in being able to extend it to larger workforces to allow the comparison of rates of cancer by job title.

The day concluded with presentations from Dr. Eric Holowaty on the experience of United States cancer registries collecting occupational history information. Dr. Loraine Marrett outlined preliminary work conducted at Cancer Care Ontario on the burden of mesothelioma in Ontario. Dr. Michel Camus concluded the day with a presentation of the burden of mesothelioma in Quebec.

The second day of the workshop focussed on the use of large databases, including record linkage, to generate hypotheses for more detailed research investigation (referred to as "surveillance research"). Mr. Rick Gallagher provided an overview of the occupational epidemiology program at the BC Cancer Agency, funded in part by the BC Workers' Compensation Board, including the objectives, research team and study designs ranging from mortality
to case-control to cohort. Participants were also shown sample Web pages from the Registry of Occupational Cancer Risk and Exposure Information in BC , which will be made available to external users in the coming months. Dr. Kristen Aronson presented work performed in cooperation with Statistics Canada that resulted in a database of 1970sera national employment surveys linked with death records of workers these surveys identified. The objectives were to develop a monitoring system to detect previously unsuspected potential associations between the workplace and specific causes of death. Dr. Cam Mustard gave an overview of a study now underway that links occupational information collected on the long-form of the 1991 Census for approximately 4.5 million residents with mortality data from the National Mortality Database from 1991 through 2001. The linkage will result in a database that can be used to answer many questions regarding the cancer risk as a function of occupation.

These presentations were followed by another series that focussed specifically on Statistics Canada and its repository of large databases that can be accessed for research studies. Following a presentation by Mr. Luc Albert of Statistics Canada on the policy for record linkage that is consistent with current privacy legislation, Ms. Karen Roberts provided an overview of databases held at Statistics Canada and various studies that have made use of them, either alone or linked with others. Finally, Dr. Robert Schnatter of ExxonMobil Biomedical Sciences gave an overview of surveillance work carried out for ExxonMobil. Dr. Schnatter concluded that linkage systems can be used for occupational health surveillance, which itself can provide the needed data on potential health risks and provide the evidence to help shape prevention programs.

[^8]
## Conclusion

Participants agreed that surveillance priorities should be developed as a function of what data are currently available, what is already known about exposures in relation to certain cancers, what is already known about the prevalence of certain exposures in Ontario workplaces, and what has been shown to be feasible in other jurisdictions in Canada. A focus on a few specific carcinogens could make for some early success stories which would then form the basis for expanding the scope of the work.

Much of the discussion from the second day focused on how to develop the infrastructure needed to carry out work in the area of occupational cancer, be it at the provincial or federal level. Similarly, this infrastructure is required in both the areas of surveillance as well as research. Lessons can be learned in terms of what has worked in the past in the provinces of Quebec and British Columbia, which both have a record of work in this area.

Cancer Care Ontario is now developing priorities in the area of occupational cancer surveillance, which will be put forward to both Cancer Care Ontario and the Ontario Workplace Safety \& Insurance Board as potential next steps in developing an occupational cancer surveillance system in Ontario.

## Acknowledgements

The workshop was made possible by the contributions of Cancer Care Ontario and the Ontario Workplace Safety \& Insurance Board. Special thanks go to Ms. Anisha Abreo and Ms. Lori-Ann Larmand for their help in organizing the workshop, to Dr. Fred Ashbury for his work in facilitating the workshop, to Ms. Bronwen Waller for her help in summarizing responses to the pre-workshop questionnaire and to the workshop evaluation, to the break-out group chairs and notetakers, to the individual speakers, and to the participants, all of whom contributed to the success of the workshop.

For further information on the workshop, including speaker slides and break-out group discussion materials, please refer to the Cancer Care Ontario Web site (www. cancercare. on.ca) or write directly to the following address: Public Affairs, Cancer Care Ontario, 620 University Avenue, Toronto, Ontario M5G 2L7

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## 2004 Peer Reviewers

In the Winter 2005 issue of CDIC, we neglected to express our heartfelt gratitude to our reviewers of 2004 for their valuable contributions of time and expertise:

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## Calendar of Events

| 23-24 October, 2005 <br> Salt Lake City, Utah, USA | $14^{\text {th }}$ Annual Meeting International Genetic Epidemiology Society | <http://www.biostat.wustl.edu/ ~ genetics/iges/ meetings.html > |
| :---: | :---: | :---: |
| 23-26 October, 2005 <br> Vancouver, British Columbia, Canada | $1{ }^{\text {st }}$ International Cancer Control Congress | < http://www.cancercontrol2005.com> |
| 6-9 November, 2005 <br> Ottawa, Ontario, Canada | $12^{\text {th }}$ Canadian Conference on International Health: Your Money or Your Life: Health in the Global Economy | < http://www.csih.org/what/conferences2005.html > |
| 9-12 November, 2005 <br> Gatineau, Québec, Canada | Canadian Society for Exercise Physiology's annual scientific conference Ideas to Action: Healthy Living in Canada | < http://www.cpha.ca/english/conf/CSEP_05 Programme_1.pdf > |
| 10-14 December, 2005 <br> Philadelphia, Pennsylvania, USA | American Public Health Association $133^{\text {rd }}$ annual meeting: Evidence Based Policy and Practice | e-mail:diane.lentini@apha.org <br> < http://www.apha.org/meetings/future_past.htm > |
| $\begin{aligned} & \text { 6-8 May, } 2006 \\ & \text { Montréal, Quebec, Canada } \end{aligned}$ | Canadian Breast Cancer Research Alliance Reasons for Hope 2006 - CBCRA's $4^{\text {th }}$ Scientific Conference | Susan Wall <br> Coordinator, Conferences and Meetings <br> Tel.: (416) 596-6598 x 313 <br> E-mail: swall@cbcf.org <br> < http://www.breast.cancer.ca/reasons_for_hope_ conferences/Default.asp?language $=$ English > |
| 3-6 December, 2006 <br> Winnipeg, Manitoba, Canada | $7^{\text {th }}$ Canadian Immunization Conference | < http://www.phac-aspc.gc.ca/cnic-ccni/index.html > |

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Cover letter: Signed by all authors, stating that all have seen and approved the final manuscript and have met the authorship including a full statement regarding any prior or duplicate publication or submission for publication.

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Second title page: Title only; start page numbering here as page 1 .


#### Abstract

Unstructured (one paragraph, no headings), maximum 175 words (100 for short reports); include 3-8 key words (preferably from the Medical Subject Headings (MeSH) of Index Medicus).


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[^7]:    Occup = occupational
    1 For each pairwise Spearman rank correlation $\left(r_{s}\right)$, the weighted correlation coefficient is shown, followed by the unweighted sample size contributing to the co-efficient (in brackets).
    2 Highest level of education among household members aged 25 and older.
    3 Highest level of occupational prestige among household members aged 25 and older, based on the Pineo-Porter-McRoberts occupational prestige measure.
    4 Highest Blishen SES Index score among household members aged 25 and older.
    5 Categories of household income adequacy, taking household size into account.
    6 Income quintiles at the EA level, adjusted for region and household size.
    7 Average household income at the EA level (no adjustments for region or household size).
    8 At the EA level, proportion of residents over age 15 estimated to have graduated from secondary school.
    9 At the EA level, proportion of residents over age 15 and in labour force, estimated to be employed.
    $\dagger$ Weighted using NPHS sampling weights.

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