Estimation of smoking prevalence in Canada: Implications of survey characteristics in the CCHS and CTUMS/CTADS

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ABSTRACT

One of the main enterprises associated with tobacco control is surveillance, that is, to measure and follow over time the extent of smoking among the Canadian population. While surveillance systems have been in place for more than 50 years, knowing the exact prevalence of smoking in Canada continues to be a complex matter and understanding its estimation requires a critical appreciation of our national surveys' idiosyncrasies. This commentary describes the two Statistics Canada surveys that are most commonly used to examine smoking prevalence in this country: the Canadian Community Health Survey (CCHS) and the Canadian Tobacco, Alcohol and Drugs Survey (CTADS). It compares estimates of smoking prevalence obtained from each source and examines potential reasons for their noticeable discrepancies. Canadian researchers interested in smoking prevalence should be aware of current and future limitations, and should discuss and analyze these accordingly.

KEY WORDS: Canada; surveys and questionnaires; epidemiology; smoking

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Smoking continues to be a primary cause of morbidity and mortality in Canada. As a result of decades of successful public health interventions, Canada enjoyed a large decrease in prevalence with an approximate 60% relative reduction since the 1950s.¹ One of the main activities associated with such a massive endeavour has been surveillance, that is, to measure and follow over time the extent of smoking among the Canadian population. Currently, smoking prevalence measures continue to be a vital tool to assist researchers and policy-makers in better understanding what populations are initiating and persisting in smoking at the national, regional and subregional levels, and deciding which should be our priorities.

This commentary provides insight into a simple yet difficult-to-answer question: What is the prevalence of smoking in Canada? Many data sources can be used to estimate the extent of smoking behaviour in Canada and its provinces (e.g., a 2015 directory updated by the Ontario Tobacco Research Unit lists more than 60 sources²). In contrast to other countries, such as New Zealand, our national census does not inquire into Canadians' smoking status. The assessment of the prevalence of smoking in Canada, therefore, requires specific national surveys. To fulfill the mandate of producing representative estimates of smoking prevalence at the national and regional levels, Statistics Canada operates two main surveys: the Canadian Community Health Survey (CCHS) and the Canadian Tobacco, Alcohol and Drugs Survey (CTADS). Upon closer inspection, understanding the estimation of smoking prevalence requires a critical appreciation of these surveys and their idiosyncrasies.

While a definitive answer (or number) cannot be offered here, this commentary proposes to contribute to this issue by reviewing the two main data sources that are used to study smoking prevalence, examining how smoking prevalence is measured in

these surveys, and exploring potential reasons for their noticeable discrepancies.

ESTIMATING SMOKING PREVALENCE: THE CANADIAN COMMUNITY HEALTH SURVEY AND THE CANADIAN TOBACCO, ALCOHOL AND DRUGS SURVEY

The CCHS is a repeated cross-sectional survey created in 2000 that collects annually information related to health status, health care utilization and health determinants for the Canadian population. It collected and published information bi-annually from 2000–2001 through to 2007, whereupon it became an annual survey.³ The CTADS is a repeated cross-sectional survey created in 2013 to provide bi-annual data on tobacco, alcohol and drug use and related issues, with a focus on 15–24 year olds.⁴ The CTADS built upon the longstanding Canadian Tobacco Use Monitoring Survey (CTUMS), which repeated annually from 1999 until 2012, and was combined with Statistics Canada's last alcohol and drugs survey, the Canadian Alcohol and Drugs Use Monitoring Survey (CADUMS).

How do these surveys measure smoking? The most common definition of smoking is "current smoking status", which includes daily and non-daily (occasional) smokers based on responses to the question "At the present time do you smoke cigarettes every day,

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Figure 1. CCHS and CTUMS/CTADS estimates of current smoking prevalence. Prevalence estimates include both daily and occasional smoking.

occasionally, or not at all?”. This question was developed in the mid-1990s to standardize measures across Statistics Canada surveys.⁵ In order to ensure consistency, this question follows no skip patterns and its wording and ordering within the full questionnaire remains almost identical across surveys. Notably, the CTUMS/CTADS questionnaire adds the following preamble: “I am going to start with questions about cigarette smoking. Include cigarettes that are bought ready-made as well as cigarettes that you make yourself.”

Figure 1 presents the prevalence estimates in the CCHS and CTUMS/CTADS between 2001 (the first year of the CCHS) and 2013 (the latest available year for CTADS data when this commentary was written) (full estimates are given in Supplementary Table 1, in the ARTICLE TOOLS section on the journal website). During this period, smoking prevalence changed from 25.9% (95% CI: 25.6–26.3) to 19.3% (95% CI: 18.7–19.9) in the CCHS; and from 21.7% (95% CI: 20.6–22.9) to 14.6% (95% CI: 13.5–15.8) according to the CTUMS/CTADS. The latter reports a systematically lower smoking prevalence estimate than that of the CCHS. Percentage point differences varied from 2.1 (2003) to 4.7 (2013) with an average difference of 3.4 between surveys. Readers can compare the non-overlapping confidence intervals as a conservative test to confirm that the differences in estimates are statistically significant.

EXPLORING POTENTIAL REASONS FOR DISCREPANCIES BETWEEN SURVEYS

Why do these sources produce different smoking prevalence estimates? Statistics Canada’s Health Division addresses this concern by providing the following warning:

“Users should be aware of a number of differences between CCHS and CTADS. CCHS collects information from respondents aged 12 and over, CTADS collects information from respondents aged 15 and over; the two surveys use different sampling frames; the annual sample for CTADS is 20,000 compared to 65,000 for CCHS; in CCHS, smoking questions are asked in the context of a wide range of health-related behaviours whereas in CTADS, all questions are related to the use of multiple products and substances with addictive properties.”⁶

Table 1 presents and compares the main survey design elements of both surveys (i.e., coverage, sampling, non-response and measurement). Differences suggested here above can be summarized to age range, sampling frame, sample size and survey context. Some of these differences are unlikely to explain the lower prevalence systematically observed in the CTADS. First, the lower age group included in the CCHS (12+ versus 15+) should not produce a higher estimate because smoking rates at ages 12–14 years are significantly lower than those in the rest of the population. Second, the sample sizes used in both surveys are determined based on their statistical ability to provide precise estimates at the national level; therefore, they are unlikely to be at the base of their consistently different results. On the other hand, differences in sampling frame and questionnaire content may contribute to the discrepancies between CCHS and CTUMS/CTADS.

Statistics Canada has been aware of the potential for producing differences in smoking prevalence estimates across its different surveys since the development of the CTUMS and its first results in 2000–2001. A working group was formed to tackle this issue and a summary of findings from an unpublished internal report was made available online.⁵ This report explored several hypotheses related to sampling frame, use of proxy respondents, questions’ wording and ordering, mode of administration and survey context. Among these factors, two were deemed to be potential sources of bias. First, it was proposed that CCHS used a warmer contact approach: participants were contacted in advance for face-to-face interviews, and questions regarding smoking status were asked only after a bond of confidence was established. On the other hand, CTUMS resorted to phone interviews with no advance contacts, and surveyed smoking status earlier in their questionnaire. Second, the report referenced a study documenting discrepancies in the measurement of disabilities (i.e., an outcome liable to social desirability bias and under-reporting) and proposed that respondents could be more open to report their characteristics when it was done in a general health survey (i.e., CCHS) that did not label them as smokers.

The importance of these two factors may have changed since CTUMS’ inception. In particular, the new format of the CTADS may further influence the responses of respondents with the

Table 1. Survey characteristics of CCHS and CTUMS/CTADS

Survey elements	How can it introduce error?	How does this manifest in the CCHS and CTUMS/CTADS?
Coverage Target population Sampling frame	Coverage issues, either due to over- or under-coverage, may result in estimates inferring to a different population than the one targeted. Over-coverage is defined as the systematic sampling of individuals outside the target population. Under-coverage is defined as the systematic inability to sample certain individuals within the target population.	CCHS uses this operational definition for non-eligible individuals: "Excluded from these surveys' coverage are: persons living on reserves and other Aboriginal settlements in the provinces; full-time members of the Canadian Forces; the institutionalized population and persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James. Altogether, these exclusions represent less than 3% of the Canadian population aged 12 and over." CCHS changed its sampling frame in 2013 to cover a higher proportion of Canadians in Nunavut (from 71% to 92%). Notably, CTUMS/CTADS targets Canadians ages 15 and up, CTUMS/CTADS also does not sample residents of the Yukon, Northwest Territories and Nunavut. CCHS was developed to produce reliable estimates at the subprovincial (health region) level; CTUMS/CTADS was developed to produce reliable estimates at the provincial level. This should not introduce error unless sampling at the provincial level provides significantly different sampling probabilities to certain subregions and these probabilities are associated with smoking prevalence.
Sampling Sample size	Sample sizes have a higher chance of providing unreliable prevalence estimates due to random sampling error as they become smaller, especially if the outcome is rare. Statistics Canada often reports coefficients of variation to help interpret the variability of estimates.	CCHS surveyed approximately 130 000 individuals (i.e., 120 000 adults and 10 000 children between 12 and 17 years of age) in the 2001, 2003 and 2005 cycles, and 65 000 individuals in annual cycles since 2007; CTUMS/CTADS survey approximately 20 000 individuals in annual cycles. Both sample sizes were chosen by Statistics Canada based on their ability to produce reliable estimates at the mandated level (provincial or subprovincial).
Non-response Response rate	Non-response refers to eligible respondents who cannot be reached or who, upon contact, refused to participate. The influence of non-response on estimation depends on the distribution of non-response. Non-response that is completely at random (MCAR) should not bias prevalence estimates; non-response that is associated with correlates of smoking but not smoking (MAR) introduces bias that can be mitigated if researchers have information on these correlates' true distribution; non-response directly associated with the outcome (e.g., smoking) is non-random (MNAR) and introduces bias that cannot be corrected.	CCHS and CTUMS/CTADS use a two-step approach to measure response rates because they initially contact potential participants by reaching households randomly, and then participants randomly within that household. This produces two response rates (RR): household and person. Multiplying these, CCHS' overall RRs decreased from 84.0% in 2001 to 66.8% in 2013; CTUMS/CTADS' overall RRs decreased from 77.5% in 2001 to 63.1% in 2013. Results in Zhao et al. (2009) suggest that both surveys are liable to non-response bias as participants in the 2002 CCHS and 2004 CAS were more often married, educated and financially better off than the general population. ¹⁰ Complete information on RRs is available online (see Supplementary Table 2, in the ARTICLE TOOLS section on the journal website).
Measurement Questionnaire Respondent Mode of administration Mode of contact	Measurement error refers to systematic bias due to instrument design (e.g., survey questionnaire), the administrator (e.g., phone interviewer, data entry software) and other elements of the contact experience (e.g., respondent's capacity to complete the survey, mode of administration, mode of contact, etc.).	Both surveys use the same standardized question and ordering within the full questionnaire. A recent study examined participants of another Statistics Canada study, the Canadian Health Measures Survey (CHMS), and found that self-reported smoking status was a very strong surrogate of smoking status when compared with urinary cotinine, a biomarker associated with smoking (sensitivity = 92%, specificity = 98%). ¹⁶ This study found that sensitivity could be lower among certain participants, especially young men (76%), but differences were not statistically significant. Gilmore (2002) argued that mode of administration (including face-to-face interviews) and contact (providing advance contacts) in the CCHS could have lowered social desirability bias in contrast to the CTUMS/CTADS. ⁵

inclusion of alcohol- and drug-related issues. Drugs and alcohol surveys tend to have higher non-response rates, which in turn are known to be associated with smoking behaviour.^{7,8} This issue is especially problematic given the relatively strong association between cigarette smoking, alcohol and drug use among Canadians.⁹ This inclusion may have resulted in survey avoidance by potential respondents because of their alcohol or drug use. The extent of this influence is, however, unknown. Zhao et al. (2009) compared non-respondents in the 2004 Canadian Addictions Survey (CAS, a past iteration of the CADUMS) with those in the 2002 CCHS and found that their samples were not significantly different in terms of educational attainment, household income and marital status.¹⁰

Other factors have also changed in importance over time as well. For instance, the CCHS and CTADS use a slightly different sampling frame: the CCHS used a combination of an area frame

(40%–50%), lists of telephone numbers (40%–50%) and random-digit dialing (RDD) ($\pm 1\%$) to cover their sampling frame while the CTUMS/CTADS used an RDD-only strategy. RDD cannot reach potential respondents without landline phones (i.e., those without phones or with only cellphones). This sampling frame can translate into a potential selection bias because these individuals without landline are often younger, have lower incomes and also higher smoking rates.¹¹ In 2002, the Statistics Canada report comparing CCHS and CTUMS argued that these differences were marginal given that only a small percentage of the population did not have landline phones. This argument is however untenable today: in 2013, 21% of Canadian households and 60% of individuals aged 35 years or younger had a cellphone, but no landline phones.¹² Fortunately, CTADS updated their sampling frame in 2015 to include telephone lists that include cellphones.

DISCUSSION

Canadian public health policy and practice face continued challenges as a result of increasing social inequalities in smoking.^{1,13} Notably, this behaviour is increasingly concentrated within specific subpopulations, such as young adults and those who are socio-economically disadvantaged. This necessitates the continual adaptation of surveillance infrastructures, including the use of new survey methodologies, statistical approaches, and information technologies in order to provide the best evidence. There is considerable Canadian research devoted to finding solutions to survey-related issues that arise within the broader context of decreasing response rates and new information technologies.¹⁴ The application of new approaches in survey methodology nonetheless constitutes a considerable hurdle for longstanding surveys, as it hampers their ability to attribute changes in estimates to true behavioural changes rather than to changes in methodology themselves.

Beyond comparisons between CCHS and CTUMS/CTADS, another legitimate question is the extent to which the current utilization of these surveys produces unbiased estimates. The standard approach used to produce prevalence estimates (e.g., descriptive statistics with survey weighting) can also benefit from recent innovations that adjust for sources of error such as non-response and under-reporting in order to obtain stronger estimates of smoking prevalence. For instance, Zhao et al. (2009) used predictive models to correct for non-response associated with socio-demographic characteristics (e.g., marital status, educational attainment, household income) and obtained higher prevalence estimates of alcohol and drug use in the Canadian Addiction Survey, with percentage point differences ranging from 0.9 to 2.6.¹⁰ Likewise, Land et al. (2014) examined predictors of smoking status under-reporting during pregnancy and used a predictive model integrating socio-demographic correlates to produce more accurate smoking prevalence estimates among pregnant women (in their case, under-reporting lowered self-report estimates by values ranging from 1.1 to 1.9 percentage points).¹⁵

CONCLUSION

This commentary aimed to present how smoking prevalence is reported and measured in Canada and to introduce some of the challenges associated with its estimation. Researchers should be more critical of prevalence estimates taken at face value, especially when comparing sources with different methodologies and/or from other countries. Although these challenges influence single-point prevalence estimates, the trends produced by both surveys are extremely consistent over time. Rather than comparing smoking rates produced from the two surveys, Statistics Canada advises users to choose a single source, based on their objectives, and to use that source consistently.

Researchers need to acknowledge the uncertainty over the true value of smoking prevalence in order to address it. To this end, tobacco surveillance experts are encouraged to use multiple data sources and more precise estimation approaches whenever applicable, to systematically discuss their limitations when reporting on prevalence and its change over time, and to continue to explore how potential sources of error should guide the development and utilization of available data sources.

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RÉSUMÉ

L'une des principales entreprises associées à la lutte contre le tabagisme est la surveillance, c'est-à-dire la mesure et le suivi de l'ampleur du tabagisme dans la population canadienne. Bien que les systèmes de surveillance soient en place depuis plus de cinquante ans, connaître la prévalence exacte du tabagisme au Canada continue d'être une question complexe. La compréhension de son estimation nécessite ainsi une appréciation critique des particularités de nos enquêtes nationales. Ce commentaire décrit les deux enquêtes de Statistique Canada les plus couramment utilisées pour examiner la prévalence du tabagisme au Canada : l'Enquête sur la santé dans les collectivités canadiennes (ESCC) et l'Enquête canadienne sur le tabac, l'alcool et les drogues (ECTAD). Il compare les estimations de la prévalence du tabagisme obtenues à partir de chaque source et examine les raisons potentielles de leurs divergences. Les chercheurs canadiens qui s'intéressent à la prévalence du tabagisme devraient être plus conscients des limites actuelles et futures de nos données et travailler à les dépasser.

MOTS CLÉS : Canada; survols et questionnaires; épidémiologie; tabagisme