Original Investigation

Secondhand Smoke Exposure Among Canadians: Cotinine and Self-Report Measures From the Canadian Health Measures Survey 2007–2009

Suzy L. Wong, Ph.D., Eric Malaison, M.Sc., David Hammond, Ph.D., & Scott T. Leatherdale, Ph.D.

1 Health Analysis Division, Statistics Canada, Ottawa, Ontario, Canada
2 Tobacco Research Division, Office of Research and Surveillance, Controlled Substances and Tobacco Directorate, Health Canada, Ottawa, Ontario, Canada
3 School of Public Health and Health Systems, University of Waterloo, Waterloo, Ontario, Canada

Corresponding Author: Suzy L. Wong, Ph.D., Health Analysis Division, Statistics Canada, 100 Tunney’s Pasture Driveway, RHC-24K, Ottawa, Ontario, Canada, K1A 0T6. Telephone: 613-951-4774; Fax: 613-951-3959; E-mail: suzy.wong@statcan.gc.ca

Received February 21, 2012; accepted July 14, 2012

Abstract

Introduction: Secondhand smoke (SHS) exposure is associated with numerous adverse health effects, including cancer, cardiovascular disease, asthma, respiratory infections, and decreased pulmonary function. This study provides population estimates of SHS exposure among the Canadian non-smoking population based on self-report and urinary cotinine concentrations.


Results: An estimated 22% of nonsmokers reported being exposed to SHS every day or almost every day. Of those, 70% of children (6–11 years) and 48% of adolescents (12–19 years) had detectable cotinine levels compared with 23% of adults (20–79 years). An estimated 77% of nonsmokers exposed to SHS only in the home had detectable cotinine levels compared with 11% of nonsmokers exposed to SHS only outside the home. Of those exposed to SHS only in the home, a higher percentage of children (5.1%) had detectable cotinine levels compared with adults (3.1%).

Conclusions: Despite well-known health risks associated with exposure to tobacco smoke, a substantial proportion of the Canadian population continues to be exposed to SHS. Higher percentages of certain subpopulations had detectable cotinine concentrations, including children, adolescents, and those exposed to SHS in the home.

Introduction

The health risks associated with exposure to secondhand smoke (SHS) are well documented and widely recognized. SHS exposure is associated with numerous types of cancer, cardiovascular disease, asthma, respiratory infections, and decreased pulmonary function (U.S. Department of Health and Human Services [USDHHS], 2006; U.S. Environmental Protection Agency [USEPA], 1992). SHS has been classified by the U.S. EPA as a Class A carcinogen (USEPA, 1992) and the U.S. Surgeon General concluded that there is no safe level of exposure to tobacco smoke (USDHHS, 2006). Tobacco-related illness costs Canadians billions of dollars each year in health care expenditures, with additional indirect costs such as lost productivity, longer term disability, and premature death (Rehm et al., 2006).

Although exposure to SHS declined during 2000–2005, there remains a substantial proportion of Canadians that are exposed to SHS (Shields, 2007). In 2005, 23% of nonsmokers reported being exposed to SHS in the home, vehicles, and/or public places every day or almost every day (Shields, 2007). Further, a greater proportion of youth reported being exposed to SHS. Of nonsmokers aged 12–17 years, 40% reported being regularly exposed to SHS in at least one location compared with 31% for those aged 18–34 and 19% for those aged 35–64.

Previous Canadian national surveys have been limited to self-report measures of SHS exposure (Gilmore, 2002; Health Canada, 2010b; Statistics Canada, 2010). However, objective measures of SHS exposure exist. Cotinine measurements in serum, urine, and saliva are a commonly used and widely accepted biomarker of exposure to tobacco smoke (Benowitz, 1999). Cotinine is the major metabolite of nicotine, with
a half-life of about 16–20 hr (Jarvis, Russell, Benowitz, & Feverabend, 1988). It is considered an accurate quantitative measure of recent exposure to tobacco smoke due to its high sensitivity and specificity (Jarvis, TunSTALL-Pedoe, Feverabend, Vesey, & Saloojee, 1987) and can provide an objectively measured estimate of the extent of nonsmokers’ recent exposure to SHS.

Research based on cotinine concentrations has shown that children may be at greater risk of SHS exposure (Centers for Disease Control and Prevention [CDC], 2010). Data from 2007–2008 from the United States have shown that the percentage of nonsmokers with detectable serum cotinine was highest for children aged 3–11 years (53.6%) compared with adults aged 20 and older (36.7%; CDC, 2010). Reductions in SHS exposure in Canada and the United States have been attributed to widespread implementation of legislation that prohibits smoking in workplaces and public places (Pirkle, Bernert, Caudill, Sosnoff, & Pechacek, 2006; Shields, 2007; USDHHS, 2006). However, private settings, such as homes, represent a major source of SHS exposure for many individuals, particularly children (CDC, 2010). Moreover, children are least able to remove themselves from SHS exposure in the home (Ashley & Ferrence, 1998). Indeed, although home SHS exposure declined for all ages in the United States, it was not uniform across ages. From 1988–1994 to 1999–2004, home SHS exposure declined by 37.7%, 44.9%, and 59.8% among those aged 4–11 years, 12–19 years, and 20 years and older, respectively (CDC, 2008).

The Canadian Health Measures Survey (CHMS) 2007–2009 addressed the limitations of previous surveys by providing the first nationally representative measures of cotinine in Canada and including respondents as young as 6 years. Thus, the objective of this study was to examine the extent of exposure to SHS among the Canadian nonsmoking population aged 6–79 based on self-report and urinary cotinine concentrations.

**Methods**

**CHMS**

The CHMS is a nationally representative, cross-sectional survey that covers the Canadian household population aged 6–79 years. Full-time members of the Canadian Forces and residents of Crown lands, Indian reserves, institutions, and certain remote regions were excluded. The survey was designed to provide national-level estimates by age group (6–11, 12–19, 20–39, 40–59, and 60–79 years) and sex, for a total of 10 age–gender groups. The area frame of Canada’s well-established, national survey, the Labour Force Survey, was used to select the collection sites. The Labour Force Survey geographic units used to define the sites were also grouped with respect to provincial and census-metropolitan-area boundaries and population density criteria. Using this frame, 257 sites were created. These sites were stratified based on five regions of Canada. It was determined that a sample of 15 collection sites would be required. Within each region, sites were sorted according to the size of their population and whether or not they belonged to a census metropolitan area. Sites were randomly selected using a systematic sampling method with probability proportional to the size of each site’s population. Within each of the 15 selected sites, the list of the 2006 Census dwellings were used as a frame. Using the date of birth of household members present at the 2006 Census, dwellings were stratified according to the five age groups. The sample was allocated in each stratum to obtain an equal number of respondents by age group. Selected dwellings were asked for the household member list at the time of the survey and one or two persons per household were selected to participate in the survey. The selection of persons was done randomly and used a vector with variable selection probabilities by age group. Additional details of the sampling strategy have been published elsewhere (Giroux, 2007). Data were collected from March 2007–February 2009. The sample represented approximately 96% of the population.

In order for estimates produced from the survey data to be representative of the population covered and not merely of the sample itself, weighting factors (survey weights) must be incorporated into the statistical analyses. A survey weight was assigned to each person who responded to the entire survey. This weight corresponded to the number of people represented by the respondent in the population as a whole. The CHMS used two sampling frames for selecting its sample: an area frame of geographic units for constructing and selecting collection sites, and an area frame of dwellings within each site. In accordance with the weighting strategy, the selection weights for collection sites were multiplied by the selection weights for dwellings, adjusted for nonresponse. Following the conversion of household weights into person weights, the latter were adjusted for nonresponse at the interview stage and the mobile-examination-center stage, and with several other adjustments, this weight became the final person weight. Details of the survey weights, including all of the adjustments, are available elsewhere (Statistics Canada, 2011).

The CHMS consisted of a household interview to gather information on sociodemographic characteristics, health, and lifestyle, followed by a visit to a mobile examination center to perform direct measurements, including the collection of blood and urine samples. Of the households selected for the CHMS, 69.6% agreed to participate. One or two members of each responding household were invited to participate in the survey. Of these, 88.3% responded to the household questionnaire. Of those who completed the questionnaire, 84.9% reported to the mobile examination center for direct measurements, resulting in a total sample size of 5,604 respondents. The overall response rate, after adjusting for the sampling strategy, was 51.7%. Ethics approval for conducting the CHMS was obtained from Health Canada’s Research Ethics Board. Written informed consent was obtained from participating respondents. Of those who completed the questionnaire, 84.9% reported to the mobile examination center for direct measurements, resulting in a total sample size of 5,604 respondents. The overall response rate, after adjusting for the sampling strategy, was 51.7%. Ethics approval for conducting the CHMS was obtained from Health Canada’s Research Ethics Board. Written informed consent was obtained from participating respondents. Participation was voluntary; respondents could opt out of any part of the survey at any time. Additional information about the survey is available in previously published reports (Bryan, St-Denis, & Wojtas, 2007; Day, Langlois, Tremblay, & Knoppers, 2007; Giroux, 2007; Tremblay, Langlois, Bryan, Esliger, & Patterson, 2007; Tremblay, Wolfson, & Gorber, 2007) and on Statistics Canada’s Web site (http://www.statcan.gc.ca).

**Household and Mobile Examination Interview**

During the household interview, respondents were asked about smoking behavior, exposure to SHS and use of medications. Respondents aged 12–79 were asked if they smoked cigarettes.
daily, occasionally or not at all, at the present time. Those who responded not at all were considered nonsmokers. All respondents aged 6–11 years were assumed to be nonsmokers and were not asked any of the smoking behavior questions.

Respondents were asked if they were exposed to SHS in the past month inside their home every day, almost every day, at least once a week, at least once in the past month, or never. Those who responded every day or almost every day were considered to be regularly exposed to SHS in the home. Respondents were also asked if they were exposed to SHS every day or almost every day (a) in a car or other private vehicle, (b) in public places, such as bars, restaurants, shopping malls, arenas, bingo halls, bowling alleys, or (c) at their place of work (respondents aged 12–79 years only), within the past month. Respondents who answered “yes” were considered to be regularly exposed to SHS from each of these sources.

Respondents aged 12 years and older were asked if they smoked cigars or a pipe or used snuff or chewing tobacco in the past month. During the household interview, respondents were asked if they used any prescription or over-the-counter medications in the past month. During the mobile-examination-center visit, respondents were asked to confirm the medications they had previously reported using, if there were any other medications they were using, and to report the last time all medications were taken. Reported medications, including those for nicotine replacement therapy, were coded according to the Anatomical Therapeutic Codes.

Parents and guardians were invited to be present and assist respondents aged 6–11 years in responding to interview questions. For respondents aged 12–19 years, parents and guardians were requested to leave the room when questions about sensitive topics, including smoking, were being asked in order to facilitate obtaining honest and accurate answers.

### Urinary Cotinine Analysis

Respondents were asked to refrain from smoking for a 2-hr period prior to the mobile-examination-clinic visit. The mean compliance rate (agreement to provide the sample among eligible respondents) across data collection sites was 97% (range: 95.0%–98.8%). The mean duration between household interview and mobile-examination-clinic visit was 14.7 days (range: 1–59). Urine was collected from 5,540 respondents. The spot midstream urine samples were collected at the beginning of each appointment in a 120-ml container. After collection at the mobile examination center, urine samples were frozen at −20 °C and shipped on dry ice to the testing laboratory at the Institut national de santé publique du Québec (INSPQ; accredited under ISO 17025). Free cotinine was recovered by solid-phase extraction in a 96-well plate format on an automated robotic workstation (INSPQ, Laboratoire de toxicologie, 2009). Deuterated cotinine was used as the internal standard. The extract was then redissolved into 250 µl of mobile phase and 10 µl were injected into the UPLC-MS-MS instrument, operated in the MRM mode with ion source in positive electrospray (INSPQ, Laboratoire de toxicologie, 2009). The limit of detection (the level at which the urinary concentration was so low that it could not be reliably or accurately determined by the laboratory test method) was 1.1 ng/ml.

### Statistical Analysis

Respondents were excluded from the analyses if they reported that they smoked cigarettes daily or occasionally at the present time (n = 818); did not have a valid cotinine test result, for example, insufficient volume of urine collected to test for cotinine (n = 77); reported using a medication with nicotine as an active ingredient (Anatomical Therapeutic Code N07BA01), such as nicotine replacement therapy, in the past month (n = 4); reported smoking cigars or a pipe, or using snuff or chewing tobacco in the past month (n = 258); reported being a nonsmoker, but had a urinary cotinine concentration above 50 ng/ml (it is generally accepted that a urinary cotinine concentration cutpoint of 50 ng/ml can be used to distinguish smokers from nonsmokers [SRNT Subcommittee on Biochemical Verification, 2002] and therefore a respondent with a urinary cotinine concentration above 50 ng/ml is not considered a nonsmoker for this study; n = 135). Some respondents met more than one exclusion criteria. This left a final sample size of 4,455.

The proportion of nonsmokers reporting regular exposure to SHS (i.e., exposure to SHS every day or almost every day in the home, private vehicles, public places, and/or workplaces) was calculated. The proportion of nonsmokers (overall, regularly exposed to SHS, and not regularly exposed to SHS) with detectable cotinine concentrations was also calculated. The proportion of nonsmokers with cotinine concentrations below the limit of detection was too high (>75%) to calculate meaningful geometric means. To examine SHS exposure by source of exposure, nonsmokers reporting regular exposure to SHS were categorized into one of three mutually exclusive groups: (a) regular SHS exposure only in the home, (b) only outside the home (i.e., only exposed to SHS in private vehicles, public places, and/or workplaces), and (c) in the home plus other (i.e., in the home and from at least one of private vehicles, public places, and workplaces). The proportion of respondents in each category, and the proportion with detectable cotinine levels, was calculated.

Where possible, results are presented overall by age group (ages 6–11 years [children], 12–19 years [adolescents], and 20–79 years [adults] years) and by sex. Statistical analyses were performed using SAS and SUDAAN software. To account for the survey design, the number of df was specified as 11 in the SUDAAN procedure statements and SE, coefficients of variation, and 95% CI were calculated with the bootstrap technique (Rao, Wu, & Yue, 1992; Rust & Rao, 1996) using replicate weights provided on the datafile. Differences between estimates were tested for statistical significance, established at the level of p < .05. For additional information on the measured cotinine levels, arithmetic mean, geometric mean, and percentile distributions of urinary cotinine, overall, by age group and sex, for the Canadian household population aged 6–79 years based on data from the CHMS, refer to the previously published report (Health Canada, 2010a) and Health Canada’s Web site (http://www hc-sc.gc.ca).

### Results

Overall, 22.4% of nonsmokers aged 6–79 years reported regularly being exposed to SHS in any of the four locations they were asked about (i.e., in the home, private vehicles, public places, and/or workplaces; data not shown). An estimated 24.6% of male and 20.3% of female nonsmokers reported regular SHS exposure...
Secondhand Smoke Exposure Among Canadians

The percentage of nonsmokers reporting regular exposure to secondhand smoke, by age group and sex, is shown in Figure 1. A significantly higher percentage of adolescents (12–19 years) reported being regularly exposed to SHS compared with children (6–11 years; $p < .001$) and adults (20–79 years; $p < .01$), respectively. A significantly higher percentage of adults reported regular exposure to SHS compared with children ($p < .001$).

The percentage of nonsmokers with detectable cotinine concentrations is shown in Table 1. There was a significantly higher percentage of children ($p < .01$) and adolescents ($p = .01$) with detectable cotinine concentrations compared with adults. There were similar differences between age groups for males ($p < .05$ for children vs. adults, $p < .05$ for adolescents vs. adults) and females ($p < .05$ for children vs. adults, $p = .06$ for adolescents vs. adults).

Among nonsmokers reporting regular exposure to SHS there was a significantly higher percentage of children ($p < .001$) and adolescents ($p = .01$) with detectable cotinine concentrations compared with adults, and a significantly higher percentage of children than adolescents with detectable cotinine concentrations ($p < .05$). There were similar differences between age groups for males ($p < .05$ for children vs. adults, $p < .05$ for adolescents vs. adults) and females ($p < .01$ for children vs. adults), although the difference between female adolescents and adults was borderline significant ($p = .05$).

Among nonsmokers reporting no regular exposure to SHS there was a significantly higher percentage of children with detectable cotinine levels compared with adults ($p < .01$) and for females ($p < .01$), but no other significant differences by age group or sex. Of nonsmokers aged 6–79 years, 16.0% reported regularly being exposed to SHS outside the home only, compared with 3.6% being exposed in the home only and 2.8% being exposed in the home and from at least one other source (private vehicle, public places, and workplace; data not shown).

The percentage of nonsmokers reporting regular exposure to SHS, by source of SHS exposure, is shown in Figure 2. Considering SHS exposure in the home only, there was a significantly higher percentage of children reporting regular exposure to SHS in the home only compared with adults ($p < .05$). Conversely, there was a significantly higher percentage of adolescents ($p < .01$) and adults ($p < .001$) reporting regular exposure to SHS outside the home only compared with children. Among those reporting regular exposure to SHS in the home and from at least one other source, there was a significantly higher percentage of adolescents compared with children ($p < .01$) and adults ($p < .01$).

The percentage of nonsmokers with detectable urinary cotinine concentrations, by source of SHS exposure, is shown in Table 2. Among nonsmokers reporting regular exposure to SHS only in the home, the majority (77.3%) had detectable cotinine levels. By comparison, 11.2% of nonsmokers reporting regular exposure to SHS only outside the home had detectable cotinine concentrations.

There was a significantly higher percentage of children with detectable cotinine levels compared with adults ($p < .05$) among nonsmokers reporting regular exposure to SHS only in the home, only outside the home ($p < .05$), and in the home and from at least one other source (private vehicle, public places, and workplaces; $p < .05$).
This is the first study to examine the extent of SHS exposure among the Canadian nonsmoking population using nationally representative measures of self-reported SHS exposure and cotinine, a biomarker of tobacco smoke exposure. Findings identified that a substantial number of Canadians are exposed to SHS at levels that result in detectable levels of cotinine, and that there were a number of differences among subpopulations.

An estimated 10% of nonsmokers aged 6–79 years had detectable urinary cotinine levels. Results from nationally representative surveys from other countries show substantially higher detectable cotinine levels among nonsmokers. In the United
States, 43% of those aged 4 years or older had detectable serum cotinine levels (Pirkle et al., 2006). In Germany, 51% of children (Conrad et al., 2010) and 23% of adults had detectable urinary cotinine levels (Heinrich et al., 2005). In United Kingdom, 59% of children (Jarvis, Sims, Gilmore, & Mindell, 2012) and 46% of adults had detectable salivary cotinine levels (Sims et al., 2011). However, these results are not directly comparable. Surveys differed in methodology, including the biological specimen tested (i.e., urine, saliva, and serum) and assay used, and data collection periods that ranged from as early as 1997–1999 (Heinrich et al., 2005) to as recent as 2007–2009 (CHMS).

An estimated 22% of nonsmokers reported being exposed to SHS every day or almost every day. A higher percentage of adolescents and adults reported being regularly exposed to SHS compared with children. However, of those, a higher percentage of children (70%) had detectable cotinine concentrations compared with adolescents (48%) and adults (23%). It is unlikely that these differences reflect underreporting due to a social desirability bias of parents/guardians assisting children in responding to questions, since a higher percentage of children reported regular exposure to SHS only in the home compared with adults. Existing literature reports no evidence of a difference in the rate of nicotine metabolism between children and adolescents compared with adults (Benowitz, Hukkanen, & Jacob, 2009). Thus, differences between self-reported exposure to SHS and detectable cotinine concentrations may reflect differences in aspects of SHS exposure that were not captured by self-report, such as the duration of exposure, the number of smokers present, the size of the space, and the amount of ventilation.

Approximately 5% of nonsmokers reporting no regular exposure to SHS had detectable cotinine levels. These may have included nonregularly exposed nonsmokers that were recently exposed to enough SHS to have detectable levels of cotinine, nonsmokers who were regularly exposed to SHS but did not report themselves to be, and occasional smokers who reported themselves to be nonsmokers.

A higher percentage of children reported regular exposure to SHS only in the home compared with adults. This is consistent with previous research that observed that nonsmoking children and adolescents are more likely to be exposed to SHS in the home compared with nonsmoking adults (CDC, 2010). This may reflect the fact that children and adolescents have more limited choice than adults in whom they live with, as well as less influence in controlling smoking behaviors of household members and regular visitors.

A higher percentage of adults and adolescents reported regular exposure to SHS only outside the home compared with children. As of January 2011, smoking was banned in indoor public places and workplaces (including restaurants, bars, and casinos) in all territories and provinces in Canada (Non-Smokers’ Rights Association [NSRA], 2010). However, at the time of data collection, smoking was permitted in indoor public places and workplaces in some jurisdictions (NSRA, 2010). Thus, the higher percentage of adults and adolescents reporting regular SHS exposure outside the home may reflect greater exposure from workplaces and the choice to spend time in public places where smoking was permitted.

The percentage of nonsmokers with detectable cotinine concentrations differed substantially depending on the source of SHS exposure. More than 75% of those regularly exposed to SHS only in the home, or in the home and at least one other source, had detectable cotinine concentrations. By contrast, less than 15% of those regularly exposed to SHS only outside the home had detectable cotinine concentrations. Consistent with previous research (Sims et al., 2010), these findings suggest that SHS exposure in the home contributes significantly to cotinine concentrations. The low percentage of detectable cotinine levels in those reporting regular exposure to SHS only outside the home may reflect differences in the nature and variability of SHS exposure in the home compared with outside the home. For example, SHS exposure in the home may occur for hours each morning.

Approximately 5% of nonsmokers reporting no regular exposure to SHS had detectable cotinine levels. These may have included nonregularly exposed nonsmokers that were recently exposed to enough SHS to have detectable levels of cotinine, nonsmokers who were regularly exposed to SHS but did not report themselves to be, and occasional smokers who reported themselves to be nonsmokers.

A higher percentage of children reported regular exposure to SHS only in the home compared with adults. This is consistent with previous research that observed that nonsmoking children and adolescents are more likely to be exposed to SHS in the home compared with nonsmoking adults (CDC, 2010). This may reflect the fact that children and adolescents have more limited choice than adults in who they live with, as well as less influence in controlling smoking behaviors of household members and regular visitors.

A higher percentage of adults and adolescents reported regular exposure to SHS only outside the home compared with children. As of January 2011, smoking was banned in indoor public places and workplaces (including restaurants, bars, and casinos) in all territories and provinces in Canada (Non-Smokers’ Rights Association [NSRA], 2010). However, at the time of data collection, smoking was permitted in indoor public places and workplaces in some jurisdictions (NSRA, 2010). Thus, the higher percentage of adults and adolescents reporting regular SHS exposure outside the home may reflect greater exposure from workplaces and the choice to spend time in public places where smoking was permitted.

The percentage of nonsmokers with detectable cotinine concentrations differed substantially depending on the source of SHS exposure. More than 75% of those regularly exposed to SHS only in the home, or in the home and at least one other source, had detectable cotinine concentrations. By contrast, less than 15% of those regularly exposed to SHS only outside the home had detectable cotinine concentrations. Consistent with previous research (Sims et al., 2010), these findings suggest that SHS exposure in the home contributes significantly to cotinine concentrations. The low percentage of detectable cotinine levels in those reporting regular exposure to SHS only outside the home may reflect differences in the nature and variability of SHS exposure in the home compared with outside the home. For example, SHS exposure in the home may occur for hours in a confined space, whereas SHS exposure outside the home may include respondents who report regularly being exposed at work if they walk past people smoking outside their building each morning.

Limitations of this study include the assumption that all children aged 6–11 years were nonsmokers. However, based on results from the 2006–2007 Youth Smoking Survey, 2% of youth in grades 5–9 (approximately aged 10–15 years) reported being current smokers (Health Canada, 2010b). For the 2008–2009 Youth Smoking Survey, students in grade 5 were not included for the first time since the survey’s inception in 1994 primarily due to the low smoking prevalence of this group (Health Canada, 2010b). Thus, it is unlikely that the assumption that children aged 6–11 years were nonsmokers had a substantial effect on the results of this study.

### Table 2. Percentage of Nonsmokers With Detectable Urinary Cotinine Concentrations by Self-Reported Source of Secondhand Smoke Exposure, Overall and by Age Group, Among the Household Population Aged 6–79 Years, Canada, March 2007–February 2009

<table>
<thead>
<tr>
<th>Source of Exposure</th>
<th>Only in the home % (95% CI)</th>
<th>Only outside the home % (95% CI)</th>
<th>In the home + other % (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total, 6–79 years</td>
<td>77.3 (62.2–87.3)</td>
<td>11.2 (7.5–16.2)</td>
<td>75.0 (61.4–85.0)</td>
</tr>
<tr>
<td>Total, 6–11 years</td>
<td>90.9 (80.1–96.2)</td>
<td>32.0 (16.1–53.7)</td>
<td>90.4 (84.6–94.2)</td>
</tr>
<tr>
<td>Total, 12–19 years</td>
<td>F</td>
<td>22.6 (10.2–42.7)</td>
<td>F</td>
</tr>
<tr>
<td>Total, 20–79 years</td>
<td>71.6* (50.7–86.1)</td>
<td>8.5* (5.0–14.1)</td>
<td>67.5* (41.7–85.7)</td>
</tr>
</tbody>
</table>

Note. F = estimate too unreliable to be reported (coefficient of variation > 33.3%).

*Significantly different from estimate for respondents aged 6–11 years (p < .05).

The presence of cotinine in the urine due to sources other than tobacco smoke exposure, such as the use of smokeless tobacco products and nicotine replacement therapy, was a potential confounding factor. Previous research has reported low levels (approximately 1% of adults) of underreporting of nicotine product use among U.S. National Health and Nutrition Examination Survey respondents (Yeager & Kronick, 2010). The extent of underreporting of smokeless tobacco products and nicotine replacement therapy by CHMS respondents is not known, however this study did exclude respondents that reported using them.

The delay between the household interview and the mobile-examination-clinic visit may have resulted in misclassifying respondents who experienced a major life change or made a significant change in behavior during that time. For example, a respondent who was regularly exposed to SHS in the home at the time of the household interview may have changed households and no longer been regularly exposed to SHS in the home at the time of the clinic visit. The mean duration of delay was 14.7 days, so the proportion of respondents experiencing a major life change within that timeframe was likely relatively low. Further, respondents who reported being nonsmokers at the household interview, became a smoker, and smoked recently would likely have a cotinine concentration above 50 ng/ml and been excluded from the analysis for this study. Overall, it is unlikely that the delay had a substantial effect on the results of this study.

For a given population, a lower limit of detection would result in a greater percentage of that population having detectable levels of cotinine. The limit of detection for the urinary cotinine assay used by the CHMS was 1.1 ng/ml. Limits of detection for other national surveys have been lower: 0.050 ng/ml and 0.015 ng/ml for the U.S. National Health and Nutrition Examination Survey (Pirkle et al., 2006) and 0.1 ng/ml for the Health Survey for England (Jarvis et al., 2012). However, these surveys measured serum and salivary cotinine, respectively. Although serum and salivary cotinine are approximately equivalent, urinary cotinine is not. This is evident as the generally accepted cotinine cutpoints to distinguish smokers from nonsmokers differ for serum or saliva (15 ng/ml) compared with urine (50 ng/ml; SRNT Subcommittee on Biochemical Verification, 2002). Urinary cotinine concentrations of 5 ng/ml and 10 ng/ml have been proposed as cutpoints to distinguish nonsmokers exposed or not exposed to SHS (Haufroid & Lison, 1998). Based on these cutpoints, those with undetectable levels of urinary cotinine in the CHMS would be considered nonsmokers not exposed to SHS. Further, the limit of detection for the cotinine assay used by the CHMS was lower compared with other national surveys measuring urinary cotinine: 2 ng/ml for the German Environmental Survey for Children (Conrad et al., 2010) and 4 ng/ml for the German Environmental Survey III (Heinrich et al., 2005).

The sample size of the survey did not permit analyses by age group, sex, and/or source of SHS exposure (home, vehicle, public places, and work) for some estimates. However, the CHMS does provide the first nationally representative cotinine data for Canada. Further, results of this study provide the baseline values upon which to examine trends over time. Pooling of data from additional cycles of the CHMS will enable more detailed analyses in the future.

Despite well-known health risks associated with exposure to tobacco smoke, a substantial proportion of the Canadian nonsmoking population continues to be exposed to SHS, with some subpopulations at greater risk of exposure. There was a significantly higher percentage of children and adolescents with detectable cotinine concentrations compared with adults. Further, a significantly greater proportion of nonsmokers reporting regular exposure to SHS only in the home, or in the home and at least one other source, had detectable cotinine levels compared with those reporting regular exposure to SHS only outside the home. Future studies using self-report to assess exposure to SHS may wish to consider the source of exposure, as well as duration of exposure, the number of smokers present, the size of the space, and the amount of ventilation, in order to more accurately characterize the extent of SHS exposure.

Funding

D.H. is supported by the Propel Centre for Population Health Impact, a Canadian Institutes of Health Research New Investigator Award, and the Canadian Cancer Society Research Institute Junior Investigator Award. S.T.L. is supported by a Cancer Care Ontario Research Chair.

Declaration of Interests

None declared.

Acknowledgments

The authors wish to thank Tracey Bushnik (Statistics Canada) and Johanne Levesque (Statistics Canada) for their contributions to this study.

References


Secondhand Smoke Exposure Among Canadians


Institut national de santé publique du Québec. Laboratoire de toxicologie. (2009). Analytical method for the determination of cotinine in urine by HPLC-MS-MS robotic workstation method (C-550), condensed version for CHMS. Québec, Canada: Institut national de santé publique du Québec.


