Title: Should alcohol policies aim to reduce total alcohol consumption? New analyses of Canadian drinking patterns

Running title: Drinking patterns and alcohol policy

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Abstract

Background: We investigated whether high-risk drinking patterns are restricted to a few high-volume drinkers or are evenly distributed across the population to inform discussion regarding the optimal mix of targeted versus universal prevention strategies.

Methods: Drinking patterns reported in the 2004 Canadian Addiction Survey (CAS, n = 13,909) were assessed against various low risk drinking guidelines. Under-reporting was assessed against known alcohol sales for 2004. Non-response bias due to the low response rate (47%) was investigated through comparisons with the 2002 Canadian Community Health Survey (CCHS). Results: Self-reported alcohol consumption for the past week and past year accounted for between 31.9% and 37.0% respectively of official alcohol sales data. Comparisons with the 2002 CCHS suggested only limited non-response bias. Many more respondents regularly placed themselves at risk of short-term harm (20.6%) than exceeded guidelines for avoiding long-term health problems (3.9%). Ten percent of respondents consumed more than 50% of total self-reported consumption. Most alcohol (73.4%) consumed by the sample in the previous week was drunk in excess of Canadian low-risk drinking guidelines – for 19 to 24 year olds this figure was 89.4%.

Interpretation: These data provide support both for universal prevention strategies (e.g. reducing economic and physical availability of alcohol) as well as targeted interventions for risky drinkers (e.g. screening and brief interventions in primary health care settings).

Key words: Alcohol, acute harm, chronic harm, drinking patterns, prevention, policy

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1. INTRODUCTION

Alcohol misuse contributes significantly to the burden of disease in Canada. In 2002, direct and indirect costs of alcohol misuse totaled $14.6 billion or $463 per capita. Direct alcohol-related health care costs alone totaled $3.3 billion. By comparison, direct health care costs for cardiovascular diseases were $7.7 billion and direct costs for cancer were $2.7 billion (Rehm et al 2006).

Two contrasting approaches to reducing alcohol-related public health and safety problems are (i) population-level policies that restrict overall consumption, for example, by controlling the physical and economic availability of alcohol (Babor 2003) and (ii) "targeted interventions" which focus on high-risk drinking, high-risk drinking settings and drinkers, for example, applying routine screening and brief interventions for at-risk drinkers in primary health care settings (Heather 2003). While specific programs and policies under both types of approaches have evidence of effectiveness (Toumbourou et al 2007), the relative investment in these two types of approach should also be informed by evidence of the extent to which alcohol related problems are primarily due to a small number of high risk drinkers or are evenly distributed across the whole population. While a relatively small number of heavy drinkers may account for a large proportion of alcohol consumption and a disproportionate amount of harmful outcomes, there is still the perception to be dealt with that whole of population or universal policies are somehow unfairly targeting low risk as well as high risk drinkers. This issue has also frequently

been discussed previously in the context of whether the Prevention Paradox applies to alcohol-related harm (Gmel et al 2001; Skog 2006; Stockwell et al 1996). Put simply, the Prevention Paradox applies if most cases of a particular variety of alcohol-related harm are experienced by the great majority of drinkers who on average drink low to moderate amounts rather than a relatively small number of high risk and heavy drinking individuals. Kreitman (1986) first advanced this argument in relation to alcohol generating much debate as well as a number of alternative analyses of patterns of drinking and risk of alcohol-related harm in different national surveys (Kreitman 1986). Kreitman (1986) then asserted that because the Prevention Paradox applied it followed that prevention strategies that addressed the drinking of the whole population were recommended. While there has since been some argument as to whether these findings are truly "paradoxical" (Stockwell et al 1996) most subsequent analyses and their commentators have concluded that patterns of hazardous alcohol use and related harms tend to be widely distributed across the entire population of drinkers thus supporting whole of population or "universal" prevention strategies concerned with the price and physical availability of alcohol (Gmel et al 2001; Skog 2006; Stockwell et al 1996). Stockwell et al (1996) in their analyses of Australian survey data suggested that the Prevention Paradox appeared to apply in relation to acute alcohol-related problems i.e. those associated with intoxication but not necessarily in relation to health and social problems caused by the more chronic effects of long-term consumption.

This paper will investigate the closely related issue of the nature of the distribution of patterns of hazardous drinking in the general population using a recent national Canadian alcohol and other drug use survey. Two related questions will be

addressed: (i) whether only a small minority of drinkers consume alcohol above low risk levels, and (ii) whether only a small proportion of all the alcohol consumed in a year is consumed above low-risk levels. These questions will be assessed for patterns of drinking that pose risks for short as well as long-term alcohol-related harms. A 2004 national survey of Canadians was analyzed to investigate the distribution of hazardous drinking assessed against both Canadian and international low-risk drinking guidelines in order to describe how 'spread out' or concentrated high-risk drinking patterns are in the general population.

Characterising drinking patterns with the use of self-report surveys is complicated by the extent of underreporting that occurs in even well-designed national surveys (Stockwell et al 2004). This problem is likely not unique to measures of alcohol consumption the population and may well apply to self reports of cigarette smoking and eating habits. There is, however, a tradition in alcohol epidemiology of estimating the extent of underreporting. When compared against official alcohol sales data, population surveys typically underestimate actual consumption by between 40% and 60% (WHO 2007). In the present study, the extent of such underreporting was assessed by comparing estimates of per capita alcohol consumption from Statistics Canada (2006) based on sales and tax data with those derived from the 2004 CAS (Statistics Canada 2006). While surveys almost invariably under-estimate the prevalence of risky drinking, it is important to bear in mind that most of the epidemiological studies upon which low-risk drinking guidelines are derived also used self-report survey methods (Bondy et al 1999; National Health and Medical Research Council 2001). It follows that while the extent of underreporting in drinking surveys is usually large, the estimates they generate of the

prevalence of risky alcohol consumption in the population, while certainly conservative, may not be so wide of the mark.

Another recently emerging problem with population-based telephone surveys such as the 2004 Canadian Addiction Survey (CAS) is that response rates have been falling over the last two decades (Greenfield et al 1999). The 2004 CAS had a substantially lower response rate (47%) than the equivalent Canadian survey (76%) conducted in 1994 (Adlaf & Rehm 2005). Encouragingly, a recent comparison of the results of a US telephone survey of drinking behaviour with a relatively low response rate corresponded closely with the results of a large US household survey with a much higher response rate (Greenfield 2000). The potential impact of non-response bias in the present study was investigated by comparing demographic and substance use variables in the 2004 CAS against the Canadian Census and also with results of the 2002 Canadian Community Health Survey (CCHS).

After discussing and evaluating the methodological limitations of the 2004 CAS, the implications of the substantive findings for direction of alcohol prevention policy will be discussed.

2. METHODS

2.1. Data source

The CAS was a national telephone survey of Canadians' attitudes, beliefs, and personal use of alcohol and other drugs (Adlaf & Rehm 2005) using a two-stage (household, respondent) random sample stratified by 21 regional areas. The survey used random-digit-dialing (RDD) and Computer Assisted Telephone Interviewing (CATI). The sampling frame was based on an electronic inventory (Statplus) of all active

telephone area codes and exchanges in Canada. Within each of the 21 strata defined by Statistics Canada's Census Metropolitan Area (CMA) versus non-CMA areas within each province, a random sample of telephone numbers was selected with equal probability in the first stage of selection. Within selected households, one respondent age 15 years or older who could complete the interview in English or French was selected according to the most recent birthday of household members. A minimum of 12 call-backs were placed to unanswered numbers and all households who refused to participate on the first contact were re-contacted in order to secure maximum participation. The CAS sample consisted of 13,909 respondents aged 15 years and over and represented some 24,214,815 Canadians aged 15 years and older. Descriptions of the CAS methodology are available elsewhere (Adlaf & Rehm 2005). The overall response rate for the CAS was 47%, substantially below the equivalent surveys in 1994 (75.6%) and 1989 (78.7%), reflecting the trend toward lower response rates in North American surveys (Greenfield et al 1999).

2.2. Procedures to assess non-response bias

Of the 59,795 selected telephone numbers (of which 29,573 were known to be eligible or estimated to be eligible), 13,909 respondents participated, representing an effective response rate of 47.0% in the 2004 CAS sample. Response rates varied from 43.6% in British Columbia to 51.1% in Manitoba signifying the potential for non-response bias (United Nations 2005). Assessing potential non-response bias can proceed in several ways. One can compare the results from the survey of interest with those from outside sources in order to assess whether there are significant differences in the value of specific parameters and estimates (United Nations 2005). Following this approach, we first compared demographic characteristics of the 2004 CAS sample to that of the 2002

Canadian Community Health Survey (CCHS) Cycle 1.2 to population data from the 2001 Canadian Census in order to assess differences between respondents and non-respondents. There are very similar demographic characteristics in the weighted CAS and CCHS samples to the census data. Second, we compared the prevalence of alcohol in the CAS sample to that estimated from the 2002 CCHS sample (which had a response rate of 77.0%) in order to assess whether there were significant differences in pattern of self-reported alcohol and illicit drug use between the two surveys. The CAS estimates are higher than the CCHS despite the much higher response rate in the latter. The information on CCHS cycle 1.2 can be found elsewhere (Statistics Canada 2003). Moreover, we correlated the response rates in 10 provinces with the alcohol use rates in order to evaluate the effects of non-response on drinking patterns. No significant association was found between lifetime and past 12-month alcohol uses and response rates (R=0.1055 and P=0.0971). In summary, these analyses did not suggest obvious non-response bias.

2.3. Estimating underreporting of alcohol consumption

We estimated annual alcohol consumption per adult aged 15 years and over based on the 2004 CAS data in order to identify the extent of underreporting alcohol consumption in the survey. Annual per capita alcohol consumption in litres was estimated using two methods: the Quantity-Frequency (QF) and the Last 7 Days (L7D). The QF and L7D methods are the usual methods and have frequently been used in estimating alcohol use in surveys (Stockwell et al 2004).

2.3.1. Estimating volume from QF method

The most widely used approach of alcohol consumption estimate is the Quantity-Frequency or QF method. The QF method asks for the overall frequency of drinking during the reference period and the usual number of drinks consumed on days when drinking took place. The QF method asks two questions: (1) "How often did you drink alcoholic beverages during the past 12 months?" The response options to this question include less than once a month, once a month, 2 to 3 times a month, once a week, 2 to 3 times a week, 4 to 6 times a week and every day. (2) "During the past 12 months, on those days when you drank, how many drinks did you usually have?" (Including light beer, but NOT include fully de-alcoholised beer). The category frequency response was converted to number of drinking days per year in order to estimate total volume of ethanol intake. The mid-point of the category was used as the frequency value to estimate days/year for each of the category. These two questions were multiplied to estimate alcohol consumption of each respondent in the last year. Annual per capita alcohol consumption in litres (Canadian standard drink=13.6 g ethanol) was estimated based on total alcohol consumption reported by those who had some alcohol consumption divided by 13,667 respondents aged 15 years and over ie the 98.33% complete cases. The percentage of estimated ethanol volume by QF method was then compared to official data on alcohol sales in order to gauge the extent of underreporting of self-reported alcohol consumption.

2.3.2. Estimating volume by L7D method

The L7D method requires people to complete a retrospective 'diary' showing how much alcohol they drank on each of the last 7 days (WHO 2007). The question used was:

"How many drinks did you have on Sunday?" and then repeated for each day of the preceding week. One advantage of using the L7D method is that recent recall may provide more reliable reporting, sometimes resulting in higher consumption estimates than the alternative approach of having respondents summarize their usual drinking patterns over a longer period (Lemmens et al 1992). The overall volume of ethanol for the week is the sum over all days of the number of drinks multiplied by the grams of ethanol (13.6 g) assumed to be in a standard drink. The annual volume of consumption is estimated as the weekly volume times 52. Annual per capita alcohol consumption in litres was estimated regarding total alcohol consumption reported by those who had some alcohol consumption divided by 13,873 respondents aged 15 years and over ie the 99.74% complete cases. Once again, the estimated total ethanol volume from the L7D method was compared to official alcohol sales data in order to estimate the underreporting of alcohol consumption.

2.4. Estimates of elevated and high risk drinking for acute and chronic harms

2.4.1. Criteria for drinking risk of acute and chronic harms

Since national low-risk drinking guidelines do not exist for Canada, we specified drinking risk levels for acute and chronic harms from two sources: (i) those suggested for Canadians by the Centre for Addiction and Mental Health (CAMH) in Ontario (Bondy et al 1999), and (ii) what we have termed "international drinking guidelines" which are consistent with both Australian guidelines (National Health and Medical Research Council 2001) and definitions of low risk drinking found in some WHO documents (National Health and Medical Research Council 2001; WHO 2007). These two sets of drinking guidelines are presented in Table 1. The CAMH guidelines suggest no more

than 2 standard drinks on any one day and up to 9 standard drinks a week for women and up to 14 a week for men with one Canadian standard drink defined as 13.6 g of ethanol (Bondy et al 1999). In contrast, the Australian national low-risk drinking guidelines suggest up to 6 standard drinks on any one day for men and up to 4 for women with one Australian standard drink defined as 10 g of ethanol (National Health and Medical Research Council 2001). Recently, more conservative low risk guidelines have been proposed for Australia (NHMRC, 2007). The low risk guidelines used by CAMH, Australia and implied by WHO were converted into Canadian standard drinks (13.6g of ethanol) to allow for direct comparison in Table 1. The Canadian CAMH guidelines are referred to as "lowest risk" denoting a level of drinking at which there is no or only a minimal risk of harm as well as possible health benefits for some older people in the population. “Low risk” levels are those defined in the 2001 Australian guidelines based on the level of drinking at which the risk of premature mortality is equal to that of people defined as abstainers in relevant prospective studies (National Health and Medical Research Council 2001). “Elevated risk” consumption levels are those at which risk of harm is significantly increased beyond any possible benefits and “high risk” drinking levels are those at which there is substantial risk of serious harm, and above which risk continues to increase rapidly (Bondy et al 1999; WHO 2007).

[Insert Table 1 here]

The extent of risky alcohol consumption was estimated for five age groups. For the youngest age group a cutoff of 18 years was chosen in the study since the minimum legal drinking is 19 years olds in most of the provinces in Canada.

2.4.2. Estimating the *proportion of people* drinking at levels that increase risk for acute and chronic harms

To assess each respondent's risk of harm from the chronic effects of alcohol, the average number of drinks consumed per week in the past year was calculated from their responses to the QF questions (i.e. quantity usually consumed per day X frequency of drinking days). The definitions of risk levels shown in Table 1 for risk of long-term or *chronic* effects of alcohol were then applied to these responses.

Respondents' risk of harm from the *acute* effects of alcohol was assessed from their responses to questions about how often in the past 12 months they had consumed more than five drinks (for men) or four drinks (for women) on a single occasion. Respondents reporting drinking at this level at least once a month were classified as at elevated risk for acute harm.

2.4.3. Estimating the *proportion of alcohol* consumed at risk levels for acute and chronic harms

The detailed answers of each respondent to how many drinks they had on each day of the preceding week (L7D method) were used to estimate what proportion of the sample's consumption was within or above the low risk drinking guidelines. To achieve this, the total number of drinks reported to have been consumed on each day was classified according to whether this was at a lowest, low or elevated/high risk for acute harm (see Table 1). The total number of drinks reported over the entire seven days was also classified for each respondent as to whether it was above or below recommended average weekly levels for reducing risks of long-term or chronic harm. Responses from

all respondents were then summed to develop descriptive statistics for all the alcohol reported consumed across the entire sample.

2.4.4 Describing the distribution of total and elevated risk drinking in the sample

The distribution of alcohol consumption in the sample was described by arranging all drinkers into deciles according to their average weekly intake of alcohol based on the last 12 months QF method. The proportion of total alcohol consumption in the whole sample contributed by each decile was then calculated. Starting with the top 10% of drinkers by volume, the cumulative contributions of each decile of drinkers to total alcohol consumption in the sample was plotted.

A similar procedure was then followed for describing the distribution of elevated risk drinking for acute and/or chronic harm in the entire sample. Using the same deciles of drinkers based on total volume of drinking reported in the last 12 months, the contribution of each decile of drinkers to total elevated risk consumption was estimated. Here elevated risk consumption was calculated from self-reported consumption in the last seven days (i.e. L7D method). Again starting with the heaviest 10% of drinkers by volume consumed in the past year, the cumulative contribution of each decile was plotted so as to describe the distribution of elevated risk consumption across the whole sample.

2.5. Statistical analyses

All estimates presented in this report were computed using SAS-9 (SAS Institute. 2004). Several survey procedures including PROC SURVEYMEANS, PROC SURVEYFREQ, and PROC SURVEYREG were used to produce estimates of alcohol consumption in the Canadian population aged 15 years and over and test statistical hypothesis, based on the 2004 CAS sample of 13,909 Canadians aged 15 years and over.

Statistical analyses were conducted using these procedures with the specifications of strata, cluster and weighting variables in the procedures to account for the complex sampling design (Canadian Centre for Substance Abuse 2004; SAS Institute. 2004).

Weights were used to restore population representation because the sample is allocated disproportionately to the provincial representation and reflected adjustments for non-response and post-stratification (Canadian Centre for Substance Abuse 2004). The weights for the CAS sample were based on 252 population classes, stratified by 21 regional areas, by six age groups and by sex. The precision and reliability of an estimate was evaluated using the 95% confidence interval (CI) and the coefficient of variation (CV). A 95% CI indicates that estimates would be within the CI 95 times if the same survey was conducted 100 times. The CIs for estimates obtained from the sample have been displayed in the tables. These CIs could be used to generalize the estimates to the population aged 15 and over in Canada. The reliability of an estimate was evaluated by examining the CV which is the ratio of the standard error to its estimate. The estimates with a CV from 0 to 16.5 are stable and reported without qualification (Adlaf & Rehm 2005). Estimates with a CV between 16.6 and 33.3 have moderate sampling variability and are reported with qualification. This suggests that the estimate might be unstable and might not generalizable to the population. Estimates with a CV greater than 33.3 are considered unstable and are suppressed in the analysis.

3. RESULTS

3.1. Under-reporting of actual alcohol consumption

Using the quantity-frequency (QF) questions from the CAS (2004), self-reported annual per capita consumption for Canadian was 2.96 (95% confidence interval: 2.74-

3.19) litres of ethanol or 37.00% of recorded alcohol sales (Ramstedt 2004). Using the reported number of standard drinks in the past 7 days, an even lower estimate of 2.52 (95% confidence interval: 2.05-3.05) litres of ethanol per adult is obtained respresenting 31.88% of actual recorded sales. Thus, self-reported alcohol consumption from the CAS greatly under-estimates actual consumption as compared to official sales data as is frequently found in national alcohol surveys (Stockwell et al, 2004).

3.2. Elevated and high risk drinking for acute and chronic harms

3.2.1. Percentage of Canadians drinking within guidelines to reduce risk of long-term health problems

Table 2 shows the percentages of respondents from the 2004 CAS whose average consumption per week over the last 12 months was within various low-risk guidelines by age group and sex. These data suggest that only a very small proportion (6.9%) of the Canadian population drinks in excess of the (Canadian) lowest risk drinking guidelines, and only 3.9% drinking in excess of the (Australian/international) low risk drinking guidelines. The proportions of respondents who were at different risk drinking levels is significantly different between age groups for males and females ($X^2_{(16df)}$=143.87 and P<0.001). For both genders, those most likely to report drinking above the low risk guidelines were young adults aged 19 to 24. While 5.2% of respondents aged 19-24 drank in excess of the low risk drinking guidelines, only 3.3% of those aged 15-18 and 25-39 did so.

[Insert Table 2 here]

3.2.2. Percentage of Canadians at elevated risk of short-term health problems from alcohol use

Table 3 shows that considerably more respondents reported engaging in drinking patterns that put themselves at risk of acute or short-term harms related to intoxication. While 20.6% in the sample met or exceeded these criteria for elevated or high-risk consumption, there was a significant difference in the proportion of respondents drinking at different risk levels across the age groups for males and females ($X^2_{(8df)}$=299.89 and P<0.001). Young adults aged 19 to 24 again reported exceeding the guidelines more frequently than any other age group at a rate of 43%. Those aged 65 and above (6.4%) were the least likely to be at the elevated and/or high risk levels. However, the estimate for those aged 65 years and over was unstable because of low cell sizes.

[Insert Table 3 here]

3.2.3. Percentage of Canadians at different drinking risk levels for acute and/or chronic harm

Table 4 presents the percentage of respondents abstaining, at different drinking risk levels for acute and/or chronic harm as defined in the drinking risk guidelines by age group among Canadians aged 15 years and over in 2004. All told, approximately 22% of Canadians aged 15 years and over met or exceeded risk drinking criteria for either acute and/or chronic harms. There was a statistically significant difference in the proportion of respondents drinking at or above risk levels between the five age groups for males and females ($X^2_{(8df)}$=953.07 and P<0.0001). Young adults aged 19 to 24 reported exceeding risk drinking guidelines more frequently than any other age group at a rate of 43.2%.

Those aged 65 and above (8.9%) were the least likely to be at the elevated and/or high risk levels.

[Insert Table 4 here]

3.2.4. Percentage of alcohol consumed by Canadians at different levels of risk for long-term health problems from alcohol use

Table 5 presents the percentages of alcohol consumed at different risk levels for chronic harm as defined in the drinking risk guidelines by age group among Canadians aged 15 years and over in 2004. As can be seen in Table 5, a quarter of all reported alcohol consumption was consumed *above* low risk levels for long-term harm. There was a significant difference in means of drinks at different drinking risk levels between the age groups for males and females ($F\text{-value}_{(4df)}= 13.16$ and $P<0.0001$). The proportion was highest (almost one third) among the age group consisting primarily of drinkers aged 65 year olds or over.

[Insert Table 5 here]

3.2.5. Percentage of alcohol consumed by Canadians at different levels of risk for short-term health problems from alcohol use

Table 6 presents the percentages of alcohol consumed at different risk levels for acute harm as defined in the drinking guidelines by age group among Canadians aged 15 years and over in 2004. All told, over 41% of all alcohol was consumed at levels that increase risk for short-term harm. There was no statistically significant difference in means of drinks at different drinking risk levels between age groups for males and females ($F\text{-value}_{(4df)}= 1.46$ and $P=0.2113$).

[Insert Table 6 here]

3.2.6. Percentage of alcohol consumed by Canadians at different levels of risk for long-term and/or short-term health problems from alcohol use

Table 7 presents the percentages of alcohol consumed at different risk levels for acute and/or chronic harm as defined in the drinking risk guidelines by age group among Canadians aged 15 years and over in Canada in 2004. As can be seen in Table 7, 52% of the alcohol was reported to have been consumed in ways that increase short and/or long-term risk as assessed against the less restrictive Australian/international drinking guidelines. When assessed against the more conservative CAMH "lowest" risk guidelines, as much as 73.2% of all the alcohol consumed in Canada was reported to have been consumed in patterns that elevate short and/or long-term risk. This proportion was highest among the age group consisting primarily of underage drinkers 15 to 18 year olds (91.8%), followed closely by young adults aged 19 to 24 at 89.4%. In this analysis there was a significant difference in means of drinks at different drinking risk levels between age groups for males and females ($F\text{-value}_{(4df)} = 13.16$ and $P<0.0001$).

[Insert Table 7 here]

3.2.7. The distribution of total and elevated risk alcohol consumption across the sample

Figure 1 attempts to describe the distribution of both total alcohol consumption and elevated risk alcohol consumption across the entire sample. For this Figure all current drinkers are categorised into deciles defined according to the volume of alcohol they consumed in the past year. These data suggest that a relatively small number of drinkers consumed the bulk of all alcohol consumed – the 10% who drank the most account for approximately 53% of the total volume and the heaviest 20% of drinkers account for approximately 72% of the total volume. The analysis also suggests that the

10% who drank the most accounted for approximately 60% of the total risky volume and the heaviest 20% of drinkers account for approximately 79% of the total risky volume.

4. Discussion

These descriptive analyses of Canadian drinking patterns provide support for both population level and targeted approaches. The main findings can be summarised as follows: (i) alcohol consumption and in particular elevated risk or high risk alcohol consumption tends to be concentrated in a relatively small number of drinkers with just 10% of the population consuming more than 50% of all the alcohol; (ii) while many people drink alcohol to excess on an occasional basis and place themselves at risk of acute or short-term harms (e.g., intentional and unintentional injuries, some strokes, interpersonal violence, etc.), a relatively small number of people report doing so with sufficient regularity to put themselves at risk of long-term harms (e.g., cirrhosis, some cancers); (iii) young drinkers are especially likely to drink in excess of low risk drinking guidelines; (iv) across all drinkers, almost three quarters of all the alcohol reportedly consumed in Canada according to the 2004 CAS was drunk in the pattern that was inconsistent with Canadian low risk drinking guidelines. While there was evidence of substantial underreporting of alcohol consumption and a relatively low response rate for the CAS (47%), it is unlikely these main patterns of results and contrasts (acute versus chronic risk, young versus old drinkers) are seriously compromised. These analyses suggest that that the appropriate combination of effective targeted and universal strategies will have complimentary and possibly even synergistic benefits in reducing the serious toll of alcohol-related harm in the Canadian population.

Many previous studies have found that per capita consumption estimates derived from survey-generated self-reports of drinking behavior achieved only 40 and 60% coverage of official estimates based on taxation and sales data (Pernanan 1974). Applying the Quantity-Frequency method to the 2004 CAS resulted in an estimate of per capita alcohol consumption for Canada of 2.96 litres of ethanol which accounts for 37.0% of recorded sales. Reasons for the underreporting of volume of consumption relative to sales data likely include sample limitations, type of questioning method, deliberate underestimation and poor recall (Midanik 1982; WHO 2007). Applying the Last Seven Days (L7D) method resulted in an even lower estimate of 2.52 litres of ethanol per person which accounts for only 31.9% of actual recorded sales. This result is counter-intuitive since most people recall more recent consumption better, though similar results have been reported before (Room 1990). This result might be associated with the time of year at which the interviews which were conducted which was between December 16, 2003 and April 21, 2004. A recent Canadian study found that alcohol consumption estimated from official sales data was 1.3 times higher between July and September than between January and March (Macdonald et al 2007). Marked seasonal trends have also been noted in US (Cho et al 2001) and European studies (Lemmens & Knibbe 1993).

The analysis presented here also suggests that a relatively small proportion of regular heavy drinkers account for the majority of alcohol consumed in Canada. Thus, if one were to enact a full range of targeted policies and programs and successfully reduce over-consumption among the heaviest 20% of drinkers, aggregate consumption would fall unless a substantial number of abstainers and light drinkers where somehow convinced to increase their consumption. It follows that both population health and

targeted interventions will result in reductions in annual per capita consumption of alcohol, thereby explaining the almost universal finding of strong relationships between overall rates of alcohol consumption and rates of both acute and chronic alcohol-related deaths (Skog 2001).

Those supporting the use of targeted approaches sometimes argue that population health approaches are questionable because they "punish the many for the sins of a few", based on the false assumption that only a minority of drinkers misuse alcohol in Canada (Stockwell 1995). In fact, the data presented here indicate that drinking above low-risk levels for acute harm is a common drinking pattern in Canada – especially for teenagers and young adults. Furthermore, the majority of alcohol consumed in Canada, (up to 73.4%) is consumed in ways that increase the health and safety risks of drinkers. And, to re-emphasize, these estimates are highly conservative given the substantial under-reporting in the 2004 CAS.

Another data limitation with the 2004 CAS was the low response of 47 % which is lower than prior national addiction surveys and thus, a potential source of non-response bias (Adlaf & Rehm 2005; United Nations 2005). Although the response rate is lower than some recent Statistics Canada surveys, it is similar to some comparable U.S. health surveys. For instance, the overall response rate for the 2002 Behavioral Risk Factor Surveillance System, one of the U.S. government's key surveillance surveys, was 45% (Centers for Disease Control and Prevention 2004). Moreover, the potential bias of non-response is not solely a function of the response rate (Adlaf & Ialomiteanu 2004). It is important to note that an evaluation of non-response bias through a comparison of demographic characteristics and key substance use indicators in the CAS sample and the

2002 CCHS and 2001 Canada Census data reported elsewhere (Zhao et al submitted) indicated that there were broadly similar demographic and substance use profiles in the CAS and CCHS samples and evidence only of a relatively small degree of under-estimation due to non-response bias. Surprisingly, the trends were actually opposite with significantly higher proportions of respondents reporting being drinkers in the 2004 CAS than the 2002 CCHS. This result is consistent with a study assessing non-response bias in college alcohol use surveys in Canada and the U.S (Kuo et al 2002) though is at odds with the discussion by Gmel and Rehm of non-response bias in alcohol consumption surveys (Gmel & Rehm 2004).

Another potential concern with the 2004 CAS is the requirement that potential respondents lived in households that were listed as having an active telephone landline. Whether drug use estimates would be significantly biased by projecting to all households depends on the size of non-telephone coverage rates and their demographic composition. Fortunately, Canada has high telephone coverage rates exceeding 97% (Groves & Couper 1998). As well, household surveys are limited to those residing in conventional households and are not intended as a sample of all possible adults (Adlaf & Rehm 2005). Thus, those in prisons, hospitals, military establishments, and transient populations such as the homeless were not included. These excluded groups often contain an especially large number of drug users and heavy drinkers (Rossi 1989). However, the size of such marginalized groups is small compared with the whole Canadian population and thus the total bias is probably minimal (Kandel 1991; Trinkoff et al 1990).

The population-level strategy with the strongest evidence for effectiveness is the maintenance of relatively high alcohol taxes (Babor 2003; Toumbourou et al 2007). It has

also been observed that taxation strategies are highly cost-effective in comparison with more labour and resource intensive treatment and prevention strategies (Canadian Centre for Substance Abuse 2004). Until the 2006 Federal Budget, alcohol excise taxes had not been raised in Canada since 1986, resulting in an effective reduction of 30% due compared with the cost of living (Stockwell et al 2006). Per capita alcohol consumption has increased from 7.2 litres in 1997 to 8.0 litres in 2006 (Statistics Canada 2007). It has also been recently advocated that a further increase in alcohol taxes could provide much needed revenue for Canadian mental health and addictions services (Stockwell et al 2006). The analyses presented in this paper suggest that population-level approaches would be an effective and fair means of both influencing the behavior of high-risk drinkers, who account for a majority of alcohol consumed in Canada, and also of reducing the overall health and social harms of alcohol misuse.

We suggest that our main conclusions are unlikely to be seriously compromised by certain evident weaknesses in the 2004 Canadian Addiction Survey including those already reported (principally the low response rate) and those uncovered in the present study. This is because the estimates of levels of at risk drinking reported here are clearly on the conservative side given the level of under reporting and even these conservative estimates indicate that a substantial proportion of all alcohol consumption in Canada is consumed above low-risk levels. However, future surveys of drinking behaviour in Canada would benefit from using alternative questioning methods such as the amount of alcohol consumed the day before the interview (the "Yesterday Method") proven to correct for the under reporting that is commonplace for both QF and Last 7 Day methods

(Stockwell et al 2007) by a variety of means, including developing a more accurate estimate of the actual amount of alcohol in a 'standard drink'.

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Table 1. Definitions of risk levels for LONG-TERM (chronic) and SHORT-TERM (acute) health effects of alcohol consumption in Canadian standard drinks (=13.6g ethyl alcohol) among Canadians

Risk level	Reference guidelines	# of Standard Drinks per week for Chronic Harm		# of Standard Drinks on any one day for Acute Harm	
		Male	Female	Male	Female
Lowest risk	Canadian, CAMH	1-14	1-9	1 - 2	1 - 2
Low risk	International	15-21	10	3 - 4	3
Elevated risk	International	22-30	11-21	5 - 7	4
High risk	International	31 +	22 +	8 +	5 +

Table 2. Percentages of respondents abstaining and drinking within different guidelines to reduce risk of long-term health problems by age group and sex among Canadians aged 15 years and over in Canada in 2004

Risk level of drinker	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Ages	
	N †	% †	N	%	N	%	N	%	N	%	N	%
Male												
Abstaining ‡	130	**32.5**	52	**8.0**	203	**12.3**	495	**19.2**	197	**27.9**	1,077	**18.2**
Lowest risk	270	**58.7**	454	**79.5**	1,173	**79.5**	1,674	**71.8**	394	**63.1**	3,965	**72.6**
Low risk	13	**Δ 2.9**	41	**7.7**	66	**4.2**	94	**3.8**	13	**Δ 4.8**	227	**4.4**
Elevated risk	6	**Δ 0.7**	25	**1.7**	39	**2.1**	53	**2.9**	20	**Δ 2.9**	143	**2.4**
High risk	11	**Δ 5.2**	17	**Δ 3.1**	38	**1.9**	54	**2.4**	4	**Δ 1.2**	124	**2.4**
Total	430	**100.0**	589	**100.0**	1,519	**100.0**	2,370	**100.0**	628	**100.0**	5,536	**100.0**
Female												
Abstaining ‡	107	**28.6**	87	**12.0**	386	**18.0**	889	**23.1**	541	**35.7**	2,010	**23.2**
Lowest risk	245	**70.1**	505	**77.0**	1,632	**78.5**	2,490	**72.4**	670	**59.7**	5,542	**72.0**
Low risk	4	**Δ 0.5**	18	**5.3**	26	**0.9**	41	**2.0**	3	**Δ 0.3**	92	**1.7**
Elevated risk	6	**Δ 0.5**	30	**Δ 4.0**	28	**2.1**	60	**1.9**	30	**Δ 4.2**	154	**2.5**
High risk	2	**Δ 0.3**	13	**Δ 1.7**	13	**Δ 0.5**	13	**Δ 0.6**	3	**Δ 0.1**	44	**0.6**
Total	364	**100.0**	653	**100.0**	2,085	**100.0**	3,493	**100.0**	1,247	**100.0**	7,842	**100.0**
Total												
Abstaining ‡	237	**30.6**	139	**9.9**	589	**15.2**	1,384	**21.1**	738	**32.4**	3,087	**20.8**
Lowest risk	515	**64.4**	959	**78.3**	2,805	**79.0**	4,164	**72.1**	1,064	**61.2**	9,507	**72.3**
Low risk	17	**Δ 1.7**	59	**6.6**	92	**2.6**	135	**2.9**	16	**Δ 2.3**	319	**3.0**
Elevated risk	12	**0.6**	55	**2.8**	67	**2.1**	113	**2.4**	50	**3.6**	297	**2.5**
High risk	13	**Δ 2.7**	30	**2.4**	51	**1.2**	67	**1.5**	7	**Δ 0.6**	168	**1.4**
Total	794	**100.0**	1,242	**100.0**	3,604	**100.0**	5,863	**100.0**	1,875	**100.0**	13,378	**100.0**

Note: † N=unweighted sample and %=weighted estimates. ‡ Those classified as abstainers include lifetime abstainers, who never consumed alcohol beyond sips or tastes, and former drinkers, who drank sometimes during their lives but not during the 12 months preceding the survey. Δ Unstable estimates due to low cell sizes and assessed against the value of coefficient of variation (CV) of 33.3 (Adlaf & Ialomiteanu 2004).

Table 3. Percentages of respondents abstaining, drinking at low risk or elevated/high risk levels for short term harm by age group and sex among Canadians aged 15 years and over in 2004

Risk level of drinker	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Ages	
	N†	%†	N	%	N	%	N	%	N	%	N	%
Male												
Abstainer ‡	130	**32.1**	52	**8.0**	203	**12.3**	495	**19.1**	197	**27.9**	1,077	**18.1**
Low risk	154	**32.0**	238	**44.7**	797	**54.6**	1,308	**56.6**	386	**61.3**	2,883	**53.9**
Elevated/high	151	**35.9**	306	**47.3**	527	**33.2**	577	**24.3**	46	**10.8**	1,607	**28.0**
Total	435	**100.0**	596	**100.0**	1,527	**100.0**	2,380	**100.0**	629	**100.0**	5,567	**100.0**
Female												
Abstainer ‡	107	**28.4**	87	**11.8**	386	**17.9**	889	**23.1**	541	**35.7**	2,010	**23.2**
Low risk	170	**49.2**	315	**49.7**	1,350	**66.9**	2,290	**67.5**	679	**61.2**	4,804	**63.4**
Elevated/high	93	**22.4**	261	**38.5**	360	**15.2**	319	**9.4**	27	**3.1**	1,060	**13.4**
Total	370	**100.0**	663	**100.0**	2,096	**100.0**	3,498	**100.0**	1,247	**100.0**	7,874	**100.0**
Total												
Abstainer ‡	237	**30.3**	139	**9.8**	589	**15.1**	1,384	**21.1**	738	**32.3**	3,087	**20.7**
Low risk	324	**40.5**	553	**47.1**	2,147	**60.8**	3,598	**62.1**	1,065	**61.2**	7,687	**58.7**
Elevated/high	244	**29.2**	567	**43.0**	887	**24.1**	896	**16.8**	73	**Δ 6.4**	2,667	**20.6**
Total	805	**100.0**	1,259	**100.0**	3,623	**100.0**	5,878	**100.0**	1,876	**100.0**	13,441	**100.0**

Note: † N=unweighted sample and %=weighted estimates. ‡ Those were classified into abstaining level included lifetime abstainers who never had an alcohol beyond sips or tastes and former drinkers who drank sometimes during their lives but not during the past 12 months preceding the survey. Δ Unstable estimates due to low cell sizes and assessed against the value of coefficient of Variation (CV) of 33.33 (Adlaf & Ialomiteanu 2004).

Table 4. Percentages of respondents at different risk levels for acute and/or chronic harm as defined in the drinking risk guidelines by age group and sex among Canadians aged 15 years and over in 2004

Risk level of drinker	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Age	
	N†	%†	N	%	N	%	N	%	N	%	N	%
Male												
Abstainer ‡	130	**32.1**	52	**8.0**	203	**12.3**	495	**19.1**	197	**27.9**	1,077	**18.1**
Low risk	154	**32.0**	236	**44.6**	791	**54.0**	1,291	**56.1**	371	**59.4**	2,843	**53.2**
Elevated/high	151	**35.9**	308	**47.4**	533	**33.8**	594	**24.8**	61	**12.7**	1,647	**28.7**
Total	435	**100.0**	596	**100.0**	1,527	**100.0**	2,380	**100.0**	629	**100.0**	5,567	**100.0**
Female												
Abstainer ‡	107	**28.4**	87	**11.8**	386	**17.9**	889	**23.1**	541	**35.7**	2,010	**23.2**
Low risk	170	**49.2**	313	**49.5**	1,341	**65.9**	2,261	**66.6**	656	**58.2**	4,741	**62.2**
Elevated/high	93	**22.4**	263	**38.7**	369	**16.1**	348	**10.3**	50	**6.0**	1,123	**14.6**
Total	370	**100.0**	663	**100.0**	2,096	**100.0**	3,498	**100.0**	1,247	**100.0**	7,874	**100.0**
Total												
Abstainer ‡	237	**30.3**	139	**9.8**	589	**15.1**	1,384	**21.1**	738	**32.3**	3,087	**20.7**
Low risk	324	**40.5**	549	**47.0**	2,132	**60.0**	3,552	**61.4**	1,027	**58.7**	7,584	**57.8**
Elevated/high	244	**29.2**	571	**43.2**	902	**24.9**	942	**17.5**	111	**8.9**	2,770	**21.5**
Total	805	**100.0**	1,259	**100.0**	3,623	**100.0**	5,878	**100.0**	1,876	**100.0**	13,441	**100.0**

Note: † N=unweighted sample and %=weighted estimates. ‡ Those were classified into abstaining level included lifetime abstainers who never had an alcohol beyond sips or tastes and former drinkers who drank sometimes during their lives but not during the past 12 months preceding the survey.

Table 5. Percentages of alcohol consumed at different risk levels for chronic harm as defined in the drinking risk guidelines by age group and sex among Canadians aged 15 years and over in 2004

Risk level of consumption	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Age	
	N†	%†	N	%	N	%	N	%	N	%	N	%
Male												
Lowest	687	**43.3**	1,976	**60.9**	4,097	**64.7**	5,453	**60.7**	1,028	**56.7**	13,241	**60.4**
Low	236	**11.3**	632	**19.5**	910	**12.4**	1,107	**11.7**	150	**19.6**	3,035	**14.0**
Elevated	84	**3.5**	491	**6.0**	582	**8.8**	877	**8.7**	332	**14.0**	2,366	**8.7**
High	253	**41.9**	560	**13.6**	1,214	**14.1**	1,358	**18.9**	119	**9.6**	3,504	**16.9**
Total	1,260	**100.0**	3,659	**100.0**	6,803	**100.0**	8,795	**100.0**	1,629	**100.0**	22,146	**100.0**
Female												
Lowest	466	**93.4**	1,209	**58.0**	2,441	**76.3**	3,826	**68.2**	817	**55.8**	8,759	**67.8**
Low	7	**0.7**	122	**11.4**	242	**5.3**	299	**9.6**	30	**1.7**	700	**7.3**
Elevated	52	**2.8**	407	**13.9**	233	**10.5**	596	**13.9**	274	**40.5**	1,562	**16.2**
High	37	**3.1**	299	**16.8**	258	**7.9**	238	**8.3**	57	**2.0**	889	**8.6**
Total	562	**100.0**	2,037	**100.0**	3,174	**100.0**	4,959	**100.0**	1,178	**100.0**	11,910	**100.0**
Total												
Lowest	1,153	**60.4**	3,185	**59.8**	6,538	**68.1**	9,279	**62.8**	1,845	**56.4**	22,000	**62.7**
Low	243	**7.7**	754	**16.6**	1,152	**10.3**	1,406	**11.1**	180	**13.5**	3,735	**12.0**
Elevated	136	**3.2**	898	**8.8**	815	**9.3**	1,473	**10.1**	606	**23.1**	3,928	**11.0**
High	290	**28.7**	859	**14.7**	1,472	**12.3**	1,596	**16.0**	176	**7.0**	4,393	**14.4**
Total	1,822	**100.0**	5,696	**100.0**	9,977	**100.0**	13,754	**100.0**	2,807	**100.0**	34,056	**100.0**

Note: † N=unweighted sample and %=weighted estimates. The N and % data do not coincide in this table since the N refers to numbers of drinkers and % to volume of alcohol.

Table 6. Percentages of alcohol consumed at different risk levels for acute harm as defined in the drinking risk guidelines by age group and sex among Canadians aged 15 years and over in 2004

Risk level of consumption	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Age	
	N†	%†	N	%	N	%	N	%	N	%	N	%
Male												
Lowest	120	**9.7**	461	**17.3**	1,485	**28.1**	3,236	**35.8**	928	**57.3**	6,230	**32.5**
Low	206	**26.6**	497	**14.7**	1,174	**18.7**	2,121	**25.3**	500	**32.2**	4,498	**23.0**
Elevated	287	**19.6**	660	**22.1**	1,402	**22.5**	1,682	**16.5**	172	**9.8**	4,203	**18.2**
High	647	**44.2**	2,041	**45.9**	2,742	**30.7**	1,756	**22.4**	29	**0.6**	7,215	**26.4**
Total	1,260	**100.0**	3,659	**100.0**	6,803	**100.0**	8,795	**100.0**	1,629	**100.0**	22,146	**100.0**
Female												
Lowest	119	**22.4**	347	**20.1**	1,316	**49.3**	3,182	**63.2**	1,008	**81.9**	5,972	**52.3**
Low	63	**7.9**	180	**9.3**	384	**12.6**	771	**14.2**	75	**13.5**	1,473	**12.5**
Elevated	92	**14.1**	192	**9.1**	360	**12.6**	388	**8.4**	28	**2.1**	1,060	**8.9**
High	288	**55.6**	1,318	**61.5**	1,114	**25.5**	618	**14.1**	67	**2.6**	3,405	**26.3**
Total	562	**100.0**	2,037	**100.0**	3,174	**100.0**	4,959	**100.0**	1,178	**100.0**	11,910	**100.0**
Total												
Lowest	239	**14.0**	808	**18.3**	2,801	**34.3**	6,418	**43.3**	1,936	**65.7**	12,202	**38.5**
Low	269	**20.2**	677	**12.8**	1,558	**16.9**	2,892	**22.3**	575	**25.8**	5,971	**19.8**
Elevated	379	**17.7**	852	**17.5**	1,762	**19.6**	2,070	**14.3**	200	**7.2**	5,263	**15.4**
High	935	**48.1**	3,359	**51.4**	3,856	**29.2**	2,374	**20.2**	96	**1.3**	10,620	**26.3**
Total	1,822	**100.0**	5,696	**100.0**	9,977	**100.0**	13,754	**100.0**	2,807	**100.0**	34,056	**100.0**

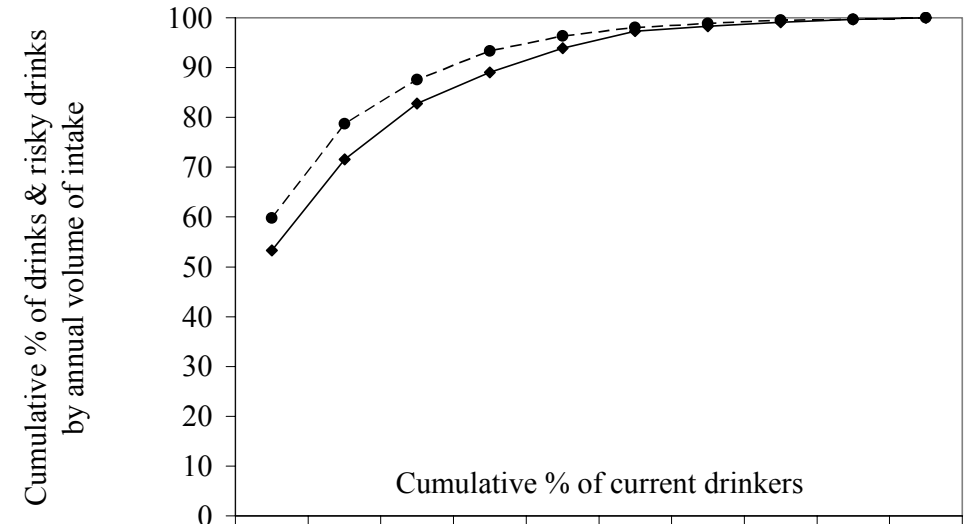
Note: † N=unweighted sample and %=weighted estimates. The N and % data do not coincide in this table since the N refers to numbers of drinkers and % to volume of alcohol.

Table 7. Percentages of alcohol consumed at different risk levels for acute and/or chronic harm as defined in the drinking risk guidelines by age group and sex among Canadians aged 15 years and over in 2004

Risk level of consumption	Age Group (Years)											
	15-18		19-24		25-39		40-64		65+		All Age	
	N	%	N	%	N	%	N	%	N	%	N	%
Male												
Lowest	62	**4.8**	220	**9.8**	952	**18.7**	2,221	**24.4**	748	**43.7**	4,203	**22.2**
Low	125	**11.6**	346	**13.2**	1,029	**18.1**	2,196	**26.6**	529	**35.3**	4,225	**22.9**
Elevated	291	**27.7**	618	**21.3**	1,441	**23.4**	1,935	**19.7**	206	**12.0**	4,491	**20.3**
High	782	**55.9**	2,475	**55.6**	3,381	**39.7**	2,443	**29.3**	146	**9.0**	9,227	**34.6**
Total	1,260	**100.0**	3,659	**100.0**	6,803	**100.0**	8,795	**100.0**	1,629	**100.0**	22,146	**100.0**
Female												
Lowest	69	**15.0**	193	**12.0**	1,027	**37.7**	2,406	**46.3**	780	**53.0**	4,475	**37.1**
Low	45	**4.3**	136	**6.5**	396	**13.6**	803	**15.1**	62	**2.7**	1,442	**10.8**
Elevated	87	**11.4**	230	**11.1**	415	**13.6**	943	**19.9**	250	**41.2**	1,925	**19.3**
High	361	**69.3**	1,478	**70.3**	1,336	**35.1**	807	**18.7**	86	**3.1**	4,068	**32.8**
Total	562	**100.0**	2,037	**100.0**	3,174	**100.0**	4,959	**100.0**	1,178	**100.0**	11,910	**100.0**
Total												
Lowest	131	**8.3**	413	**10.6**	1,979	**24.3**	4,627	**30.4**	1,528	**46.8**	8,678	**26.7**
Low	170	**9.1**	482	**10.9**	1,425	**16.8**	2,999	**23.4**	591	**24.2**	5,667	**19.2**
Elevated	378	**22.2**	848	**17.7**	1,856	**20.5**	2,878	**19.8**	456	**22.0**	6,416	**20.0**
High	1,143	**60.5**	3,953	**60.8**	4,717	**38.4**	3,250	**26.4**	232	**7.0**	13,295	**34.0**
Total	1,822	**100.0**	5,696	**100.0**	9,977	**100.0**	13,754	**100.0**	2,807	**100.0**	34,056	**100.0**

Note: † N=unweighted sample and %=weighted estimates. The N and % data do not coincide in this table since the N refers to numbers of drinkers and % to volume of alcohol.

Figure 1. Cumulative percentages of total and elevated risk consumption in the entire sample arranged by deciles of current drinkers defined according to their volume of alcohol consumption in the past year



	10	20	30	40	50	60	70	80	90	100
Drinks	53.3	71.6	82.8	89.0	93.9	97.3	98.3	99.1	99.7	100.0
Risky drinks	59.8	78.7	87.5	93.3	96.4	98.0	98.9	99.5	99.7	100.0