AVOIDABLE COST OF ALCOHOL ABUSE IN CANADA 2002

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ALL MODULES (1-6)

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EXECUTIVE SUMMARY

Purpose of the study

To estimate avoidable burden and avoidable costs of alcohol abuse in Canada for the year 2002. To date, this was the first attempt to systematically estimate the avoidable costs of alcohol abuse. It is also a pioneer study in the application of the methodology from the first *International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse* (Collins et al., 2006).

Methodology

We attempt to examine all four approaches recommended by Guidelines to estimate avoidable cost of alcohol abuse: 1) determining time-dependent avoidable burden based on the proportional reduction of current use, where the level of proportional reduction is informed by successful interventions; 2) the Arcadian normal of the lowest rates of disease categories; 3) the lowest attributable fraction in economically comparable regions; and 4) the proven outcome of major interventions. As a result, we found that the most valuable is the last approach based on the outcome of proven effective major interventions. Therefore, we used this approach to estimate the avoidable alcohol-attributable burden and costs of health care, criminality problems and lost productivity due to disability or premature mortality. We modeled the impact of the following six alcohol policy interventions relative to baseline costs obtained from the Second Canadian Cost Study (Rehm et al., 2006): taxation increases, lowering the blood alcohol concentration (BAC) legal limit from 0.08% to 0.05%, zero BAC restriction for all drivers under the age of 21, increasing the minimum legal drinking age (MLDA) from 19 to 21 years, a Safer Bars intervention, and brief interventions. Moreover, in addition to the six interventions that reduce alcohol consumption, we also modeled one intervention frequently discussed in Canada that would actually increase alcohol consumption and alcohol-attributable costs: -- the change from a government monopoly to privatized alcohol sales. The effect of these interventions was modeled for the Canadian population older than 15 years of age with the exception of BAC restriction and MLDA, which were modeled for the age group 19-21.

Results

Under conservative assumptions, it was estimated that a combination of six interventions related to alcohol policy would result in cost savings of about $1 billion in Canada per year. By implementing all six interventions, the greatest saving would be achieved by lowering

productivity losses, i.e. more than $561 million or 58%, followed by health care, almost $230 million or 24%, and criminality, almost $178 million or 18% of the total avoidable cost.

The potential gains to Canadian society may be even much higher, as sensitivity analyses on three of the six selected interventions resulted in a doubling of the avoidable alcohol-attributable burden and cost. The largest impact of avoidable burden and costs would result from comprehensive interventions affecting the overall level of drinking such as brief interventions (5% - 12%) and increasing alcohol taxation (2%). Substantial increases in burden (from 8% to 16%) and cost (from 6% to 12%) would occur if Canadian provinces were to privatize alcohol sales.

Conclusion

Alcohol causes considerable health and criminal burden on Canadian society. This study provides the evidence that suggests the implementation of proven effective population-based interventions would reduce alcohol-attributable burden and its costs in Canada to a considerable degree.

Results from other approaches to calculate feasible minimum and recommendations for future research are discussed.

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CHAPTER I: INTRODUCTION

Background of the study

The recently published Second Canadian Study of Social Costs Attributable to Substance Abuse (Rehm et al., 2006) estimated the **attributable burden and costs** of alcohol and other psychoactive substances for Canada in 2002. The manner in which attributable fractions were derived for this study allowed the authors to estimate how many deaths, hospitalizations, and legal problems in 2002 were due to past alcohol abuse (i.e. alcohol abuse prior and up to 2002). If there had been no alcohol abuse, then all of these deaths, hospitalizations and legal problems and consequently the costs would not have occurred. In other words, this cost-of-illness study calculated all the external costs of substance abuse and compared them with a hypothetical situation where no substance abuse existed.

While these aggregate burden and cost are a valuable indicator of the overall economic burden due to substance abuse in Canada, it does not indicate the proportion of such cost that is potentially avoidable and the nature of the policies to achieve this cost avoidance. However, without prior estimation of aggregate cost of substance abuse, which forms the basis for other types of cost estimates, it would not be possible to estimate avoidable costs. Thus, as a continuation of this research we have made an attempt to estimate the avoidable burden and costs that indicate the benefits potentially available to harm minimization programs in Canada in 2002. To date no such study has been undertaken in Canada or elsewhere to estimate the avoidable costs of alcohol abuse.

What is the nature of avoidable costs and why we measure it?

Avoidable cost estimates provide an indication of the benefits potentially available to the community as a whole by directing public resources to specific policies, strategies and programs (Collins et al. 2006). These estimates not only provide valuable economic information on the basis of which a more efficient allocation of productive resources could be achieved but also help

identify information gaps, target problems, and identify potential solutions, effective strategies, policies and programs.

To calculate avoidable costs, we have to identify a counterfactual scenario, i.e. the conditions against which the current conditions should be evaluated. This counterfactual scenario should depict the situation of alcohol abuse on the lowest possible level for our society, the so-called **feasible minimum**. We based the counterfactual scenario for avoidable costs on the recently published first *International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse* developed by world experts of the field (Collins et al., 2006). These guidelines were commissioned by Health Canada as part of an international initiative to develop methodologies and approaches for pilot studies in both developed and developing countries on estimating the socioeconomic avoidable costs of substance abuse. In this document, the authors argue that the target of zero alcohol or other substance abuse is not realistic and achievable for societies such as Canada. Thus a feasible minimum, different from zero alcohol consumption, has to be adopted.

The guidelines (Collins et al., 2006) suggest a number of different approaches that can be used to estimate both avoidable burden and avoidable costs of alcohol abuse. The approaches are based on:

1. determining time-dependent avoidable burden based on the proportional reduction of current use, where the level of proportional reduction is informed by successful interventions (Rehm et al. 2006);
2. the Arcadian normal of the lowest rates of disease categories (Armstrong, 1990);
3. the lowest attributable fraction in economically comparable regions (attributable fractions have been published in Ezzati et al., 2004);
4. the proven outcome of major interventions.

In this study we attempt to examine all these four approaches. For the results of the first three approaches please see Appendixes A, B, and C.

The main approach of this study

The main approach of this study is based on the outcome of **proven effective major interventions** (last approach recommended by Guidelines). This decision was made in

partnership with the Steering Committee for the study. We believe that this approach is more politically relevant because it can estimate the impact of the available effective interventions on alcohol-attributable burden and its cost. Thus, it is potentially most useful from a policy implementation perspective. This approach relies on the evidence about the effectiveness of interventions designed to reduce or alleviate the effects of substance abuse and can be seen as one way to operationalize the **feasible minimum**, i.e. the maximum reduction in burden that can be achieved by the interventions. A comparison between existing substance abuse policies and available interventions shown to be effective in reducing alcohol consumption and attributable harm in Canada and similar societies may indicate the extent to which aggregate costs are avoidable.

The most common evidence-based interventions, which are specifically aimed at reducing alcohol consumption and/or alcohol-attributable harm, were identified from monograph under the title Alcohol: No Ordinary Commodity; Research and Public Policy, produced in collaboration with the World Health Organization (Babor et al., 2003). The Steering Committee assisted the research team in selecting the most effective and cost-effective interventions in alcohol control feasible for Canada. Most of the selected interventions are highly cost-effective (with low money cost to implement) and associated with considerable health and social benefits based on scientific evidence from different jurisdictions. The choice of the combination of these interventions was made based on evidence that suggests the most effective approach is to implement multiple alcohol policies of the following strategies: increase in alcohol prices, reducing the availability of alcohol, and measures against drunk driving and underage drinking (WHO, 2004).

To estimate avoidable alcohol-attributable burden and costs of health care, criminality problems and indirect costs of lost productivity due to disability or premature death, the effects of the six selected policy interventions were modeled: taxation increases, lowering the blood alcohol concentration (BAC) legal limit from 0.08% to 0.05%, zero BAC restriction for all drivers under the age of 21, increasing the minimum legal drinking age (MLDA) from 19 to 21 years, a Safer Bars intervention, and brief interventions. Moreover, in addition to the six interventions that reduce alcohol consumption, we also modeled one intervention that would actually increase alcohol consumption and frequently discussed in Canada -- the change from a government monopoly to privatized alcohol sales. We believe that it was important to demonstrate what

would happen in terms of alcohol-attributable burden and associated costs if all Canadian provinces and territories gave up monopoly on alcohol sales.

Avoidable costs included in this study

The following avoidable costs have been included in this study:

1. Direct health care costs: total
    - 1.1 morbidity - acute care hospitalization
        - psychiatric hospitalization
    - 1.2 inpatient specialized treatment
    - 1.3 outpatient specialized treatment
    - 1.4 ambulatory care: physician fees
    - 1.5 family physician visit
    - 1.6 prescription drugs
2. Direct law enforcement costs
    - 2.1 police
    - 2.2 courts
    - 2.3 corrections (including probation)
3. Indirect costs: productivity losses (main scenario)
    - 3.1 due to long-term disability
    - 3.2 due to short-term disability (days in bed)
    - 3.3 due to short-term disability (days with reduced activity)
    - 3.4 due to premature mortality

Please note that the modules of this report are individually authored and are not presented in a sequence.

CHAPTER II

MODULE IV: USING EVIDENCE ON THE FFECTIVENESS OF INTERVENTIONS FOR REDUCING ALCOHOL-RELATED HARM

S. Popova & J. Rehm

Introduction

There are a number of different approaches that can be used to estimate both avoidable burden and avoidable costs of alcohol consumption. One of these approaches relies on the evidence on the effectiveness of interventions designed to reduce or alleviate the effects of substance abuse (Collins et al., 2006). This approach can be seen as one way to operationalize the so called "feasible minimum", i.e. what reduction in burden can be reached maximally by interventions. A comparison between existing substance abuse policies and available interventions shown to be quantifiably effective, may indicate the extent to which aggregate costs are avoidable. This evidence of the effectiveness of policy interventions may be a very useful addition to the tools of avoidable cost methodology (Collins et al., 2006).

The most common evidence-based interventions, specifically aimed at reducing hazardous alcohol use, were identified from Babor et al. (2003). Evidence on the effectiveness of a range of interventions is presented in Table 1.

-Insert Table 1 about here-

The list of these interventions was presented to the Steering Committee of the project. The Steering Committee assisted the research team in identifying the interventions which seemed feasible for Canada. These selected interventions are listed as the following:

- pricing and taxation,
- regulating blood alcohol concentration (BAC) levels and other drunk driving interventions,
- monopoly and other state intervention strategies (minimum legal purchasing age, hours/days of sale, limiting outlet density),

- awareness campaigns (e.g., educational type of initiatives),
- safer bars (server/bartender interventions, reduced hours of serving alcohol, server liability),
- warning labels,
- brief interventions and primary care, and
- low-risk drinking guidelines.

Further, collection of evidence (proportional reduction in population consumption, morbidity or mortality) of the selected interventions was performed in multiple electronic bibliographic databases, including: Ovid MEDLINE (1966-2006), PubMed (1980-2006), EMBASE (1980-2006), Web of Science (including Science Citation Index, Social Sciences Citation Index, Arts and Humanities Citation Index) and PsychINFO (1980-2006). This was done with a preference for meta-analyses and Cochrane reviews. The search was restricted to the English language only.

Evidence on effects of interventions

Pricing and taxation

Research studies have found that the price of alcohol, which can be influenced by the amount of tax charged, is a powerful determinant of alcohol consumption and alcohol problems (Babor et al., 2003; Chaloupka et al., 1993; Chisholm et al., 2004, 2006; Edwards et al., 1994; Grossman et al., 1998; Mann et al., 2005). Several studies have indicated that frequent and heavy drinkers are more sensitive to price than infrequent and light drinkers (Babor, 1985; Grossmann et al., 1987; Farrell et al., 2003); however, other studies found that both light and heavy drinkers are much less price elastic than moderate drinkers (see, for example, Manning et al., 1995). While this research question is not fully settled, for policy measures it is a good assumption that taxation will likely affect most drinkers, including heavy consumers.

Laixuthai and Chaloupka (1993) estimated that an increase in the Federal beer tax, offsetting the effect of inflation since 1951, would have reduced the probability of having any binge-drinking episodes by 18.4% in 1982, but only by 6.5% in 1989.
Chaloupka and Wechsler (1996) estimated the potential results of a policy that would have equated the tax on the alcohol in beer to the tax on the alcohol in distilled spirits in 1951 and adjusted the tax for the rate of inflation since 1951. Such an increase would have resulted in a

more than tenfold increase in the tax. The results have implied that such a policy would have reduced the number of underage college women who drank in the past year by about 15% and the number of underage and older college women engaging in any binge drinking by roughly 20%. In contrast to these statistically significant negative effects of price on underage drinking and binge drinking by female students, no such effect was found for male students. Grossman and colleagues (1998) examined the effects of a tax increase. They postulated that such an increase would have matched the taxes on the alcohol in beer to those on the alcohol in distilled spirits in 1951, and therefore accounted for the rate of inflation since 1951. Such an increase was estimated to have reduced average consumption by more than 40% in 1982 and 1983 (the middle years of the sample).

Studies by Saffer and Grossman (1987a, b) predicted a policy for adjusting the beer tax for the inflation rate since 1951 that would have reduced fatalities among 18- to 20-year-old youths by 15%. Moreover, a uniform minimum legal drinking age of 21 years would have lowered youth fatalities by 8% between 1975 and 1981.

Chaloupka and colleagues (1993) concluded that the higher beer excise taxes are among the most effective means for reducing drinking and driving in all segments of the population. For example, between 1982 and 1988, a policy adjusting the Federal beer tax for the inflation rate since 1951 would have reduced total fatalities by 11.5% and fatalities among 18- to 20-year-olds by 32.1%.

Another study, based on self-reported data on drinking and driving obtained in the 1985 National Health Interview Survey, estimated that a 10% increase in the price of alcoholic beverages would reduce the probability of drinking and driving by about 7.4% for men and 8.1% for women (Kenkel, 1993). Even larger reductions of 12.6% among men and 21.1% among women would occur among people ages 21 years and younger.

A study using self-reported data on involvement in traffic crashes obtained during the 1982 and 1989 Monitoring the Future surveys concluded that a policy adjusting the Federal beer tax for the inflation rate since 1951 would reduce the probability of nonfatal traffic crashes by almost 6% for both men and women (Chaloupka and Laixuthai, 1997).

Cook and Tauchen (1982) concluded that a $1 increase in the distilled spirits tax was estimated to lower cirrhosis death rates by 5.4 to 10.8%. Additionally, Grossman (1993) estimated that a 10% increase in the price of alcohol would reduce cirrhosis mortality by 8.3 to 12.8% after the levels of heavy drinking had fully adjusted to the price change in future years.

Ohsfeldt and Morrisey (1997) predicted that a 25% increase in the beer tax in 1992 would have reduced work-loss days from nonfatal workplace injuries by 4.6 million, thereby reducing the costs of lost productivity by $491 million. In contrast, alcohol availability has little impact on nonfatal workplace injuries according to these analyses.

Grossman and Markowitz (2001) explored the effects of variations in alcoholic beverage prices among states on violence on college campuses. The study used data from the 1989, 1990, and 1991 Core Alcohol and Drug Surveys of College Students. The study found that the incidence of each act of violence is inversely related to the beer price in the state in which the student attends college. For example, a 10% price increase would result in the following reductions in violent acts:

- The proportion of students who get into trouble with the police and college authorities would decline from 12.3% to 11.7%.
- The proportion of students involved in property damage would be reduced from 7.5% to 7.1%.
- The percentage of students who get into verbal or physical fights would fall from 31.2% to 30.2%.
- The proportion of students involved in sexual misconduct would decline from 14.3% to 13.8%.
- The number of students involved in violence each year would be reduced by approximately 200,000, or by 4%.

Markowitz and Grossman (1998) found that a 10% increase in the excise tax on beer was estimated to reduce the probabilities of overall child abuse and severe child abuse by 1.2% and 2.3%, respectively. Furthermore, such an increase was estimated to reduce unconditional overall child abuse (i.e., a measure of child abuse that includes the frequency of the abuse) by about 2.1%. A 10% increase in the beer tax would have lowered the number of severely abused children by approximately 132,500.

Markowitz and Grossman (2000) found that a 10% increase in the excise tax on beer was estimated to reduce the number of mothers who commit violent acts against their children by approximately 2%.

Markowitz (2000) estimated that a 1% increase in the price per ounce of pure alcohol would decrease the probability of being a victim of wife abuse by 5.3%. In 1985, when there were 54.4 million married women in the United States, of whom 3.6 % were estimated to be abused, a 1% increase in the price of pure alcohol would have decreased the number of abused married women by approximately 104,600.

The results of this overview are summarized in the Table 2.

-Insert Table 2 about here-

Implications for modelling in the avoidable cost study "taxation":

Research conducted has demonstrated a strong link between the cost of alcohol and its consumption. The evidence indicates that increases in the cost of alcohol to the consumer will act to decrease consumption rates, and thus to decrease alcohol-related problem rates. In the avoidable cost analysis, the effect of this measure will be modeled via the impact of taxation on price specific to each beverage type (for details see Chisholm et al., 2004). We will be using a hypothetical 25% increase in tax, which would result in price increases of 1.7% for beer, 6.8% for spirits, and 7.5% for wine, which together resulted in a 4.1% reduction in the alcohol consumption rate in Canada.

Regulating blood alcohol concentration (BAC) levels

Almost all developed countries in the world established a limit of the driver's blood alcohol concentration (BAC) (usually 0.05% or 0.08%; for young drivers 0.02% or 0.0%) above which a driver could be arrested.

It was estimated that for drivers with BACs in the 0.05% to 0.09% range, the risk of a fatal single vehicle crash for males aged 25 and over was nearly nine times higher than for their counterparts with BACs of 0.01% or below (Zador, 1991). A study by Zador et al. (2000) reported the following: "each 0.02 percentage point increase in the BAC of a driver with a non-

zero BAC more than doubled the risk of receiving a fatal injury in a single vehicle crash among male drivers aged 16-20, and nearly doubled the comparable risk among the other driver groups".

A Traffic Injury Research Foundation (TIRF) study demonstrated that drivers with BACs of 0.05% to 0.08% are 7.2 times more likely to be involved in a fatal crash than drivers with 0.00% BACs (TIRF, 1996). Moreover, 16-19 year old drivers with BACs of 0.08% to 0.099% have 40 times the risk of a fatal crash than those counterparts who have not consumed alcohol (Mayhew et al., 1986).

Reports done in the US have reported that for those individuals at a BAC of 0.06%, a relatively moderate level, the risk of having an automobile accident relative to their sober counterparts increases by approximately 700% for those who drink on an annual basis, 425% for those who drink monthly, and only 50% for those who consume alcohol on a daily basis. (Snyder, 1992).

Table 3 illustrates that four of the five American states had statistically significant decreases in alcohol related fatal crashes after implementing the legislation of lowering the criminal BAC limit from 0.10% to 0.08%.

- Insert Table 3 about here -

The meta-analysis conducted by Hingson et al. (2000) examined the impact of 0.08% per se laws in the six American states that lowered their limits in 1993 and 1994, and revealed that the six states with 0.08% BAC limits had a 6% greater relative decline in the percentage of fatally injured drivers with BACs above 0.10%, as compared to states that retained a 0.10% BAC limit.

Another American study (National Highway Traffic Safety Administration, 2000) of the lower BAC limit in Illinois, introduced in 1997, indicated a 13.7% decrease in the number of fatally injured drivers who had been drinking. The implementation of the 0.08% BAC law was estimated to have saved 47 lives in Illinois within the first year.

A study done by Voas et al (2000) postulated that the reductions due to the effects of the 0.08% BAC laws were responsible for 7.8% fewer fatalities among drivers with BACs between 0.01% and 0.09%. Moreover, the 0.08% BAC laws were also responsible for 8% fewer fatalities among

drivers with BACs above 0.10%. In total, the 0.08% BAC laws were estimated to have prevented 274 fatalities in 1997 in the 16 states that put said laws into effect. Moreover, Voas et al (2000) estimated that had all states implemented the 0.08% BAC throughout 1997, an additional 590 lives could have been saved.

Between 1982 and 1991 in Ontario, Canada, after the implementation of the administrative 0.05% BAC law, the rate of drinking drivers involved in crashes per 1,000 drivers was reduced by 58% (Traffic Injury Research Foundation, 1992). In the year following the introduction of the BAC law, alcohol involvement in fatal crashes declined from 64% to 36% in Prince Edward Island and from 47% to 27% in Newfoundland and Labrador (Traffic Injury Research Foundation, 2000).

Mann et al. (1998), using studies which employed the most rigorous data collection and analytic techniques (e.g. Henstridge et al., 1997; Norström and Laurell, 1997), estimated that introducing 0.05% legal BAC limit would reduce total collision fatalities by between 6% to 18%. Further, it was estimated that implementation of a measure of lowering a BAC limit from 0.08% to 0.05% could prevent between 185 and 555 motor vehicle fatalities in Canada in 1996 (Mann et al., 1998).

Implications for modelling in the avoidable cost study "reduction of BAC level":

Based on the observed results, the introduction of a 0.05% BAC legal limit has the potential to produce reduction in alcohol-related fatal collisions in Canada. Therefore, the percentage of reductions in alcohol-related fatal collisions reported for other jurisdictions (from 6% to 18%; Mann et al. 1998) will be applied to the total number of deaths from traffic injuries in Canada in 2002 in order to estimate prevented number of alcohol-attributable traffic deaths due to lowering BAC legal limit from 0.08% to 0.05% in all Canadian provinces and territories.

It could be also be possible to develop a conservative estimate for prevented number of alcohol-attributable hospitalizations by applying the above reduction (6% to 18%) to the respective hospital data. As alcohol has a higher alcohol attributable fraction (AAF) for traffic injury mortality compared to morbitdity, the reductions will be downscaled by two-thirds (Rehm et al., 2004; Rehm et al., 2006).

Lower limits for young and beginning drivers

Young drivers are often more vulnerable to the risk of an alcohol related crash, due to their inexperience as both drivers and drinkers (Shults et al., 2001). Numerous jurisdictions have implemented both a zero and low administrative BAC for young and beginning drivers, often as part of a graduated licensing program (GLP) (Lacey et al., 2000).

Hartling and colleagues (2004) systematically reviewed 13 studies evaluating 12 GLPs for the reduction of motor vehicle crashes among young drivers, implemented between 1979 and 1998 in the US (n=7), Canada (3), New Zealand (1), and Australia (1). The reviewers concluded that the GLP is effective in reducing the crash rates of young drivers, although the magnitude of the effect is unclear. Reductions in crash rates were found in all jurisdictions and for all crash types. The median decrease per population, in overall crash rates, during the first year was 31% (range 26-41%) among 16 year-old drivers. Per population injury crash rates were similar (median 28%, range 4-43%).

An Ontario survey of licensed high school students, conducted before and after the introduction of GLP, found a 25% reduction in the number of men who reported driving after drinking (Mann et al., 1997). Additionally, an evaluation of Ontario's GLP attributed a 27% decrease in alcohol related collisions to the zero BAC restriction (Boase & Tasca, 1998).

Since 1994, 12 Canadian jurisdictions have enacted at least one element of a GLP: Ontario (April 1994), Nova Scotia (October 1994), New Brunswick (January 1996), Quebec (July 1997), British Columbia (August 1998), Newfoundland (January 1999), Prince Edward Island (2000), the Yukon September 2000), Manitoba (2003), Alberta (2003), the Northwest Territories (2005) and Saskatchewan (2005) (The Traffic Injury Research Foundation, 2005). Nunavut is the only Canadian jurisdiction without a GLP.

However, the reach of GLPs is limited even though they have significantly reduced alcohol-related crashes among young beginner drivers. Canadian jurisdictions with a GLP impose a zero BAC restriction on drivers only in the initial stage of the program. In other words, BAC restriction is lifted upon completion of the graduated licensing program, which usually occurs around the age of 18 or 19. This corresponds to the legal drinking age in most Canadian

provinces, which is a period of when alcohol and binge drinking increases. Furthermore, this is also the age at which teenage drivers are most susceptible to alcohol-related deaths and injuries (Mayhew & Simpson, 1999). The existing research clearly supports the enactment of a zero BAC restriction for not just beginning and intermediate drivers, but also for all drivers under the age of 21. For example, Oregon experienced a 40% reduction in single-vehicle nighttime crashes among affected drivers after its zero BAC restriction was extended from drivers under the age of 18 to include drivers under 21 in 1991 (Lacey et al., 2000).

Hingson et al. (1994) conducted a study of the American states that introduced the zero and low administrative BAC between the years of 1983 and 1992. They found a resulting 16% decrease in single vehicle nighttime fatal crashes among young and beginning drivers, while such crashes in "control" states increased by 1%. States that implemented a zero BAC limit displayed a 22% decrease in fatal single vehicle nighttime crashes (Hingston et al, 1994). The authors estimated that, if the remaining 21 states had introduced a zero or low BAC limit for young drivers, at least 375 fatal single vehicle nighttime crashes would have been prevented each year among 15-20 year old drivers.

Lacey et al. (2000) found that upon implementing a zero BAC restriction for drivers under the legal drinking age (under 21) in 1995 in Maine, the number of single vehicle nighttime injury crashes among this population fell by 36%. A meta-analysis that reviewed four American and two Australian studies confirmed the positive impact of zero and low BAC restrictions (Shults et al., 2001).

Villaveces et al. (2003) estimated a 12 percent reduction in alcohol-related mortality due to the implementation of zero tolerance laws for persons younger than 21 years. Their finding was consistent with findings from other studies (see, for example, a systematic review Zwerling & Jones, 1999). Previous studies estimated reductions in mortality between 11 percent and 33 percent after implementation of zero tolerance laws in the United States and Australia (Villaveces et al., 2003).

Table 4 illustrates, the relative risk of crash for young drivers at low BAC levels is lower than that for older drivers at moderate BAC levels.

-Insert Table 4 about here -

Implications for modelling in the avoidable cost study "zero BAC restriction":

Since all but one (Nunavut) Canadian provinces and territories have implemented at least one element of a GLP for novice drivers of passenger vehicles more than a decade ago, there are only small potential further gains in terms of the impact on driving fatalities. In addition, since all GLPs differ, it would be difficult to estimate the effects of implementing the most effective program in quantitative terms.

The existing research clearly supports the enactment of a zero BAC restriction for young drivers under the age of 21. This measure mainly affects drinking and driving behavior. A twelve percent reduction in alcohol-related crashes after implementation of this policy, reported in the USA study (Villaveces et al., 2003), will be used in the estimation of the avoidable burden and costs of alcohol-attributable traffic injury categories (morbidity and mortality) and drinking and driving criminality.

In order to calculate total impaired driving incidents for young adults between 19 to 21 years old, we will estimate the proportion of drinking and driving cases based on the CAMH Monitoring Survey of Ontario, 2001-2006 (unpublished data).

Monopoly and other state intervention strategies (minimum legal purchases age, hours/days of sale, outlet density)

A monopoly system on alcohol may greatly reduce the number of outlets and limits their hours of sale. The evidence is quite strong that monopoly systems limit both alcohol consumption and alcohol-related problems. For example, prior to 1968, Finland sold beer only in government monopoly stores. In 1968, beer was sold both in grocery stores and government monopoly stores; consequently, alcohol consumption rose by 46% in the next year, and alcohol problem rates also increased. The number of outlets increased from 132 to 17,600, while alcohol consumption increased by 46% (Makela et al., 2002). In addition, mortality from cirrhosis increased by 50%, hospital admissions for alcoholic cirrhosis by 110% for men and 130% for

women, and arrests for drunkenness increased by 80% for men and 160% for women (Poikolainen, 1980).

An analysis postulated that should Ontario's government controlled alcohol systems be fully privatized it would result in an increase of approximately 10% to 20% of alcohol consumption (Her et al., 1998). Studies have reported that availability and consumption of alcoholic beverages in the United States increased as a result of the privatization of sales. In a review of American literature, Wagenaar and Holder (1995) found increases in consumption ranging between 13% and 150% as a result of privatization of alcohol sales.

Zalcman & Mann (2006) identified the impact of privatization of retail sale of alcohol in Alberta on suicide mortality rates between 1976 and 1997. The privatization of retail sale of alcohol was implemented in the following three stages: privately owned wine stores were opened in 1985, the opening of privately owned cold beer stores and the selling of spirits and wine in hotels in the rural area in 1989, and privatization of all liquor stores in 1994. In 1985, at the onset of privatization, there was a statistically significant and continuing increase in male and female suicide rates in Alberta. The amount of change was estimated as 51% for males and 35% for females. In 1989, upon the implementation of the second privatization event, there was an observed increase in male and female suicide rates, 17% and 52% respectively. The 1994 privatization event was associated with a statistically significant increase in male suicide mortality rates estimated at 19%; no changes in female suicide mortality rates were observed.

Zalcman and Mann (2006) found a significant and positive effect of total alcohol consumption for females, but not for males. The coefficient for the alcohol effect for females is 0.08, which means that a 1-litre increase in alcohol consumption resulted in an increase of about 8% in female suicide mortality rates. Moreover, it was found that Alcoholics Anonymous (AA) membership rate was significantly and negatively related to suicide mortality rates in both females and males. An increase of one AA member per 100,000 population reduced male and female suicide mortality rates by 1%. Finally, the unemployment rate was significantly and positively related to suicide rates in males and females. An increase of one unemployed person per 100 aged 15-64 in the workforce, increased suicide mortality rates by 4% for both males and females (Zalcman & Mann, 2006).

Additional evidence shows that privatization in Alberta is associated with an increase in criminal offences, such as liquor store break-ins and more relaxed enforcement of laws pertaining to underage purchases (Laxer et al., 1994). Moreover, Alberta continues to display some of the highest rates of alcohol-related problems, such as drunk driving fatalities within Canada (Mayhew et al., 2002).

Implications for modelling in the avoidable cost study "state interventions":

Research on public versus private control of retail outlets suggests that under privately controlled retail distribution systems, larger numbers of outlets and higher levels of consumption are found which is associated with increased alcohol problem rates. Therefore, in the avoidable cost analysis, effect of public versus private control of retail outlets will be quantitatively modeled based on Her et al. (1998) (10% and 20% increase of alcohol consumption).

Minimum alcohol purchasing age laws

Minimum alcohol purchasing age laws appear to have been the most effective strategy in reducing alcohol-related problems, as well as the strongest amount of empirical support (Grube & Nygaard, 2001). Almost all developed countries legally restrict alcohol sales by a minimum age. Restriction on the minimum age of drinking ranges from 16 to 21 years of age. This is an extremely effective policy which has significant effects on youth drinking.

Many studies found that raising the minimum age reduces alcohol use among young people and reduces traffic crashes, alcohol-related injury admissions to hospitals and injury fatalities (Jones et al., 1992; Smith, 1988). Raising the minimum legal drinking age from 18 to 21 decreased single vehicle nighttime crashes involving young drinkers by 11% to 16% (Saffer & Grossmann, 1987a).

A study conducted in the US demonstrated that the enactment of the national uniform age 21 minimum drinking age law was responsible for a 19% net decrease in fatal crashes involving young drinking drivers (Voas & Tippets, 1999).

It was estimated that the implementation of a drinking age of 21 years of age in the US reduced traffic fatalities by 846 deaths in 1997, and prevented a totally of 17,359 deaths since 1975 (NHTSA, 1998).

In Demark, the introduction of a minimum 15-year age limit for off-premise purchases of alcohol was associated with a 36% drop in alcohol consumption among youth under age 15 (Moller, 2002).

Moderate increases in enforcement can reduce sales to minors as much as 35% to 40%, especially when combined with media and other community activities (Wagenaar et al., 2000).

Implications for modelling the avoidable cost study "minimal legal purchasing age":

Based on strong evidence seen from the reviewed studies that minimum alcohol purchasing age laws is an effective strategy in reducing alcohol-related problems, it will be modeled based on the USA data (Shults et al., 2001) of the increasing of a legal drinking age by 21 years. In Canada this intervention will affect rate of fatal and non-fatal motor vehicle injuries of the young adults between 18 (legal purchasing age in Alberta, Manitoba and Quebec; 19 elsewhere) and 21.

Hours and days of retail sale

Restricting both the days and hours of alcohol sales may reduce alcohol purchasing and heavy consumption. Studies in Western Australia and Iceland have found direct evidence of an overall increases in problems related to alcohol use with longer hours of sale (Chikritzhs & Stockwell, 2002; Ragnarsdottir et al, 2002).

Normstrom & Stok (2001) reported a net 3.2% increase in alcohol sales with Saturday opening of liquor stores in Sweden. Re-institution of Saturday opening of liquor stores in Sweden lead to an increase in rates of domestic violence and public drunkenness (Olsson & Wikstrom, 1982).

Early closing of alcohol vendors on Friday night was associated with a 35% reduction in the number of pedestrians crossing the US border and a reduction in the number of persons with a BACs of 0.08% or higher (Baker et al, 2000).

In New Mexico a 29% increase in alcohol-related crashes and a 42% increase in alcohol-related crash fatalities was observed after the ban on Sunday packaged alcohol sales was lifted (McMillan & Lapham, 2006). Moreover, there were an estimated 543.1 alcohol-related crashes and 41.6 alcohol-related crash fatalities on Sundays after the ban was lifted.

A study from Sweden reported that after Saturday opening of alcohol retail shops in certain parts of Sweden, there was a resulting 3.7% increase in alcohol sales and 12% increase in drunk driving (Norström & Skog, 2005).

Moreover, Saturday closing of monopoly stores in Sweden in 1981 lead to a decrease in violence (Olsson & Wikstrom, 1982). In Norway in 1984, closing outlets on Saturdays resulted in a decrease of violence and intoxication (Nordlund, 1985).

Other Scandinavian studies (Nordlund, 1984: Norström & Skog, 2003) reported reduction in consumption and alcohol-related harm after limiting hours of sale among retail outlets (no sales for a 24-hour period on the weekend). On the basis of these studies, a modest reduction of 1.5 - 3.0% in the incidence of hazardous drinking and 1.5 - 4.0% in alcohol-related traffic fatalities was modeled by Chisholm and colleagues (2004). Depending on the subregional pattern of drinking, the largest effects were in subregions with the highest rate of hazardous drinking occasions (Rehm et al., 2004).

Implications for modelling in the avoidable cost study “hours of sale”:

The evidence from the reviewed literature showed that restricting both the days and hours of alcohol sales may reduce alcohol purchasing and heavy consumption. As a basis for modelling we could only use the Swedish experience, which also was the basis of Chisholm et al. (2004). However, the transferability of these data into the Canadian context does not seem to be clear. Thus, we will refrain from modelling this intervention.

Outlet density

It has also been implicated that alcohol-related problems, especially motor-vehicle accidents (Jewell & Brown, 1995; Gruenewald et al., 1996), pedestrian injury collisions (LaScala et al., 2001) and violent assaults (Alaniz et al., 1998; Stevenson et al., 1999) are more likely to occur where drinking places are more densely packed.

Jewell and Brown (1995) found that 254 counties in the US state of Texas showed that alcohol vendor restrictions significantly reduced alcohol-related motor vehicle accidents.

When density of on-premises availability in North Carolina, USA was increased, it was associated with a 16-24% increase in night-time traffic crashes for male drivers (Blose & Holder, 1987).

LaScala et al. (2001) showed that alcohol-involved pedestrian collisions occurred more often in areas with greater bar densities and greater population, and where the local population reported drinking more alcohol per drinking occasion.

One study suggested that locating an outlet near a highway may affect alcohol-related crashes more than locating the same outlet in a dense downtown area (Gruenewald & Treno, 2000).

A number of research studies have established that geographic regions with a higher consumption of alcohol have a greater incidence of violent crime. Cook and Moore (1993) estimate that a 10% increase in alcohol consumption would correspond with a 5.9% increase in the rate of assault in the US.

Scribner et al. (1995) reported that each additional liquor outlet in the Los Angeles area was associated with an extra 3.4 assaults per year.

Devery (1992) found in an examination of the temporal and geographical distribution of assault in the Sydney suburb of Waverley, that assaults were more likely to occur around hotel/nightclub closing time, as well as in close vicinity to liquor vendors (Devery, 1992).

Stevenson et al. (1999) found a significant relationship between overall alcohol sales in an area and its incidence of assault for both Sydney and the country of New South Wales. Effect of

alcohol sales from hotels and off-licences accounted for most of the alcohol-assault relationship for country New South Wales.

As seen from the above studies, fewer outlets per square kilometer and/or lower per capita outlet densities would result in reductions in both consumption and alcohol-related problems. However, Gruenewald et al. (1993) warn: “Spreading out alcohol outlets, thus increasing travel time and distance to and from sources for alcoholic beverages, may result in increases rather than decreases in problems”. Other researches also suggested that reductions in outlet densities may result in increases, rather than decreases, in drunk driving and alcohol-related traffic fatalities (Colon, 1982; Smart & Docherty, 1976).

A recent report (Mann et al. 2005) based on reviewed literature concluded that an increase in alcohol outlets will act to increase alcohol consumption, and associated alcohol related problems, such as underage consumption, drinking and driving, and alcohol-related aggression, morbidity and mortality.

Implications for modelling in the avoidable cost study “outlet density”:

There is no existing data for Canada, therefore, Steering Committee decided to exclude this measure from the analysis.

Awareness campaigns (e.g. educational type of initiatives)

In recent years, a number of educational programs has been developed, but many of them have not been evaluated. Even when evaluations are conducted, they often do not meet methodological criteria (Foxcroft et al., 1997). The results of evaluations do not provide an adequate basis for recommending these prevention programs (Chisholm et al., 2004). Usually the impact of these strategies tends to be very small. For example, Caulkins and colleagues (2002) found a very small 1–2% benefit over controlling the effect of school-based alcohol and drug prevention.

Foxcroft et al. (1997) reviewed and assessed the methodological quality of evaluations of alcohol misuse prevention programmes for young people. Only 33 studies (out of 500) merited

inclusion in the review, and most of these had some methodological shortcomings. Twenty-one studies reported some significant short- and medium-term reductions in drinking behaviour. Of two studies, which carried out longer-term evaluations, only one reported a significant longer-term effect, with small effect sizes. Authors concluded that the lack of reliable evidence means that no one type of prevention programme can be recommended.

In a conclusion quoted by Foxcroft (2006), “It is likely that the true effect of school-based prevention is either nil or small, but that at present we do not know if it is nil or small”.

Foxcroft et al. (2002) performed a systematic review on rigorous evaluations of psychosocial and educational interventions aimed at the primary prevention of alcohol misuse by young people over the longer-term (more than three years). The authors found that 20 of the 56 studies were ineffective. Evidence of effectiveness of prevention interventions in the short- and medium-term was not found. Over the longer-term, the Strengthening Families Program (SFP) showed promise as an effective prevention intervention. The Number Needed to Treat (NNT) for the SFP over four years for all three alcohol initiation behaviours (alcohol use, alcohol use without permission and first drunkenness) was nine.

Implications for modelling in the avoidable cost study “educational interventions”:

Based on the reviewed literature, the evidence for the effectiveness of school-based awareness campaigns and psychosocial and educational interventions was clear about a very small or no effect. The very small effect cannot be quantified, so no effect will be modeled for these interventions.

Safer bars (server/bartender interventions, reduced hours of serving alcohol, server liability)

Aggressive behavior, violence and homicide are major problems associated with drinking in licensed premises in many countries. One strategy of reducing these problems is the modification of the drinking context by reducing the heavy consumption of alcohol. In order to reach this goal, bar staff are trained to provide Responsive Beverage Service (RBS). The

primary goal of RBS is to prevent intoxication and underage drinking. RBS has occurred mostly in Canada, US, Australia & Sweden.

Several studies found that server training results in lower BAC levels of patrons (Geller et al., 1987; Russ & Geller, 1987). Time-series analyses of mandatory training suggests that training is associated with fewer visibly intoxicated patrons (Dresser, 2000) and fewer single-vehicle night-time injury producing crashes (Holder & Wagenaar, 1994). Thus, in the first six months under the new mandatory policy of requiring alcohol servers to be trained, there was an estimated reduction in single-vehicle nighttime crashes of 4%. There was an observed 11% reduction in single-vehicle nighttime crashes by the end of the first year, an 18% reduction by the end of the second year, and a 23% reduction by the end of the third year (Holder & Wagenaar, 1994).

Wallen et al (2003) found in a time-series quasi-experimental study on police-reported violence during the period of January 1994 to September 2000 in Stockholm, Sweden, that a 10-year multicomponent program based on community mobilization, training in responsible beverage service for servers and stricter enforcement of existing alcohol laws significantly decreased the rate of violent crimes by 29% (Wallin et al., 2003).

A coordinated, comprehensive, community-based intervention encouraging responsible beverage service results in the following: it reduces underage drinking by limiting access to alcohol, increases local enforcement of drinking and driving laws, and limiting access to alcohol by using zoning, resulted in self-reported amount of alcohol consumed per drinking occasion declined 6% from 1.37 to 1.29 drinks (Holder et al., 2000). As a result of this program, self-reported rates of "having had too much to drink" declined 49% from 0.43 to 0.22 times per 6-month period. Moreover, self-reported driving when over the legal BAC limit was reduced by 51% (0.77 versus 0.38 times) per 6-month period in the intervention communities relative to the comparison communities. Traffic data revealed that, in the intervention versus comparison communities, nighttime injury crashes were reduced by 10% and crashes in which the driver was impaired by alcohol declined by 6%. Assault injuries observed in emergency departments declined by 43% in the intervention communities versus the comparison communities, and all hospitalized assault injuries declined by 2%.

The US has seen consistent benefits from holding servers legally liable for consequences of providing more alcohol to persons who are already intoxicated or those underage. This practice has yielded lower rates of traffic fatalities (Chaloupka et al., 1993) and homicide (Sloan et al., 1994) as compared to states that do not implement server liability.

Wagenaar and Holder (1991) examined effects on the frequency of injuries due to motor vehicle crashes of a sudden change in exposure to legal liability of servers of alcoholic beverages in Texas. Results of this study showed a 6.5% and 5.3% declines in injurious traffic crashes following the filing of two major liability suits in 1983 and 1984, respectively. A 12% decrease in single-vehicle night-time injury-producing traffic crashes was observed when one state deliberately distributed publicity policy regarding the legal liability of servers; a statistically significant change when compared to trends in other states.

Resent systematic review of 20 studies by Ker and Chinnock (2006) did not find reliable evidence that interventions in the alcohol server setting are effective in reducing injury. The authors concluded that compliance with interventions appears to be a problem, hence mandated interventions may be more likely to show an effect. This review included one non-randomized study (Holder, 1994), which investigated server training and estimated a reduction of 23% in single vehicle night-time crashes, in the experimental area (controlled for crashes in the control area). Another non-randomized study (Lacey, 2000) examined the impact of a drunk driving service, and reported a reduction in injury road crashes of 15% in the experimental area, with no change in the control. In addition, no difference was found for fatal crashes. Felson (1997) (non-randomized study) investigated the impact of a policy intervention and reported that pre-intervention of serious assault rate in the experimental area was 52% higher than the rate in the control area. After intervention, the serious assault rate in the experimental area was 37% lower than in the control. One randomized control study (Warburton, 2000) included in the review of Ker and Chinnock (2006) compared the effectiveness of two types of drinking glassware: toughened glassware (experimental) and annealed glassware (control) in reducing bar-staff injuries. Results showed that a greater number of injuries were detected in the experimental group (RR = 1.72, 95% CI 1.15 to 2.59).

Casteel (2004) (non-randomized study) investigated the impact of a intervention aiming to reduce crime experienced by drinking premises and found a lower rate of all crime in the experimental premises (rate ratio 4.6, 95% CI 1.7 to 12, p = 0.01), no difference

was found for the rate of injury (rate ratio 1.1, 95% CI 0.1 to 10, p = 0.093).

Graham et al. (2004) in randomized controlled trial evaluated the effectiveness of Safer Bars, an intervention to reduce aggression in bars in Toronto, Ontario. Hierarchical linear modeling (HLM) indicated a significant effect of the intervention in reducing severe and moderate aggression. This effect was moderated by turnover of managers and door/security staff with higher post-intervention aggression associated with higher turnover in the intervention bars. The results indicate the potential for a stand-alone relatively brief intervention to reduce severe and moderate physical aggression in bars.

Implications for modelling in the avoidable cost study "safer bar":

The reviewed literature showed the evidence that modification of the drinking context is effective measure for reducing the heavy consumption of alcohol and thus, for reducing alcohol related problems such as violence and aggression. In a randomized controlled trial in Canadian bars, Graham and colleagues (2004; Table 5) reported a 34% reduction in violence and aggressive behavior after implementation of a comprehensive RBS program entitled Safer Bars. Assuming 10% of all alcohol-attributable crimes in Canada are bar related (expert opinion; e-mail communication with Dr. K. Graham, March 2007) we will model the effect of the Safer Bars program on avoidable burden and costs of alcohol-attributable homicide (morbidity and mortality) and homicide and other violent crimes.

-Insert Table 5 about here-

Warning labels

Several recent reviews of the existing research literature agree that the impact of warning labels on the consumption of alcohol or related behaviour is either nonexistent or minimal (Shafer et al., 2005; Stockwell, 2005). Currently, a few studies have found a relationship between awareness of labels and self reported decreases in drinking. However, the lack of studies, showing causal relationships, small effect sizes, as well as the use of self-report measures all limit the conclusiveness of statements that can be made about the labels' impact.

In a study of the exposure of US drinkers to warning labels in 1990, Greenfield and Graves (1993) found that after its introduction, drinkers were significantly more likely to report not driving because they had been drinking as compared to drinkers in 1989. Moreover, the respondents in Ontario were less likely to avoid driving after drinking during that time. In 1991, the percentage increased again to 55%, but then decreased to 42% in 1994. Greenfield (1997) interprets this finding as a short-term effect of labelling. Although the relationship is not causal, and an alternative explanation, that postulates that those who are more aware and/or concerned about drunk driving to begin with may pay more attention to these labels and choose to alter their behavior regardless of their exposure to the labels, is also valid. No post-label change in drinking and operating machinery was found in the ARG study (Greenfield and Graves, 1993), and thus, it was concluded that there was no significant long-term change in drinking/driving behaviors (Greenfield, Graves, and Kaskutas, 1999).

Similarly, after a slight post-label decline among adolescents in reported driving with a driver who had been drinking, levels returned to baseline status (MacKinnon et al., 2000). No post-label decline in alcohol consumption was observed among the youth after the labels' implementation.

A study of African American women who reported their drinking during, before and between pregnancies did not show a causal relationship between labels and alcohol consumption (Hankin et al., 1998).

A study of urban African American and Native American women showed that 68% of non-risk pregnant drinkers reported that the warning label swayed their decision concerning drinking during pregnancy, while 33% of at-risk drinkers reported that the warning label had an influence on their decision (Kaskutas, 2000).

One study showed that six months following the appearance of the warning label, lighter drinkers reduced their drinking during pregnancy by a small yet statistically significant amount; however, pregnant risk drinkers did not significantly change their consumption of alcohol during this period (Hankin et al., 1996). For women who had not previously experienced a live birth, drinking decreased after the implementation of the warning label system, even though their exposure to labels was lower than those who had previously given birth. Drinking did not decrease after implementation of the warning label for women who had experienced live births

previously and had healthy babies; these women were also heavier drinkers, and both having a previous birth and heavy drinking were related to not reducing drinking during pregnancy (Hankin, et al., 1996).

One study reported significant increases in the likelihood of respondents reporting having taken part in conversations about risks of alcohol consumption from before the introduction of the labels to the year afterwards (Kaskutas and Greenfield, 1992).

A study of US adolescents from 1989 to 1994 conducted by MacKinnon et al. (2000) reported significant increases in the children's awareness of the labels and recall of their messages. However, there were no beneficial changes that could be attributed to the warning labels concerning the level of belief in the messages, in drinking behaviour and in relation to drinking and driving.

Another US study on 4,397 black pregnant consecutive attendees of an ante-natal clinic in Detroit, sampled from May 1989 (before the introduction of the labels) and up to September 1991 did not find evidence of change in drinking behaviour among the more heavy drinkers (defined as more than one ‘drink’ or .5 ounces of alcohol per day) (Hankin et al., 1993). However, there was a small but significant effect on reducing the alcohol consumption of mothers who were light drinkers.

Implications for modelling in the avoidable cost study “warning labels”:

Based on the reviewed literature, the evidence for the effectiveness of the impact of warning labels on the consumption of alcohol or alcohol-related behaviours was weak. Therefore, these types of interventions will be omitted from the foregoing analysis.

Brief interventions and primary care

A number of countries (US, Canada) recommend routine screening for alcohol misuse and delivery of brief behavioural counselling interventions to high-risk drinkers (Elford et al., 2001; Whitlock et al., 2004). Several randomized controlled trials showed evidence of effectiveness in the use of screening and brief intervention for reducing alcohol consumption (Babor et al., 1996; Curry et al., 2003; Fleming et al., 1997). In addition, several meta-analyses and systematic

reviews confirmed that heavy drinkers who obtain brief alcohol intervention, especially in a timely manner, have better outcomes than those heavy drinkers who do not receive brief alcohol intervention (Ballesteros et al., 2004; Whitlock et al., 2004).

Benefits of brief interventions have been observed in follow-up studies up to nine years of post-treatment (Wutzke et al., 2002; Nilssen, 2004), although the 10 year follow-up data did not remain significant (Wutzke et al., 2002).

Babor et al. (1996) evaluated the relative effects of simple advice and brief counseling with heavy drinkers identified in primary care and other health settings in eight countries. Authors observed men in the intervention group reported approximately 17% lower average daily alcohol consumption than those in the control group. Reductions in the intensity of drinking were approximately 10%. For women, significant reductions were observed in both the control and the intervention groups. Five minutes of simple advice was as effective as 20 minutes of brief counseling. Authors concluded that brief interventions can make a significant contribution to the secondary prevention of alcohol-related problems if they are widely used in primary care settings.

Wilk et al. (1997) analyzed eight studies and found support for the efficacy of brief interventions for hazardous drinkers in primary care (OR of 1.95 favouring brief interventions).

Ballesteros et al. (2004) analyzed a set of 12 studies and estimated 11% difference in success rate (OR = 1.6) between brief interventions and usual care or simple advice, or to the necessity to treat nine hazardous drinkers to obtain one additional success.

Dinh-Zarr et al. (2004) systematically reviewed 23 trials comparing interventions for problem drinking for injury prevention to no intervention. Twenty-two studies reported reduced motor-vehicle crashes and related injuries, falls, suicide attempts, domestic violence, assaults and child abuse, alcohol-related injuries and injury emergency visits, hospitalizations and deaths. Reductions ranged from 27% to 65%. Seven trials evaluated brief counseling in the clinical setting and found reduction in injury-related deaths: RR = 0.65; 95% CI 0.21 to 2.00.

Implications for modelling in the avoidable cost study "brief interventions":

Brief interventions, such as physician advice provided in primary health care, which involve a small number of education sessions and psychosocial counseling, will be modeled to influence the prevalence of hazardous drinking by increasing remission and reducing disability. Efficacy reviews of brief interventions estimated that they lead to a 22% net reduction in consumption among hazardous drinkers under ideal circumstances (Chisholm et al., 2004). However, the effectiveness of this intervention deployed in the community would be reduced by non-compliance and the inability to completely target the at-risk population of hazardous drinkers. Assuming that treatment compliance was 70% and that only 50% of target hazardous drinkers received the interventions, we estimated the real-world effectiveness of these interventions at 7.7%. This percentage of reduction in alcohol consumption among hazardous drinkers will be used for modeling.

Low-risk drinking guidelines

There is quite strong epidemiological evidence that drinking alcohol, from very small amounts (less than one drink daily) to large amounts (up to 5-6 drinks daily), significantly reduce (20% to 60% compared with the experience of non-drinkers) the risk of mortality from coronary heart disease (Rehm & Sempos, 1995). In this context, low-risk drinking guidelines have been developed in a number of countries such as UK, Denmark and Canada on "moderate" drinking or "low-risk" drinking to assist physicians in providing the "best advice" to individual drinkers. Guidelines vary considerably from country to country (Stockwell, 2001). For example, Bondy and colleagues (1999) in Canada developed guidelines on "low-risk" drinking which define a usual level and pattern of alcohol use that is not associated with an increased risk of alcohol-related problems for most healthy adults (Bondy et al., 1999). These guidelines are intended to reinforce low-risk drinking in both community and clinical settings. They also address the concern that evidence of a health benefit may lead to an increase in alcohol consumption.

There is a lack of evaluation research on guidelines as an instrument of behaviour change and in primary prevention, which prevents establishing widely accepted guidelines for low-risk drinking (Walsh et al., 1998). Moreover, it is unclear whether such guidelines may decrease or increase alcohol consumption and alcohol-related problems (Casswell, 1993).

Implications for modelling in the avoidable cost study "low risk drinking guidelines":

Based on the reviewed literature, the evidence for the effectiveness of the low-risk drinking guidelines on the consumption of alcohol or alcohol-related behaviour is unclear. Therefore, this type of the intervention will be omitted from the foregoing analysis.

Table 6 gives a summary of the effectiveness of the selected interventions for modelling in the avoidable cost study.

-Insert Table 6 about here-

Table 1. Ratings of policy-relevant strategies and interventions (Adapted from Babor et al., 2003)

Strategy or intervention	Effectiveness	Breadth of research support	Cross-cultural testing	Cost to implement	Target group[a] (TG) and comments
Regulating physical availability					
Total ban on sales	+++	+++	++	High	TG = GP; Substantial adverse side-effects from black market, which is expensive to suppress. Ineffective without enforcement.
Minimum legal purchase age	+++	+++	++	Low	TG = HR; Reduces hazardous drinking, but does not eliminate drinking. Effective with minimal enforcement but enforcement substantially increases effectiveness.
Rationing	++	++	++	High	TG = GP; Particularly affects heavy drinkers; difficult to implement.
Government monopoly of retail sales	+++	+++	++	Low	TG = GP; Effective only if operated with public health and public order goals.
Hours and days of sale restrictions	++	++	++	Low	TG = GP; Effective in certain circumstances.
Restrictions on density of outlets	++	+++	++	Low	TG = GP; Requires a longer time course for implementation when drinking establishments have become concentrated because of vested economic interests.
Server liability	+++	+	+	Low	TG = HR; Required legal definition of liability mostly limited to North America.
Different availability by alcohol strength	++	++	+	Low	TG = GP; Mostly tested for strengths of beer.

Strategy or intervention	Effectiveness	Breadth of research support	Cross-cultural testing	Cost to implement	Target group[a] (TG) and comments
Taxation and pricing					
Alcohol taxes	+++	+++	+++	Low	TG = GP; Effectiveness depends on government oversight and control of alcohol production and distribution. High taxes can increase smuggling and illicit production.
Altering the drinking context					
Outlet policy to not serve intoxicated patrons	+	+++	++	Moderate	TG = HR; Training alone is insufficient. Outside enforcement essential to effectiveness.
Training bar staff and managers to prevent and better manage aggression	+	+	+	Moderate	TG = HR
Voluntary codes of bar practice	0	+	+	Low	TG = HR; Ineffective without enforcement.
Enforcement of on-premise regulations and legal requirements	++	+	++	High	TG = HR; Compliance depends on perceived likelihood of enforcement.
Promoting alcohol-free activities and events	0	++	+	High	TG = GP; Evidence mostly from youth alternative programs.
Community mobilization	++	++	+	High	TG = GP; Sustainability of changes has not been demonstrated.
Education and persuasion					
Alcohol education in schools	0[b]	+++	++	High	TG = HR; May increase knowledge and change attitudes but has no sustained effect on drinking.
College student education	0	+	+	High	TG = HR; May increase knowledge and change attitudes but has no effect on drinking.

Strategy or intervention	Effectiveness	Breadth of research support	Cross-cultural testing	Cost to implement	Target group[a] (TG) and comments
Public service messages	0	+++	++	Moderate	TG = GP; Refers to messages to the drinker about limiting drinking; messages to strengthen policy support untested.
Warning labels	0	+	+	Low	TG = GP; Raise awareness, but do not change behaviour.
Regulating alcohol promotion					
Advertising bans	+[c]	++	++	Low	TG = GP; Strongly opposed by alcoholic beverage industry; can be circumvented by product placements on TV and in movies.
Advertising content controls	?	0	0	Moderate	TG = GP; Often subject to industry self-regulation agreements, which are rarely enforced or monitored.
Drinking-driving countermeasures					
Sobriety check points	++	+++	+++	Moderate	TG = GP; Effects of police campaigns typically short-term.
Random breath testing (RBT)	+++	++	+	Moderate	TG = GP; Somewhat expensive to implement. Effectiveness depends on number of drivers directly affected.
Lowered BAC Limits	+++	+++	++	Low	TG = GP; Diminishing returns at lower levels (e.g., 0.05-0.02%), but still significant.
Administrative license suspension	++	++	++	Moderate	TG = HD
Low BAC for young drivers (‘zero tolerance’)	+++	++	+	Low	TG = HR

Strategy or intervention	Effectiveness	Breadth of research support	Cross-cultural testing	Cost to implement	Target group[a] (TG) and comments
Graduated licensing for novice drivers	++	++	++	Low	TG = HR; Some studies note that 'zero tolerance' provisions are responsible for this effect.
Designated drivers and ride services	0	+	+	Moderate	TG = HR; Effective in getting drunk people not to drive but do not affect alcohol-related accidents.
Treatment and early intervention					
Brief intervention with at-risk drinkers	++	+++	+++	Moderate	TG = HR; Primary care practitioners lack training and time to conduct screening and brief interventions.
Alcohol problems treatment	+	+++	+++	High	TG = HD; Population reach is low because most countries have limited treatment facilities.
Mutual help/self-help attendance	+	+	++	Low	TG = HD; A feasible, cost-effective complement or alternative to formal treatment in many countries.
Mandatory treatment of repeat drinking-drivers	+	++	+	Moderate	TG = HD; Punitive and coercive approaches have time-limited effects, and sometimes distract attention from more effective interventions.

[a] Each strategy applies to one of the following three target groups (TG): GP, the general population of drinkers; HR, high-risk drinkers or groups considered to be particularly vulnerable to the adverse effects of alcohol (e.g., adolescents); HD, persons already manifesting harmful drinking and alcohol dependence.
[b] Among the hundreds of studies, only two show significant lasting effects (after 3 years), and the significance of these is questionable when reanalyzed (Foxcroft *et al.* 2003). A few more studies show shorter-term effects, and in this frame the rating could be +.
[c] Econometric studies find effects of bans but direct studies of short-term impacts have generally found no effect on total alcohol consumption.

Table 2. Pricing/taxation

Intervention	Factor	Year	Probability (in%)	Resource
Federal beer tax increase	Binge-drinking	1982	reduced by 18.4%	Laixuthai & Chaloupka, 1993
		1989	reduced by 6.5%	
Policy making more than a tenfold increase in tax	Drank in the past year	---	-reduced by 15% for underage college women	Chaloupka & Wechsler, 1996
	Binge-drinking	---	reduced by 20% for older college women	
		---	no such effect found in male students	
Matched the taxes on the alcohol in beer to those on the alcohol in distilled spirits		1982-1983	40% reduction in alcohol consumption	Grossman et al., 1998
Policy adjusting beer tax	Youth fatalities	1975 -1981	15% reduction among 18 to 20 year olds	Saffer & Grossman, 1987a,b
Uniform of minimum legal drinking age of 21 years		1975 -1981	8% reduction among 18 to 20 year olds	
Higher Beer Excise Taxes	Drinking and driving	1982 -1988	11.5% reduction in total fatalities	Chaloupka et al., 1993
			32.1% reduction among 18 and 20 year olds	
A 10% increase in the price of alcoholic beverages	Drinking and driving	---	7.4% reduction of drinking and driving for men and 8.1% for women 12.6% reduction for men and 21.1% for women would occur among people ages 21 years and younger	Kenkel, 1993
Policy adjusting the Federal beer tax	Nonfatal traffic crashes	1982 -1989	reduction by 6% for both men and women	Chaloupka & Laixuthai, 1997
$1 increase in the distilled spirits tax	Cirrhosis mortality	---	reduction by 5.4 to 10.8%	Cook & Tauchen, 1982
10% increase in the price of alcohol	Cirrhosis mortality	---	reduction by 8.3 to 12.8%	Grossman, 1993
25% increase in the beer tax	Work-loss days from nonfatal workplace injuries	1992	reduction by 4.6 million, reducing the costs of lost productivity by 491 million	Ohsfeldt & Morrisey, 1997
10% increase in the beer price	Violence	---	% of students who get into trouble with the police and college authorities would decline from 12.3 % to 11.7%	Grossman & Markowitz, 2001

			the proportion of students involved in property damage would be reduced from 7.5% to 7.1%	
			% of students who get into verbal or physical fights would fall from 31.2% to 30.2%	
			% of students involved in sexual misconduct would decline from 14.3% to 13.8%	
			the number of students involved in violence each year would be reduced by approximately 200,000, or by 4%	
10% increase in the excise tax on beer	Child Abuse Severe child abuse Unconditional overall child abuse	---	reduction by 1.2% reduction by 2.3% reduction by 2.1% number of severely abused children reduced by 135,500	Markowitz & Grossman, 1998
10% increase in the excise tax on beer	Mothers who commit violent acts against their children	---	reduction by approximately 2%	Markowitz & Grossman, 2000
1% increase in the price per ounce of pure alcohol	Victims of wife abuse	1985	reduction by 5.3%	Markowitz, 2000

Table 3. Decreases in alcohol related crashes after 0.08% BAC legislation

State	Measure	% Decrease
California	Fatally injured drivers with BACs over 0.10%	4
Oregon	Fatally injured drivers who had been drinking	9
	Fatally injured drivers with BACs over 0.10%	11
	Police reported driver alcohol involvement in fatal crashes	13
	Overall estimated alcohol involvement in fatal crashes	11
Utah	Police reported driver alcohol involvement in fatal crashes	30
Vermont	Fatally injured drivers who had been drinking	36
	Fatally injured drivers with BACs over 0.10%	31
	Overall estimated alcohol involvement in fatal crashes	40

Adapted from Chamberlain & Solomon, 2002. Source: National Center for Statistics and Analysis, 1994.

Table 4. Relative risk for young and older male drivers at "low" and "moderate" BACs

	Fatal single vehicle crash	All fatal crashes
Age 16-20 (0.020%-0.049% BAC)	4.64	3.44
Age 21-34 (0.050%-0.079% BAC)	6.53	3.76
Age >= 35 (0.050%-0.079% BAC)	5.79	3.70

Adopted from Chamberlain & Solomon, 2002. Source: Zador et al., 2000.

Table 5. Source: Graham et al. (2004)

Table 4. *Comparison of pre–post intervention rates of aggressive incidents in experimental and control bars (*t*-ratio and* p *value from HLM)*

	Average number of incidents per observation				Percent of observations with at least one incident at that level			
	Experimental bars		Control bars		Experimental bars		Control bars	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Highest level of aggression exhibited by patrons in the incident								
Consistent rating of severe physical aggression by all raters, definite intent	0.053	0.035	0.007	0.060	4.8%	3.5%	0.7%	4.6%
	$t = 5.23$, df = 28, $p < 0.001$				$t = 4.45$, df = 28, $p < 0.001$			
All severe physical aggression (including intent rated probable and/or discrepancy among raters)	0.067	0.048	0.021	0.073	6.2%	4.4%	2.1%	6.0%
	$t = 3.37$, df = 28, $p = 0.003$				$t = 2.81$, df = 28, $p = 0.009$			
All severe aggression plus consistent rating of moderate physical and more than minor verbal, definite intent	0.110	0.083	0.055	0.093	9.6%	6.6%	3.4%	8.0%
	$t = 1.96$, df = 28, $p = 0.060$				$t = 2.84$, df = 28, $p = 0.009$			
All severe aggression plus consistent rating of moderate physical (with or without verbal aggression), definite intent	0.134	0.101	0.075	0.126	11.5%	8.3%	5.5%	10.6%
	$t = 1.87$, df = 28, $p = 0.071$				$t = 2.28$, df = 28, $p = 0.031$			
All severe aggression plus all moderate physical aggression (including intent rated probable and/or discrepancy among raters)	0.182	0.131	0.143	0.152	15.3%	11.0%	10.3%	13.3%
	$t = 1.04$, df = 28, $p = 0.310$				$t = 1.84$, df = 28, $p = 0.076$			
Highest level of aggression exhibited by staff in the incident								
Consistent rating of severe physical aggression by all raters, definite intent	Frequencies too low for analyses				Frequencies too low for analyses			
All severe physical aggression (including intent rated probable and/or discrepancy among raters)	Frequencies too low for analyses				Frequencies too low for analyses			
All severe aggression plus consistent rating of moderate physical and more than minor verbal, definite intent	0.019	0.031	0.007	0.046	1.4%	3.1%	0.7%	4.6%
	$F = 2.46$, df = 28, $p = 0.021$				$t = 2.07$, df = 28, $p = 0.048$			
All severe aggression plus consistent rating of moderate physical (with or without verbal aggression), definite intent	0.029	0.056	0.014	0.053	2.4%	4.8%	1.4%	5.3%
	$F = 1.19$, df = 28, $p = 0.243$				$t = 0.99$, df = 28, $p = 0.329$			
All severe aggression plus all moderate physical aggression (including intent rated probable and/or discrepancy among raters)	0.067	0.066	034	0.060	6.2%	6.1%	3.4%	5.3%
	$F = 1.48$, df = 28, $p = 0.149$				$t = 1.11$, df = 28, $p = 0.275$			

Table 6. Selected interventions for modelling in the avoidable cost study

Type of Intervention	Effect and modeled scenarios	Reference
Increase in taxes by 25%	4.1% reductions in alcohol consumption	Chisholm et al. (2004)
Lowering BAC legal limit from 0.08% to 0.05%	Reduction of total fatal collisions from 6% to 18%. *Scenario 1: 6% reduction* *Scenario 2: 12% reduction* *Scenario 3: 18% reduction*	Mann et al. (1998)
Zero BAC for all drivers under the age of 21	12 % reduction in alcohol-related fatal crashes	Villaveces et al. (2003)
Retaining state monopoly on alcohol sales	Full privatization of alcohol systems in Ontario would result in an increase of approximately 10% to 20% of alcohol consumption. *Scenario 1: 10% increase in consumption* *Scenario 2: 20% increase in consumption*	Her et al. (1998)
Raising minimum legal drinking age from 19 to 21 years	Reduces fatal and non-fatal crashes *Scenario 1: 6% reduction in non-fatal crashes* *Scenario 2: 8% reduction in fatal crashes*	Shults et al. (2001)
Modification of the drinking context: Safer Bar	34% decrease in bar related aggression *Scenario 1:* 7.7% reduction in alcohol consumption *Scenario 2: 22*% reduction in alcohol consumption	Graham et al. (2004)
Brief interventions	Reduction in heavy alcohol consumption *Scenario 1:* 7.7% reduction in alcohol consumption *Scenario 1: 22*% reduction in alcohol consumption	Chisholm et al. (2004)

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CHAPTER III

MODULE 5: AVOIDABLE CRIMINALITY

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Executive Summary

The avoidable portion of alcohol-attributable crime namely a) drinking and driving; b) homicide and other violent crimes; and c) other alcohol-attributable criminal activities (e.g., property crime) for Canada 2002 due to implementation of effective population-based interventions was estimated in this study. Avoidable costs associated with alcohol-attributable costs for policing, court and corrections (prison cost) were also estimated. The effect of the following interventions was considered: taxation and price increases, lowering the blood alcohol concentration (BAC) legal limit from 0.08% to 0.05%, zero BAC restriction for all drivers under the age of 21, state monopoly on alcohol sales (effect of privatization was modelled), increasing minimum legal alcohol purchasing age up to 21 years, safer bars intervention, and brief interventions.

The methodology of this study was based on the International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006).

Results revealed that the most effective intervention in terms of preventing drinking and driving incidents in Canada is lowering the BAC level from 0.08% to 0.05%. Retaining state monopoly on alcohol sales in Canada is the most effective measure to avoid homicide and other violent crimes and other alcohol-attributable criminal activities in Canada.

In terms of savings in policing costs due to alcohol-attributable crimes, retaining state monopoly on alcohol sales in Canada is the most effective strategy, followed by brief interventions and pricing and taxation.

Concerning savings in court and corrections (prison) costs due to alcohol-attributable crimes, retaining state monopoly on alcohol sales is also the first most effective strategy followed by brief interventions and pricing and taxation.

Thus, this study provides evidence that implementation of effective population-based interventions will reduce both portion and associated costs of criminal activities attributable to alcohol in Canada.

Introduction

Alcohol is commonly linked to criminal activity. Alcohol-attributable crimes can lead to the imposition of a variety of social costs. These types of crimes could potentially be avoided with the implementation of different interventions, consequently saving substantial amount of public expenditures. In this report, the net savings of expenditures (or avoidable criminality costs from here onwards) due to interventions have been allocated to the three specific alcohol-attributable types of crime:[1] a) drinking and driving; b) homicide and other violent crimes; c) other alcohol-attributable criminal activities (e.g., property crime). The major cost component considered here is the law enforcement cost (policing) due to alcohol. Alcohol-attributable cost estimates with respect to criminality, considered in this report are for 1) law enforcement authorities (police and prosecutors), 2) courts, and 3) corrections (prisons, jails, and community supervision of offenders).

A number of hypotheses have been proposed to explain the observed link between psychoactive substances (PAS) and crime. Theories range from simple pharmacological effects to the complex interaction of endocrinological, neurobiological, environmental, economic, social and cultural factors (see, for example, Goldstein, 1985; National Research Council, 1993). This report briefly outlines two major concepts, which explain the links between psychoactive substances (PAS) and criminality.

The first major concept describes the link between PAS and crime in static terms. One model that falls in this category was developed by Goldstein (1985) and offers three explanations for the link between PAS and crime. This model looks at the following *proximal* links:

1. psychopharmacological, where violence or victimization results from the feelings, such as excitability or irrationality that may follow PAS use;
2. economically compulsive, where PAS users perpetrate violent crimes such as robbery to get money to buy drugs, and
3. systemic, which refers to the distribution of illegal drugs.

[1] Alcohol-attributable here means, that alcohol has a causal impact on these types of crimes. However, that does not mean that 100% of the crimes are caused by alcohol. Whereas there are crimes, where 100% is caused by alcohol (e.g. drinking driving would disappear completely in a society without alcohol), for most alcohol-attributable crime categories, the proportion caused by alcohol is less than 100%. This proportion is usually labeled alcohol-attributable fraction.

Collins et al. (2006) suggested adding the fourth element to Goldstein's tripartite model – "the crime as defined by law", which includes possession, trafficking, importation, and driving under the influence of PAS (see Figure 1).

-Insert Figure 1 about here-

A second biopsychosocial model looks at the *distal* links that connect both drug abuse and criminality to a range of biopsychosocial factors (or risk factors; see Figure 2). According to this model, deviance, drug use, or other certain marginal behaviours (i.e. drinking and driving, unprotected sex, etc.) are linked to the number of risk factors (i.e. socio-demographic background, current environment, family, peers, etc.), which "predispose" people to adopt a lifestyle in which intoxication, drinking and driving, drug use, and crime are part of everyday life.

-Insert Figure 2 about here-

The second major concept considers the link between PAS and crime in terms of a dynamic association within a deviant trajectory. Substance users move through various phases: initiation or experimental use; regular consumption without dependence; abuse or dependence, and cessation (see Figure 3).

-Insert Figure 3 about here-

In order to gain a more comprehensive understanding of the various links between PAS and criminality, International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006) recommends the integration of the three models discussed above (see Figure 4).

-Insert Figure 4 about here-

Methodology

Criminality indicators

Alcohol-attributable criminality can be divided into three major categories: a) drinking and driving; b) homicide and other violent crimes; c) other alcohol-attributable criminal activities (e.g., property crime). We outline below the procedures on how to deal with these components in the different interventions. All interventions are based on the principle of a reduction in consumption and the following steps were applied:

For *a) the drinking and driving criminality,* the alcohol-related traffic injury *morbidity* data were obtained and the reductions in alcohol-attributable fractions (AAFs) for drinking and driving (traffic accidents) *criminality* were modelled proportionally. As the Relative Risk increases for alcohol with more severe outcomes, i.e. alcohol has more impact on mortality than on morbidity, the use of morbidity AAFs becomes more appropriate for the criminality estimates than the mortality AAFs.

In terms of *b) homicide and other violent crimes*, the alcohol-related homicide and violence morbidity and mortality were derived (*average of both morbidity and mortality*) and the reductions in AAFs for homicide and violence-related *criminality* were modelled on a proportional basis.

Concerning *c) other alcohol-attributable criminal activities (e.g., property crime)*, the respective crime rates were decreased directly proportional to the decrease in alcohol consumption. This procedure was adopted, as we did not have more specific information on the link between alcohol and these criminal activities.

Presence/ absence of criminality indicators and mechanism and effects on morbidity/mortality and criminality of the select interventions are summarized in Table 1 and 2.

- Insert Table 1 and 2 about here -

Modeling effects of the specific interventions:

1. Pricing and taxation

Taxation and price increase is an intervention, which is based on the economic principle that higher prices lead to less consumption. Thus, all three components of criminality listed above (a, b, & c) were impacted and the general guidelines for the modelling consumption laid out above were applied.

Exercising taxation on alcoholic beverages has very different impacts on price and consumption patterns, as well as distorting different segments of the alcohol market. It primarily affects the incidence of drinking by reducing consumption, with effects measured in terms of price elasticity. In economics, the price elasticity measures the nature and degree of the relationship between changes in quantity demanded (e.g., reduction in use) of a commodity (e.g., alcoholic beverage) and changes in its price (e.g., increased price due to taxation). Baseline price elasticities ranged from -0.3 for the most preferred beverage category to -1.0 for the next preferred category to -1.5 for the least preferred (Babor et al., 2003; also see Chisholm et al., 2004 for detailed methodology). Alcohol per capita consumption (measured as pure alcohol in litres, e.g., beer = 4.3 litres) for the year 2002 was obtained from the Global Alcohol Database (GAD) (WHO, 2006). In Canada, beer is the most preferred beverage followed by spirits and wine. Current beverage-specific alcohol tax rates (provincial and federal) were obtained from the literature (Stockwell et al., 2006) for three major provinces: British Columbia, Ontario, Quebec (no data were available for other provinces) and were population-weighted to obtain tax rates for each beverage in Canada (e.g., beer = 22.4%). A hypothetical 25% increase in tax to the current rate was applied (e.g., beer = 28.0%). New price elasticity was then calculated using the product of baseline elasticities with the difference of tax increase to the baseline tax (e.g., beer = -0.3 * 5.6% = -1.7%). Consequently, the new consumption rate was scaled down using elasticity figures (e.g., beer = 4.3 litres * (-1.7%) = 4.23 litres) (see Table 3).

- Insert Table 3 about here -

Step 1:

The 25% increase in tax showed a 4.1% reduction of alcohol consumption rate in Canada. This rate was used to model the mortality and morbidity AAFs for injuries (by age-groups and sex) such as traffic accidents, violent crimes and other crimes. All mortality AAFs were scaled down,

from the respective AAFs from the baseline cost study (Rehm et al., 2006a) by a factor of 1/3, using half of the prevalence rate (assuming x% decrease in prevalence would result in x/2% decrease in mortality). For example, 20% baseline AAFs would be scaled down to 20% * (100% - (4.1%/2) *2/3) = 19.73%. On the other hand, morbidity AAFs were derived from the mortality AAFs (traffic injuries scaled down by a factor of 2/3 and non-traffic injuries were scaled down by a factor of 4/9; see also Rehm et. al., 2006b for methodology).

Step 2:
To obtain pooled AAFs (irrespective of sex from the overall AAFs) for drinking-driving, a crime proportion of male to female ratio of 6.94:1 (87.4% men and 12.6% women) was used; for violent crimes a ratio of 5.45:1 (84.5% for men and 15.5% for women); for other crimes (e.g., property crimes etc) a ratio of 3.39:1 (77.2% for men and 22.8% for women) were used. These pooled AAFs were then applied with the respective crime incidents to obtain avoidable criminality and consequently total criminality costs due to alcohol.

Attributable fractions for various interventions by criminality indicators are presented in Table 4.

- Insert Table 4 about here –

2. Regulating blood alcohol concentration (BAC) levels

Lowering the BAC level from 0.08% to 0.05% mainly impacts the drinking and driving behaviour. It has the potential to produce reduction in alcohol consumption, but this effect has not demonstrated specifically for Canada and thus we did not include it in either the modelling for mortality or morbidity or for criminality. Only one component of the alcohol-attributable criminality was modelled: criminality related to drinking and driving. This component of criminality was modelled based on the AAFs for morbidity.

Research has shown that lowering the BAC level from 0.08% to 0.05% led reductions in drinking and driving crimes in the range from 6% to 18% (Mann et al., 1998). Only morbidity AAFs were scaled down by 2/3 of 6% to 18% (with 12% as a sensitivity analysis) (Rehm et al., 2006b). For example, a 20% baseline AAF with 6% reduction would be translated into 20% * (100% - 6%*2/3) = 19.2%. Following this, step 2 described in the previous intervention for

MLDA was also carried out here to estimate avoidable costs of drinking and driving due to this intervention.

3. Zero BAC restriction for young drivers under the age 21

Implementation of a zero BAC restriction for young drivers under the age 21 mainly impacts the drinking and driving behaviour. Thus, only one component of alcohol-attributable criminality was modelled: drinking and driving. This component of criminality was modelled based on the AAFs for morbidity.

Firstly, to estimate the proportion of drinking and driving cases, we analysed the CAMH Monitoring Survey of Ontario, 2001-2006 (unpublished data). Results indicated that 13.3% of young adults between 19 to 21 years old reported drinking and driving incidents in the 12 months preceding the survey. A cut-off minimum age of 19 years was used based on the minimum legal drinking age in majority of provinces in Canada (18 years is only in Alberta, Manitoba and Quebec). This proportion was used to calculate total impaired driving incidents for the above target population.

Secondly, to model the zero tolerance laws, we conducted a literature review which showed that for young drivers under the age 21 there was a 12% reduction in alcohol related crashes (Villaveces et al., 2003). This figure was used to adjust the overall morbidity AAFs by sex using the similar approach described in the second intervention (lowering BAC). A pooled estimated of AAF was derived using step 2 described above to further calculate costs avoided.

4. State monopoly on alcohol sales

Monopoly systems have the potential to affect alcohol consumption. Thus, all three components of criminality listed above (a, b, & c) are impacted and the general guidelines for the modelling consumption laid out above can be applied.

It is feared that the privatization of alcohol sales could stimulate sales and lead to unbridled alcohol consumption. Indeed, research has shown that, in Canada, privatization would increase the alcohol consumption rate by 10% to 20% (Her et al., 1998). These rates were used (in two

different scenarios) to model the mortality and morbidity AAFs for different crimes (by age-groups and sex). Using the same procedure described in steps 1 and 2 (elsewhere in the document), all mortality and morbidity AAFs were scaled down, from the respective AAFs from the baseline cost study (Rehm et al., 2006a) and then applied to all three crime incidents to derive the relative increase in policing costs against the baseline costs.

5. Minimum legal drinking age (MLDA) laws

Raising the minimum alcohol purchasing age from 19 to 21 years mainly impacts the alcohol impaired driving. Thus, only one component of alcohol-attributable criminality was modelled: drinking and driving. This component of criminality was modelled based on the AAFs for morbidity (non-fatal crashes).

To model the effects of changing the minimum legal drinking age, we used data from the systematic review by Shults et al. (2001). This study reported that raising MLDA from 19 to 21 years reduces 6% (17-8% decrease in fatal crash outcomes; hence, to avoid overestimation for non-fatal crashes, 6% was taken as the best estimate) of non-fatal crash outcomes likely to involve alcohol.

As mentioned above, only morbidity AAFs were derived (scaled down by 2/3) using the proportions for two scenarios (Rehm et al., 2006b). For example, a 20% baseline AAF with 6% reduction of crimes due to policy would be translated into 20% * (100%-6%*2/3) = 19.2%. Following this, step 2 described elsewhere was also carried out here to estimate avoidable costs due to this intervention.

6. Safer bars (server/bartender interventions, reduced hours of serving alcohol, server liability)

Modification of the drinking context (e.g., safer bars intervention) is an effective measure for reducing the heavy consumption of alcohol and consequently, for reducing alcohol related problems such as violence and physical aggression. Thus, only one component of alcohol-attributable criminality was modelled: homicide and other violent crimes. This component of criminality was modelled based on the AAFs for morbidity and mortality.

According to Graham and colleagues (2004), the safer bar programme has a potential to reduce severe and moderate physical aggressions in bars exhibited by the patrons. Results from their study showed that, after the implementation of a safer bar intervention, there was a 34% reduction in bar related aggressions. To model safer bar intervention in our study, we obtained an expert's opinion on the proportion of bar related crimes (assuming 100% of alcohol-attributable) out of all alcohol-attributable crimes in Canada. The expert estimated that there are about 10% of bar related crimes out of all alcohol-attributable crimes in Canada (e-mail communication with Dr. K. Graham, March 2007) in Canada. Mortality AAFs for safer bars were estimated by reducing 10% off the baseline AAF of violent crimes followed by further 34% reduction. Morbidity AAFs were scaled down by a factor of 4/9 (Rehm et al., 2006b). Mean overall AAFs by sex was obtained from both mortality and morbidity. Following this, procedures in step 2 were carried out to estimate avoidable costs for each criminal indicator.

7. Brief interventions and primary care

Brief interventions, such as physician advice provided in primary health care, which involve a small number of education sessions and psychosocial counselling, has the potential to reduce the prevalence of hazardous drinking. Thus, all three components of criminality listed above (a, b, & c) are impacted and the general guidelines for the modelling consumption laid out above can be applied.

To model this, a reduction in consumption due to brief intervention was first estimated as follows. Efficacy reviews of brief interventions revealed that in an ideal world situation an estimated 22% net reduction in consumption among hazardous drinkers would be observed (Babor et al., 2003; Higgins-Biddle and Babor, 1996; Moyer et al., 2002). However, after adjusting for an ideal-world effect (including treatment adherence at 70% and target coverage in the population at 50% of hazardous drinkers = 35%), population-level remission rate was estimated to be 7.7% (35%*22% = 7.7%).

Secondly, this 7.7% reduction of alcohol consumption rate in Canada was used to model the mortality and morbidity AAFs for crimes for overall age by sex. All mortality AAFs were scaled down, from the respective AAFs from the baseline cost study (Rehm et al., 2006a) by a factor of 1/3, using half of the prevalence rate. On the other hand, morbidity AAFs were derived from the mortality AAFs (outlined in step 1 of first intervention: increase in taxation). Mean AAF was also derived from both mortality and morbidity AAFs.

Thirdly, to obtain pooled AAFs (irrespective of sex from the overall AAFs) for drinking-driving, violent crimes and other crimes, a crime proportion of male to female ratio as listed in step 2 of the first intervention were used. These pooled AAFs were then applied with the respective crime incidents to obtain avoidable criminality and consequently total policing costs due to alcohol. All these avoidable criminality costs estimated from 7 interventions were compared with the baseline criminality cost to weight the relative difference (proportion and costs) in intervention approach.

Sources of data

Our data for this study were derived from several sources. Crimes and charges data were obtained from the crime Statistics (2002) and Canadian Centre for Justice Statistics (2003), respectively. Sentencing data for provincial custody and Federal custody were also obtained from the Canadian Centre for Justice Statistics (2002a; 2002b respectively). Sentencing data for youth offences were taken from Canadian Centre for Justice Statistics (2002c). Note, only those sentenced to secured custodies were counted. Other than Ontario and Quebec, data for youth offenders were provided in regions (Atlantic, Prairies, and Pacific), hence population was used to estimate according to the provinces.

Costs for liquor licensing were not available for 2002, so our estimates are based on the Single et al. (1996) estimates for 1992 and inflation-corrected for 2002. Cost data for specialized drug enforcement was obtained from Treasury Board of Canada Secretariat.

National cost estimates for federal adult corrections were derived from the Canadian Centre for Justice Statistics (2002a). National cost estimates for Young offenders' corrections was obtained from Canadian Centre for Justice Statistics for 1998/1999 fiscal year and was inflation-corrected for 2002/2003 fiscal year. Estimates for provincial jurisdictions for the above-specified two cost categories were based on per capita national averages. Provincial adult corrections costs were available from the Centre for Canadian Justice Statistics (2002b) for 2002.

Results

Avoidable crimes and policing costs

All the estimates presented below for the various interventions are compared to the baseline estimates presented in the cost study by Rehm et al., (2006). To give a glimpse of the law enforcement costs due to policing for 2002, it was estimated that 30.4% of all recorded criminal offences are related to alcohol in baseline. This fraction was translated into 761,638 incidents caused due to alcohol. Of all alcohol related incidents, 3.8% were due to drinking and driving, 16.7% were violent crimes, and almost 79.5% of crimes were other alcohol related crimes. In 2002, the total public policing costs in Canada were estimated at $6,149 million. The cost fraction of policing attributable to alcohol was estimated at $1,899 million for 2002 (baseline) (see Table 5).

-Insert Table 5 about here-

Results for alcohol-attributable crimes and costs of policing avoidable due to various interventions are summarized in Table 5 and 6, respectively. Avoidable costs due to various interventions are described below. All estimates for dollars are expressed for the year 2002.

-Insert Table 6 about here-

1. Pricing and taxation

If a 25% increase in price and taxation of alcohol was implemented in for Canada, drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been reduced by 398, 1,745, and 8,418, respectively. These figures represent a 1.4% reduction compared with the baseline scenario (Table 5). In addition, the total policing cost due to alcohol would have been reduced by about $26.0 million, 1.4% less than in the baseline scenario (Table 6).

2. Regulating blood alcohol concentration (BAC) levels

Scenario 1: **Based on a 6% reduction in non-fatal crashes**

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, this would have resulted in 2,794 fewer drinking and driving incidents, 9.8% less than in the baseline scenario (Table 5). This would have translated into a saving of $6.9 million in total policing cost, 0.4% less than in the baseline scenario (Table 6).

Scenario 2: Based on a 12% reduction in non-fatal crashes

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, this would have resulted in 5,459 fewer drinking and driving incidents, 19.1% less than in the baseline scenario (Table 5). The total policing cost due to alcohol would have been be reduced by $13.4 million, 0.7% less than in the baseline scenario (Table 6).

Scenario 3: Based on a 18% reduction in non-fatal crashes

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, this would have resulted in 7,975 fewer drinking and driving incidents, 27.8% less than in the baseline scenario (Table 5). The total policing cost due to alcohol could be reduced by $19.6 million, 1.0% less than in the baseline scenario (Table 6).

3. Zero BAC restriction for young drivers under the age 21

If a Zero BAC restriction for young drivers under the age 21 would have been implemented in Canada for 2002, 786 drinking and driving incidents could have been prevented. This figure represents 2.7% less compared with the baseline scenario (Table 5). The total law enforcement costs related to policing would have been reduced by $1.9 million, 0.1% less than in the baseline scenario (Table 6).

4. State monopoly on alcohol sales

Scenario 1: 10% increase in alcohol consumption

If a 10% increase in alcohol consumption would have occurred due to the privatization of alcohol sales in Canada for 2002, drinking and driving incidents, homicide and other violent

crimes, and other alcohol-attributable criminal activities would have increased by 930, 4,229, and 20,227, respectively. Compared with the baseline scenario, these figures represent an increase of 3.4% in drinking and driving incidents and an increase of 3.3% each in homicide and other violent crimes, and other alcohol-attributable criminal activities (Table 5). This would have resulted in an increase of $62.5 million in policing costs, a 3.3% increase compared with the baseline scenario (Table 6).

Scenario 2: 20% increase in alcohol consumption

If a 20% increase in alcohol consumption would have occurred due to the privatization of alcohol sales in Canada for 2002, drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have increased by 1,906, 8,458 and 40,454, respectively. This represents an increase of approximately 6.7% in these alcohol-attributable crimes compared with the baseline scenario
6.7%, (Table 5). This would give rise to an increase of $124.9 million in policing costs in the Canadian society, a 6.6% increase compared with the baseline scenario (Table 6).

5. Minimum legal drinking age (MLDA) laws

If MLDA was increased from 19 to 21 years in Canada for 2002, 3,109 drinking and driving incidents would have been avoidable, a 10.9% reduction compared with the baseline scenario (Table 5). The total policing costs due to alcohol would have been reduced by $7.6 million, a 0.4% reduction compared with the baseline scenario (Table 6).

6. Safer bars

If safer bars interventions were implemented in Canada for 2002, this would have resulted in 4,331 fewer homicide and other violent crime incidents, 3.4% less than in the baseline scenario (Table 5). The total criminality costs due to policing would have been reduced by $10.6 million, 0.6% less than in the baseline scenario (Table 6).

7. Brief interventions and primary care

If brief interventions were implemented in Canada for 2002, the avoidable drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been reduced by 736, 3,312 and 15,503, respectively. These figures represent a 2.6% reduction in these alcohol-attributable crimes compared with the baseline scenario (Table 5). In addition, the total policing cost due to alcohol would have been reduced by $48.1, 2.5% than in the baseline scenario (Table 6).

Avoidable charges and court-related costs

All numbers presented below (in various interventions) are compared to the baseline estimates of cost study 2002 (Rehm et al., 2006). To give a glimpse of the court-related law enforcement costs for 2002, it was estimated that 35.8% of all criminal charges dealt with in courts were related to alcohol in baseline. This was translated into 206,594 alcohol-induced charges. Of all alcohol related incidents, 9.5% of charges were due to drinking and driving, 29.5% were due to violent crimes, and almost 61% of charges were other alcohol related crimes. Similarly, in 2002, total court costs related to the processing of alcohol related criminal charges were estimated to be $513.1 million for alcohol in Canada for 2002 (baseline). These costs included all expenses for court staff, including judges, as well as expenditures associated with legal aid and prosecutors (Table 7).

-Insert Table 7 about here-

Results for alcohol-attributable charges and court-related costs avoidable due to various interventions are summarized in Table 7 and 8, respectively. All numbers presented below are compared to the above baseline estimates of cost study 2002 (Rehm et al., 2006). All estimates for dollars are expressed for the year 2002.

-Insert Table 8 about here-

1. Pricing and taxation

If a 25% increase in price and taxation of alcohol was implemented in Canada, the alcohol-attributable charges due to drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been reduced by 274, 833 and 1,753, respectively. These figures represent a 1.4% reduction in the alcohol–attributable crimes compared with the baseline scenario (Table 7). In addition, the total court-related cost due to alcohol could be reduced by about $7.1 million, 1.4% less compared with the baseline scenario (Table 8).

2. Regulating blood alcohol concentration (BAC) levels

Scenario 1: **Based on a 6% reduction in non-fatal crashes**

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, this would result in 1,920 fewer alcohol-attributable charges, 9.8% less than in the baseline scenario (Table 7). This would translate into a saving of $4.8 million, 0.9% less than in the baseline scenario (Table 8).

Scenario 2: **Based on a 12% reduction in non-fatal crashes**

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, 3,751 alcohol-attributable charges due to drinking and driving incidents would have been avoidable, 19.1% less than in the baseline scenario (Table 7). The total court-related cost due to alcohol would have been reduced by $9.3 million, 1.8% less than in the baseline scenario (Table 8).

Scenario 3: **Based on a 18% reduction in non-fatal crashes**

If the BAC level was lowered from 0.08% to 0.05% in Canada for 2002, this would have resulted in 5,480 fewer alcohol-attributable charges due to drinking and driving incidents, 27.8% less than in the baseline scenario (Table 7). The total court-related cost due to alcohol would have been reduced by $13.6 million, 2.7% less than in the baseline scenario (Table 8).

3. Zero BAC restriction for young drivers under the age 21

If a Zero BAC restriction for young drivers under the age 21 would have been implemented in Canada for 2002, this would have resulted in 541 fewer alcohol-attributable charges due to drinking and driving incidents, 2.7% less than in the baseline scenario (Table 7). The total law enforcement costs related to court would have been reduced by $1.3 million, 0.3% less than in the baseline scenario (Table 8).

4. State monopoly on alcohol sales

Scenario 1: 10% increase in alcohol consumption

If a 10% increase in alcohol consumption would have occurred due to the privatization of alcohol sales in Canada for 2002, alcohol-attributable charges due to drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been increased by 660, 2,018, and 4,213, respectively. These figures represent an increase of 3.3% in alcohol-attributable criminal activities compared with the baseline scenario (Table 7). This would have resulted in an increase of $17.1 million in alcohol-attributable court-related costs, 3.3% more than in the baseline scenario (Table 8).

Scenario 2: 20% increase in alcohol consumption

If a 20% increase in alcohol consumption would have occurred due to the privatization of alcohol sales in Canada for 2002, alcohol-attributable charges due to drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been increased by 1,309, 4,035, and 8,426, respectively. These figures represent an increase of approximately 6.7% compared with the baseline scenario (Table 7). This would have given rise to an increase of $34.2 million in alcohol-attributable court-related costs, 6.7% more than in the baseline scenario (Table 8).

5. Minimum legal drinking age (MLDA) laws

If the MLDA was increased from 19 to 21 years in Canada for 2002, this would have resulted in 2,136 fewer alcohol-attributable charges due to drinking and driving incidents, 10.9% less than

in the baseline scenario (Table 7). The total alcohol-attributable court-related costs due to alcohol could be reduced by $5.3 million, 1.0% less than in the baseline scenario (Table 8).

6. Safer bars

If safer bars interventions were implemented in Canada for 2002, 2,066 alcohol-attributable charges due to homicide and other violent crime incidents would have been avoidable, 3.4% less than in the baseline scenario (Table 7). The total court-related cost due to alcohol would have been reduced by $5.1 million, 1.0% less than in the baseline scenario (Table 8).

7. Brief interventions and primary care

If brief interventions were implemented in Canada for 2002, alcohol-attributable charges due to drinking and driving incidents, homicide and other violent crimes, and other alcohol-attributable criminal activities would have been reduced by 506, 1,580 and 3,229, respectively. These figures are 2.6% less than in the baseline scenario (Table 7). In addition, the total court-related cost due to alcohol would have been reduced by $13.2, 2.6% less than in the baseline scenario (Table 8).

Avoidable sentencing and corrections costs

All numbers presented below (in various interventions) are compared to the baseline estimates of cost study 2002 (Rehm et al., 2006). To give a glimpse of the law enforcement costs due to correctional services for 2002 in baseline, these costs included costs for penal institutions, probation and parole services for adult and young offenders at both the provincial and federal level. It was estimated that 24,236 of total adult sentences to provincial custody were due to alcohol including violent crimes (4,271). Of all youth offenders sentenced to provincial custody, 2,103 were sentenced for alcohol including violent crimes (371). Off all adult sentences to federal custody, alcohol constituted sentencing of 1,823 offenders. In terms of associated costs, it was estimated that the costs of correctional services for persons sentenced for alcohol-related

offences incurred $660.4 million (adult corrections: $269.6 million, youth correction: $158.2 million, federal adult correction: $232.6 million.

Results for alcohol-attributable sentencing and its corresponding corrections costs avoidable due to various interventions are summarized in Table 9. All estimates for imprisonments and dollars are expressed for the year 2002.

-Insert Table 9 about here-

1. Pricing and taxation

If a 25% increase in the price and taxation of alcohol was implemented in Canada for 2002, adult sentencing for other alcohol offences and adult sentences for violent offences in provincial custody; youth offences for other alcohol crimes and youth offences for violent crimes; and other alcohol offences in federal custody would have been reduced by 278, 59, 24, 5, and 25, respectively. These figures represent a 1.4% decrease compared with the baseline scenario. In addition, the total corrections costs due to alcohol would have been reduced by about $9.1 million, 1.4% less compared with the baseline scenario (Table 9).

2. State monopoly on alcohol sales

Scenario 1: 10% increase in alcohol consumption

If a 10% increase in alcohol consumption would have occurred due to the privatization of alcohol sales in Canada for 2002, adult sentencing for other alcohol offences and adult sentences for violent offences in provincial custody would have been increased by 667 and 142, respectively. Youth offences for other alcohol crimes, violent crimes, and other alcohol offences would have also been increased by 58, 12, and 61, respectively. These figures represent a 3.3% increase compared with the baseline scenario. This would have resulted in an increase of $22.0 million, in corrections costs, 3.3% more than in the baseline scenario (Table 9).

Scenario 2: 20% increase in alcohol consumption

If a 20% increase in alcohol consumption had occurred due to the privatization of alcohol sales in Canada for 2002, this would have resulted in 1,334 more adult sentencing for other alcohol

offences and 284 more adult sentences for violent offences in provincial custody. In addition, youth offences for other alcohol crimes, violent crimes, and other alcohol offences in federal custody would have been increased by 116, 25, and 121, respectively. These figures represent an increase of approximately 6.7% compared with the baseline scenario. This would have given rise to an increase of $44.0 million in corrections costs, 6.7% more than in the baseline scenario (Table 9).

3. Safer bars

If safer bars interventions were implemented in Canada for 2002, this would have resulted in 145 fewer adult sentences for violent offences in provincial custody and 13 fewer youth offences for violent crimes, 3.4% less than in the baseline scenario. The total criminality costs due to corrections would have been reduced by $2.6 million, 0.4% less than in the baseline scenario (Table 9).

4. Brief interventions and primary care

If brief interventions were implemented in Canada for 2002, adult sentencing for other alcohol offences and adult sentences for violent offences in provincial custody would have been reduced by 511 and 111, respectively. Similarly, youth offences for other alcohol crimes, violent crimes, and other alcohol offences in federal custody would have been be avoidable by 44, 10 and 47, respectively. These figures are 2.6% lower than in the baseline scenario. In addition, the total corrections costs due to alcohol would have been reduced by about $17.0 million. 2.6% less than in the baseline scenario due to implementation of this policy (Table 9).

Conclusion

Law enforcement costs are defined as the value of goods and services used in the criminal justice system in trying to prevent or intervene against criminal acts attributable to substance abuse. We define criminal acts attributable to alcohol as all such acts, which would not have been committed without the occurrence of alcohol use in (Canadian) society. These acts can be prevented or avoided from society with the implementation of various interventions. In this report

we have summarized the findings of law enforcement costs attributable to alcohol (in Canada for 2002) that could be avoidable, if select interventions are implemented in Canadian society.

Results revealed that the most effective intervention in terms of preventing drinking and driving crime incidents in Canada is lowering BAC level from 0.08% to 0.05%, which could have prevented between 2,794 and 7,975 (a relative change between 9.8% to 27.8%) drinking and driving incidents against what was estimated in the cost study (Rehm et al., 2006). Similarly, retaining the state monopoly on alcohol sales in Canada is also the most effective measure in avoiding between 4,229 and 8,458 or between 3.3% and 6.6% of homicide and other violent crimes; and between 20,227 and 40,454 or between 3.3% and 6.7% of other alcohol-attributable criminal activities (e.g., property crimes etc) in Canada based on 2002 data.

In terms of savings in policing costs due to alcohol-attributable crimes, retaining state monopoly on alcohol sales in Canada is the most effective strategy, which would save between 62 and 125 million dollars (a relative change between 3.3% and 6.6% of baseline cost estimates) against what was estimated in the cost study 2002 (Rehm et al., 2006). Brief interventions are the second most effective strategy, which would save more than 48 million dollars (2.5%) in policing cost. The third best intervention is the pricing and taxation, which could save another about 26.0 million dollars (a relative change of 1.4% to baseline) in policing cost.

In terms of savings in court and corrections costs due to alcohol-attributable crimes/charges, retaining state monopoly on alcohol sales is also the first most effective strategy, which would save between 17 and 34 million dollars and between 22 to 44 million dollars, respectively (a saving of 3.3% to 6.7% of baseline estimates). The second effective intervention is the brief interventions program, which could save about 13 million dollars (2.6%) in court and another 17 million (2.6%) in corrections-related costs. Pricing and taxation is the third most effective strategy, which would save more than 7 million dollars (1.4%) in court and 9 million (1.4%) in corrections costs.

Thus, this study provides evidence that implementation of effective population-based interventions will reduce both criminal activities and resulting costs associated with those activities attributable to alcohol in Canada.

Table 1. Select interventions and impact on different indicators of alcohol-attributable criminality

Interventions	Impact on criminality indicators		
	Drinking & driving	Homicide & other violent crimes	Other criminal activities (e.g., property crime)
1. Increase in taxes	YES	YES	YES
2. Lowering BAC	YES	-	-
3. Zero BAC for young drivers under the age 21	YES	-	-
4. MLDA laws	YES	-	-
5. Safer Bars	-	YES	-
6. Brief interventions	YES	YES	YES
7. State monopoly on alcohol sales*	YES	YES	YES

BAC - Blood alcohol concentration
MLDA - Minimum legal drinking age
*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in all three components of criminality (a, b, & c).

Table 2. Mechanism and effects on morbidity/mortality and criminality of the select interventions

Intervention	Mechanism	Effect on morbidity/mortality	Effect on criminality
Increase in taxes	Economics principle: impacts on purchases and thus on the alcohol consumption level	affects all alcohol-attributable disease and injury categories	affects all three alcohol-attributable criminality categories
Lowering BAC	affects probability of driving under the influence of alcohol and thus alcohol-attributable traffic injuries	affects alcohol-attributable traffic injury categories (morbidity and mortality)	affects only one category of alcohol-attributable criminality: drinking driving
Zero BAC under the age 21	affects probability of driving under the influence of alcohol and thus alcohol-attributable traffic injuries	affects alcohol-attributable traffic injury categories (morbidity and mortality)	affects only one category of alcohol-attributable criminality: drinking driving
MLDA	affects probability of driving under the influence of alcohol and thus alcohol-attributable traffic injuries	affects alcohol-attributable traffic injury categories (morbidity and mortality)	affects only one category of alcohol-attributable criminality: drinking driving
Safer Bars program	affects a heavy consumption of alcohol and thus reduces violence and physical aggression in bars	affects alcohol-attributable homicide (morbidity and mortality)	affects only one category of alcohol-attributable criminality: homicide and other violent crimes
Brief interventions	affects the prevalence of hazardous drinking	affects all alcohol-attributable disease and injury categories	affects all three alcohol-attributable criminality categories
Privatization (vs. state monopoly on alcohol sales)*	affects alcohol consumption level	affects all alcohol-attributable disease and injury categories	affects all three alcohol-attributable criminality categories

BAC - Blood alcohol concentration;
MLDA - Minimum legal drinking age
*The effect of privatization of alcohol sales was modeled. Therefore, this effect goes in opposite direction, showing increase in morbidity/mortality and all three components of criminality (a, b, & c).

Table 3. Rate of change in alcohol prevalence due to price elasticity

Price increase	Rate of taxation			Beverage consumption			Price elasticity		
Taxation	***Beer***	***Spirit***	***Wine***	***Beer***	***Spirit***	***Wine***	***Beer -0.3***	***Spirit -1***	***Wine -1.5***
Current rate	22.4%	27.3%	19.7%	*55.1%*	*26.9%*	*17.9%*	-	-	-
Assuming beverage price=$100	$22.4	$27.3	$19.7	*55.1%*	*26.9%*	*17.9%*	-	-	-
25% increase in tax	$28.0	$34.2	$24.7	*56.5%*	*26.2%*	*17.3%*	-	-	-
Beverage price after tax increase	$105.6	$106.8	$105.0	*56.5%*	*26.2%*	*17.3%*	-1.7%	-6.8%	-7.5%

	Change in consumption volume			Total	Rate of change in per capita consumption
Beverage consumption before (in litre)	4.30	2.10	1.40	**7.80**	**-4.1%**
	4.3 * 98.3%	2.1 * 93.2%	1.4 * 92.5%		
Beverage consumption after (in litre)	= 4.23	= 1.96	= 1.30	**7.48**	

Table 4. Attributable fractions before and after various interventions for criminality indicators

Select interventions	Impaired driving*			Violent crimes[&]			Other crimes[†]		
	Before	After	Proportional change	Before	After	Proportional change	Before	After	Proportional change
Increase in taxes: 4.1% reductions in consumptions	24.5%	24.2%	-1.4%	26.2%	25.8%	-1.4%	23.1%	22.8%	-1.4%
Lowering BAC levels: 0.08% to 0.05%									
Scenario 1: 6% reductions	24.5%	22.1%	-9.8%	-	-	-	-	-	-
Scenario 2: 12% reductions	24.5%	19.8%	-19.1%	-	-	-	-	-	-
Scenario 3: 18% reductions	24.5%	17.7%	-27.8%	-	-	-	-	-	-
Zero BAC for young drivers under the age 21 reduces 12% of non-fatal crashes	24.5%	19.4%	-20.6%	-	-	-	-	-	-
State monopoly on alcohol sales (privatization)**									
Scenario 1: 10% increase in consumption	24.5%	25.3%	3.4%	26.2%	27.1%	3.3%	23.1%	23.8%	3.3%
Scenario 2: 20% increase in consumption	24.5%	26.1%	6.7%	26.2%	27.9%	6.6%	23.1%	24.6%	6.7%
Raising MLDA				-	-	-			-
Raising MLDA from 19 to 21 years reduces 6% of non-fatal crashes	24.5%	21.9%	-10.9%	-	-	-	-	-	-
Safer Bars	-	-	-	26.2%	25.3%	-3.4%	-	-	-
Brief interventions: 7.7% reduction in consumptions	24.5%	23.9%	-2.6%	26.2%	25.5%	-2.6%	23.1%	22.5%	-2.6%

- not applicable
BAC - Blood alcohol concentration
MLDA - Minimum legal drinking age
* Based on morbidity of traffic injuries
**The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in all three components of criminality (a, b,& c).
& Based on average of mortality and morbidity violent crimes AFs
† crime rates were increased or decreased directly proportional to the decrease in alcohol consumption

Table 5. Alcohol-attributable crimes avoidable due to select interventions in Canada 2002

	Baseline (Cost Study Rehm et al., 2006)	Increase in taxes by 25% [a,b,c]	Lowering BAC from 0.08% to 0.05%			Zero BAC under age 21yrs [a]	State monopoly on alcohol sales* (Privatization) [a,b,c]		MLDA 19-21 yrs [a]	Safer Bars [b]	Brief interventions [a,b,c]
			6% reduction in non-fatal crashes	12% reduction in non-fatal crashes	18% reduction in non-fatal crashes		10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in non-fatal crashes		
a: Drinking & driving criminality incidents	28,655	**28,257**	**25,861**	**23,197**	**20,681**	**27,869**	**29,615**	**30,561**	**25,546**	28,655	**27,919**
Difference between baseline and select intervention		**-398**	**-2,794**	**-5,459**	**-7,975**	**-786**	**960**	**1,906**	**-3,109**	0	**-736**
Relative change between baseline and select intervention		**-1.4%**	**-9.8%**	**-19.1%**	**-27.8%**	**-2.7%**	**3.4%**	**6.7%**	**-10.9%**	0.0%	**-2.6%**
b: Homicide & other violent crimes incidents	127,383	**125,638**	127,383	127,383	127,383	127,383	**131,613**	**135,842**	127,383	**123,052**	**124,072**
Difference between baseline and select intervention		**-1,745**	0	0	0	0	**4,229**	**8,458**	0	**-4,331**	**-3,312**
Relative change between baseline and select intervention		**-1.4%**	0.0%	0.0%	0.0%	0.0%	**3.3%**	**6.6%**	0.0%	**-3.4%**	**-2.6%**
c: Other alcohol-attributable criminal activities incidents	605,599	**597,181**	605,599	605,599	605,599	605,599	**625,826**	**646,053**	605,599	605,599	**590,095**
Difference between baseline and select intervention		**-8,418**	0	0	0	0	**20,227**	**40,454**	0	0	**-15,503**
Relative change between baseline and select intervention		**-1.4%**	0.0%	0.0%	0.0%	0.0%	**3.3%**	**6.7%**	0.0%	0.0%	**-2.6%**
Alcohol-total incidents	**761,638**	**751,076**	**758,844**	**756,179**	**753,663**	**760,852**	**787,054**	**812,455**	**758,529**	**757,307**	**742,086**
Alcohol incidents as % of total	**30.4%**	**30.0%**	**30.3%**	**30.2%**	**30.1%**	**30.4%**	**31.5%**	**32.5%**	**30.3%**	**30.3%**	**29.7%**

a Drinking and driving
b Homicide and other violent crimes
c Other criminal activities (e.g., property crime etc)
*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in all three components of criminality (a, b, & c)

Table 6. Policing costs of alcohol-attributable crimes avoidable due to select interventions in Canada 2002

	Baseline (Cost Study Rehm et al., 2006	Increase in taxes by 25%	Lowering BAC from 0.08% to 0.05%			Zero BAC under age 21yrs	State monopoly on alcohol sales* (Privatization)		MLDA 19-21 yrs	Safer Bars	Brief interventions
			6% reduction in non-fatal crashes	12% reduction in non-fatal crashes	18% reduction in non-fatal crashes		10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in non-fatal crashes		
Costs due to alcohol ($million): total costs of policing	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**	**$6,149.19**
Police costs due to alcohol incidents	$1,871.97	$1,846.02	$1,865.11	$1,858.56	$1,852.37	$1,870.04	$1,934.44	$1,996.87	$1,864.33	$1,861.33	$1,823.92
Additional policing: liquor licensing**	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79	$26.79
Total policing (crime) costs due to alcohol	**$1,898.76**	**$1,872.80**	**$1,891.90**	**$1,885.35**	**$1,879.16**	**$1,896.83**	**$1,961.23**	**$2,023.66**	**$1,891.12**	**$1,888.12**	**$1,850.71**
Difference between baseline and select intervention		**-$25.96**	**-$6.87**	**-$13.42**	**-$19.60**	**-$1.93**	**$62.47**	**$124.90**	**-$7.64**	**-$10.64**	**-$48.05**
Relative change between baseline and select intervention		**-1.4%**	**-0.4%**	**-0.7%**	**-1.0%**	**-0.1%**	**3.3%**	**6.6%**	**-0.4%**	**-0.6%**	**-2.5%**

a Drinking and driving
b Homicide and other violent crimes
c Other criminal activities (e.g., property crime etc)
*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in costs for alcohol-attributable crimes
** Liquor licensing=used 1992 Quebec + Ontario estimate n inflated to 2002 (19.4%) then estimated based on per capita average in Ontario and Quebec

Table 7. Alcohol-attributable charges avoidable due to select interventions in Canada 2002

	Baseline (Cost Study Rehm et al., 2006)	Increase in taxes by 25% [a,b,c]	Lowering BAC from 0.08% to 0.05%			Zero BAC under age 21yrs [a]	State monopoly on alcohol sales* (Privatization)* [a,b,c]		MLDA 19-21 yrs [a]	Safer Bars [b]	Brief interventions [a,b,c]
			6% reduction in non-fatal crashes	12% reduction in non-fatal crashes	18% reduction in non-fatal crashes		10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in non-fatal crashes		
a: Drinking & driving criminality incidents	19,690	**19,416**	**17,770**	**15,939**	**14,210**	**19,149**	**20,350**	**21,000**	**17,554**	19,690	**19,184**
Difference between baseline and select intervention		**-274**	**-1,920**	**-3,751**	**-5,480**	**-541**	**660**	**1,309**	**-2,136**	0	**-506**
Relative change between baseline and select intervention	1,996	**-1.4%**	**-9.8%**	**-19.1%**	**-27.8%**	**-2.7%**	**3.4%**	**6.7%**	**-10.9%**	0.0%	**-2.6%**
b: Homicide & other violent crimes incidents	60,769	**59,937**	60,769	60,769	60,769	60,769	**62,787**	**64,804**	60,769	**58,703**	**59,189**
Difference between baseline and select intervention		**-833**	0	0	0	0	**2,018**	**4,035**	0	**-2,066**	**-1,580**
Relative change between baseline and select intervention		**-1.4%**	0.0%	0.0%	0.0%	0.0%	**3.3%**	**6.6%**	0.0%	**-3.4%**	**-2.6%**
c: Other alcohol-attributable criminal activities incidents	126,135	**124,382**	126,135	126,135	126,135	126,135	**130,348**	**134,561**	126,135	126,135	**122,906**
Difference between baseline and select intervention		**-1,753**	0	0	0	0	**4,213**	**8,426**	0	0	**-3,229**
Relative change between baseline and select intervention		**-1.4%**	0.0%	0.0%	0.0%	0.0%	**3.3%**	**6.7%**	0.0%	0.0%	**-2.6%**
Alcohol-total charges	**206,594**	**203,735**	**204,675**	**202,843**	**201,115**	**206,053**	**213,485**	**220,365**	**204,458**	**204,528**	**201,279**
Alcohol incidents as % of total	**35.8%**	**35.3%**	**35.4%**	**35.1%**	**34.8%**	**35.7%**	**37.0%**	**38.2%**	**35.4%**	**35.4%**	**34.9%**

a Drinking and driving
b Homicide and other violent crimes
c Other criminal activities (e.g., property crime etc)
*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in all three components of criminality (a, b, & c)

Table 8. Court related costs of alcohol-attributable charges avoidable due to select interventions in Canada 2002

	Baseline (Cost Study Rehm et al., 2006)	Increase in taxes by 25%	Lowering BAC from 0.08% to 0.05%			Zero BAC under age 21yrs	State monopoly on alcohol sales* (Privatization)		MLDA 19-21 yrs	Safer Bars	Brief interventions
			6% reduction in non-fatal crashes	12% reduction in non-fatal crashes	18% reduction in non-fatal crashes		10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in non-fatal crashes		
Costs due to alcohol ($million): total costs of court	1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37	$1,003.37
Legal aid & crown attorney costs for criminal cases	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63	$430.63
Total court-related) costs due to alcohol	$513.07	$505.97	$508.30	$503.75	$499.46	$511.72	$530.18	$547.27	$507.76	$507.94	$499.87
Difference between baseline and select intervention		-$7.10	-$4.77	-$9.32	-$13.61	-$1.34	$17.11	$34.20	-$5.31	-$5.13	-$13.20
Relative change between baseline and select intervention		-1.4%	-0.9%	-1.8%	-2.7%	-0.3%	3.3%	6.7%	-1.0%	-1.0%	-2.6%

*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in costs of alcohol-attributable charges

Table 9. Alcohol-attributable corrections and associated costs avoidable due to select interventions in Canada 2002

	Baseline (Cost Study Rehm et al., 2006)	Increase in taxes by 25% [b,c]	State monopoly on alcohol sales* (Privatization) [a,b,c]		Safer Bars [b]	Brief interventions [b,c]
			10% increase in consumption	20% increase in consumption		
Total Sentenced to provincial custody	83,885	83,885	83,885	83,885	83,885	83,885
Total youth offenders sentenced to provincial custody	7,278	7,278	7,278	7,278	7,278	7,278
Total sentenced to federal custody	7,659	7,659	7,659	7,659	7,659	7,659
Provincial adult corrections costs (million$)	933.30	933.30	933.30	933.30	933.30	933.30
Young offender corrections costs (million)	547.43	547.43	547.43	547.43	547.43	547.43
Federal adult corrections costs (million$)	977.23	77.23	977.23	977.23	977.23	977.23
c: Sentenced for alcohol offence (provincial custody)	**19,965**	**19,687**	**20,631**	**21,298**	19,965	**19,454**
Difference between baseline and select intervention		**-278**	**667**	**1,334**	0	**-511**
Relative change between baseline and select intervention		**-1.4%**	**3.3%**	**6.7%**	0.0%	**-2.6%**
c: Sentenced for alcohol offence (youth offender)	**1,732**	**1,708**	**1,790**	**1,848**	1,732	**1,688**
Difference between baseline and select intervention		**-24**	**58**	**116**	0	**-44**
Relative change between baseline and select intervention		**-1.4%**	**3.3%**	**6.7%**	0.0%	**-2.6%**
c: Sentenced for alcohol offence (federal custody)	**1,823**	**1,798**	**1,883**	**1,944**	1,823	**1,775**
Difference between baseline and select intervention		**-25**	**61**	**121**	0	**-47**
Relative change between baseline and select intervention		**-1.4%**	**3.3%**	**6.6%**	0.0%	**-2.6%**
b: Sentenced for violent crimes (provincial custody)	**4,271**	**4,213**	**4,413**	**4,555**	**4,126**	**4,160**
Difference between baseline and select intervention		**-59**	**142**	**284**	**-145**	**-111**

	Baseline (Cost Study Rehm et al., 2006)	Increase in taxes by 25% [b,c]	State monopoly on alcohol sales* (Privatization) [a,b,c]		Safer Bars [b]	Brief interventions [b,c]
			10% increase in consumption	20% increase in consumption		
Relative change between baseline and select intervention		-1.4%	3.3%	6.6%	-3.4%	-2.6%
b: Sentenced for violent crimes (youth offender)	371	365	383	395	358	361
Difference between baseline and select intervention		-5	12	25	-13	-10
Relative change between baseline and select intervention		-1.4%	3.3%	6.6%	-3.4%	-2.6%
Alcohol attributable provincial adult corrections costs (million$)	269.64	265.91	278.64	287.64	268.03	262.72
Alcohol attributable young offender corrections costs (million)	158.16	155.97	163.44	168.72	157.21	154.10
Alcohol attributable federal adult corrections costs (million$)	232.58	229.39	240.30	248.02	232.58	226.53
Total corrections costs due to alcohol (million$)	660.39	651.27	682.38	704.38	657.82	643.36
Difference between baseline and select intervention		-9.12	22.00	43.99	-2.56	-17.03
Relative change between baseline and select intervention		-1.4%	3.3%	6.7%	-0.4%	-2.6%

*The effect of privatization of alcohol sales was modelled. Therefore, this effect goes in opposite direction, showing increase in costs of alcohol-attributable corrections (prison) cost

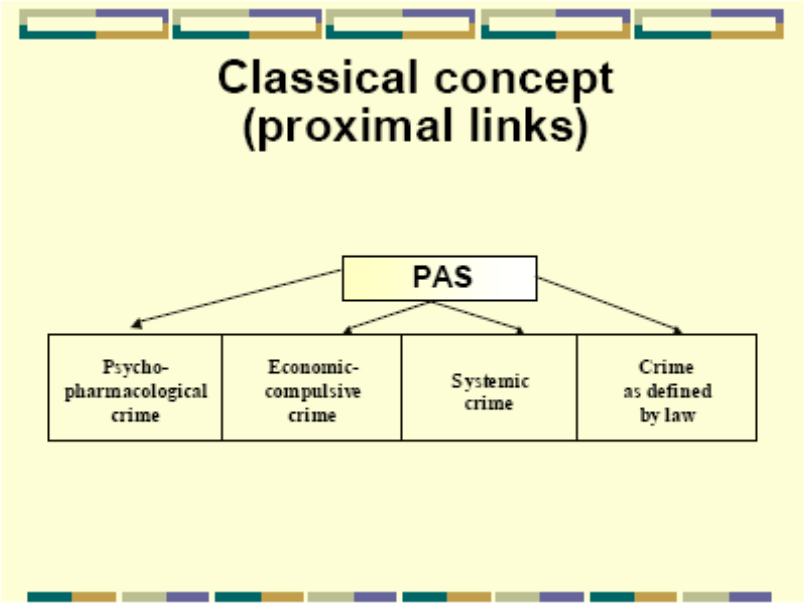

Figure 1. Classical concept (proximal links)
Source: International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006).

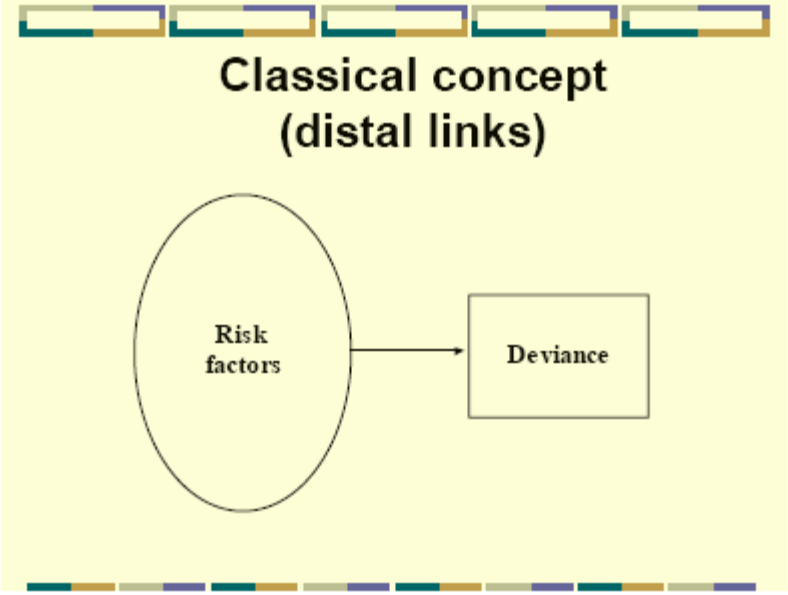

Figure 2. Classical concept (distal links)
Source: International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006).

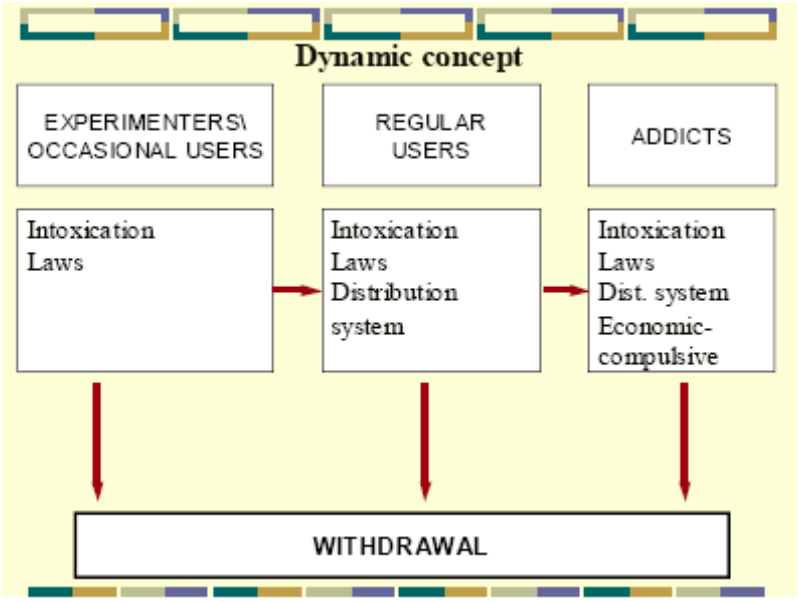

Figure 3. Dynamic concept
Source: International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006).

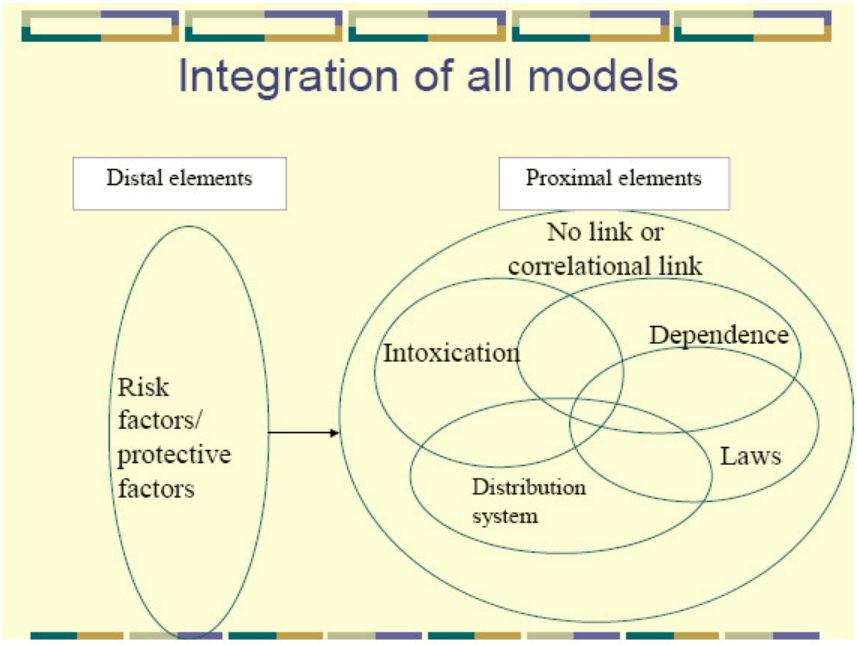

Figure 4. I ntegration of all models
Source: International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006).

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CHAPTER IV

MODULE 6: CALCULATIONS OF DIRECT HEALTH CARE AND INDIRECT COSTS

A. Sarnocinska-Hart, J. Patra & W. H. Gnam

Executive Summary

This module estimates the avoidable health care costs and avoidable indirect costs associated with selected evidence-based interventions that would decrease alcohol consumption and thereby decrease the incidence of alcohol-attributable morbidity and mortality. The effects of the following six interventions were modeled: taxation and price increases, lowering the blood alcohol concentration (BAC) legal limit from 0.08% to 0.05%, zero BAC restriction for all drivers under the age of 21, increasing the minimum legal drinking age (MLDA) from 19 to 21 years, a safer bars intervention, and brief interventions. Although privatization of alcohol sales would not result in cost savings, the additional costs incurred by privatization were also modeled.

The methodology of this study was based on the International Guidelines for the Estimation of the Avoidable Costs of Substance Abuse (Collins et al., 2006). The rationale for choosing the six interventions modeled is provided in Module 4 (Popova and Rehm, 2007). This module focuses on estimation of the impact of these interventions on the number of alcohol-attributable acute care hospital days, psychiatric hospital days, specialized outpatient and inpatient treatment days, ambulatory care services, physicians' services, number of prescription drugs used, the number of deaths and potential years of life lost, and the number of days of long-term and short-term disability. From these figures, this module estimates the avoidable direct health care costs and avoidable indirect costs. Indirect costs were defined as the cost of lost productivity due to disability or premature death.

Across most categories of direct health care costs, brief interventions were associated with the largest avoidable costs. Assuming that brief interventions resulted in a 22% reduction in alcohol consumption, our results indicate that $168.1 million in acute hospital costs, $110.7 million in

specialized inpatient care costs, $88.4 million in prescription drug costs, and $19.9 million in family physician services costs would be avoided, with other smaller avoided costs for ambulatory care physician services ($9.2 million), specialized outpatient care ($7.7 million) and for psychiatric hospital services ($2.9 million). Increases in pricing and taxes by 25% were found to be associated with $34.0 million in avoidable acute hospital costs, and $0.3 million in avoidable psychiatric hospital costs. The avoidable health care costs were generally smaller for lowering the blood alcohol concentration (BAC) legal limit from 0.08% to 0.05%, zero BAC restriction for all drivers under the age of 21, increasing the minimum legal drinking age (MLDA) from 19 to 21 years, and the safer bars intervention. By contrast, privatization of alcohol sales was found to be associated with substantial *increases* in direct health care costs. For example, privatization that resulted in a 20% increase in alcohol consumption would be associated with a $238.2 million increase in acute care hospital costs.

Our results also reveal that implementing the selected interventions was associated with substantial reductions in the indirect costs (productivity losses) of premature mortality and long-term disability. Brief interventions again produced the largest avoidable indirect costs, amounting to $904.0 million in avoidable costs due to long-term disability, and $101.2 million in avoidable costs due to premature death. The results also indicate that substantial *increases* in indirect costs would occur if provinces were to privatize alcohol sales. The magnitude of the avoidable indirect cost estimates varied substantially according to the method chosen to value lost productivity.

In conclusion, these estimates provide compelling evidence that implementing certain interventions would reduce direct health care costs and indirect (productivity) costs attributable to alcohol in Canada.

Introduction

Alcohol consumption is linked to injuries, accidents, numerous medical conditions, and to morbidity and premature death (World Health Organization, 2004). The second Canadian cost study on substance abuse (Rehm et al., 2006) estimated the direct health care costs and the indirect costs (productivity losses) of alcohol consumption for the year 2002. Included in the calculations were estimates of mortality and potential years of life lost attributable to alcohol abuse, as well as long-term and short-term disability, and reduced productivity while at work.

This module estimates the impact of six selected interventions on avoidable direct health care costs and on avoidable indirect costs, using the 2002 results (Rehm et al., 2006) as the baseline scenario. The Report on Module 4 for Health Canada, "Using Evidence on the Effectiveness of Interventions for Reducing Alcohol-Related Harm" (Popova and Rehm, 2007) provides a rationale for selection of the six interventions modeled here, as well as a detailed description of the interventions. This module also estimates the impact of privatization of alcohol sales on direct health care costs and indirect costs. Unlike the six interventions, privatization would be associated with substantial *increases* in direct health care and indirect costs. Nonetheless, privatization is included in the analyses of this module because of its policy relevance to most provinces in Canada.

Methodology

Table 6 (Chapter II) lists the six selected interventions and privatization, the estimated range of their effects, the supporting research, and the scenarios that are modeled in this module.

Estimating Avoidable Direct Health Care Costs

For all calculations of avoidable health care costs we used the results from the second Canadian cost study on substance abuse (Rehm et al., 2006) as the baseline from which changes in costs were determined.

Acute care hospital costs

The baseline scenario costs of acute care hospitalizations were estimated by multiplying the alcohol-attributable fractions for conditions known to be affected or caused by alcohol consumption by the aggregate numbers of acute care hospital days for each condition, obtained from Canadian Institute for Health Information (CIHI) by province or territory. These figures were then multiplied by the per diem cost of acute care hospital days by condition and by province or territory, using costs obtained from a variety of sources (Rehm et al., 2006; CIHI, 2004b). The total National figures were then calculated by aggregating the total costs due to alcohol-attributable conditions across provinces and territories.

To compute the avoidable costs of the interventions related to acute care hospital days, we applied the estimated percentage changes in the alcohol - attributable fractions caused by the intervention for each alcohol-attributable condition to the baseline figures. We thereby obtained the changes in costs for all alcohol-attributable conditions, which were then aggregated to provide the estimated avoidable cost of each intervention.

Psychiatric hospitalization costs

Strategies such as price and tax increases, imposing a state monopoly on sales, and brief interventions can decrease the incidence of alcohol-attributable psychiatric conditions through decreases in alcohol consumption. The baseline (Rehm et al. 2006) cost of alcohol-attributable

psychiatric hospital days was computed as the product of the total number of psychiatric hospital days for each alcohol-attributable condition and the per diem hospital cost, aggregated across all alcohol-attributable conditions. We obtained the avoidable portion of costs of psychiatric hospital days associated with the interventions by multiplying the baseline costs per condition by the intervention-specific percentage change in the alcohol-attributable proportions per condition, and then aggregating the costs across conditions.

Outpatient and inpatient specialized treatment costs

The baseline cost of outpatient specialized treatment for alcohol dependence was estimated by multiplying the number of outpatient visits by the unit cost of outpatient services in acute care hospitals. The baseline cost of specialized inpatient alcohol services was obtained as the product of the number of inpatient days in specialized treatment and the per diem cost of such inpatient days in acute care hospitals.

To estimate the avoidable costs of outpatient and inpatient specialized treatment we modelled interventions that affected alcohol-related conditions such as alcohol dependence, alcohol abuse, alcohol psychosis, etc. The modelled interventions were prices increases (as a result of taxation) and brief interventions. The impact of privatization of alcohol sales was also modeled. The avoidable costs of outpatient and inpatient specialized treatment for each intervention was determined by multiplying the baseline costs for specialized treatment by the percentage change in the alcohol-attributable fractions for alcohol-related conditions.

Ambulatory care physician fees

The baseline cost of physician services for alcohol-attributable conditions treated in ambulatory care centres (including emergency visits, day/night care visits, and specialty/private clinic visits) was calculated as the product of number of visits for alcohol-attributable conditions and CIHI's (2004c) average national and provincial per-visit physician fees in 2002. Due to data limitations the proportions of ambulatory care visits attributable to alcohol were assumed to be the same as those for alcohol attributable acute care hospital days. In order to determine the avoidable costs of ambulatory physician care due to the interventions, the baseline costs were multiplied by the intervention-specific percentage change in costs derived for acute care hospitals.

Family physician outpatient service costs

In the Rehm et al. (2006) study the baseline costs of alcohol-attributable services provided by family physicians were estimated as the product of the total number of family physician visits, the average cost per visit, and a scaling factor to exclude costs incurred by children and adolescents. The alcohol-attributable cost was estimated by multiplying this product by the proportion of total costs related to acute care hospitalizations. The avoidable cost of each intervention on family physician service costs was estimated by multiplying the baseline cost by the intervention-specific percentage change in costs derived for acute care hospitals.

Prescription drug costs

The baseline cost of alcohol-attributable prescription drugs was determined by multiplying the estimated number of cases using prescription drugs by the alcohol-attributable proportions of costs derived for acute care hospitalization costs, and the average per unit cost of drug prescriptions at the provincial level (CIHI, 2004e). The national cost was derived as the provincial total. To estimate the avoidable cost due to the interventions, we multiplied the baseline costs by the intervention-specific percentage change in avoidable acute care hospitalization costs.

Estimating Avoidable Indirect Costs

Methods for estimating indirect costs: lost or reduced productivity using the Rehm et al. (2006) study approach

In estimating the avoidable indirect costs due to the selected interventions it is important to review how such costs were determined in the baseline scenario. In the Rehm et al., 2006 study, the indirect cost of alcohol-attributable morbidity and mortality was the value of production lost due to premature mortality, long-term disability, and short-term disability (including reduced productivity while at work).

The traditional method of valuing lost production is the human capital (HC) approach (Hodgson, 1983; Hodgson, 1994). In the HC framework, the cost of premature mortality (or long-term disability) due to a disease is the discounted present value of the projected stream of production for that person – that is, the stream of production that would have occurred if they had not died or become disabled prematurely.

The rationale for the HC approach involves several assumptions that are unrealistic in contemporary Canadian labour markets. The approach assumes that there is full employment in labour markets, such that production lost by premature death is a permanent societal loss, because persons leaving the labour market are not replaced. However, involuntary unemployment has been a persistent feature of the Canadian labour market over several years (Fortin, Keil, & Symons, 2001; Amano & Macklem, 1998). Whether caused by sticky wages or imperfect macroeconomic policy, the result may be that the prevailing wage is higher than the level that would equate the quantity of labour demanded to the quantity supplied.

As an alternative to the full employment assumptions of the HC model, Koopmanschap et al. (1995) proposed that the value of lost productivity due to premature death should be limited to the cost of replacing an absent worker – the so-called 'friction cost' (FC) approach. For practical calculations, Koopmanschap and Rutten (1996) suggested that the replacement period for worker had a mean of three months. The friction cost approach may be more realistic when the labour market is not at full employment, but it does assume that the societal opportunity cost of labour is zero – that is, the sacrifice of replacement workers' leisure for work has no monetary value. However, lost leisure is a cost that should be considered, if one adopts the societal perspective that encompasses all costs and benefits that matter to citizens. In this case, the value of lost work beyond the friction period is obviously not zero – it is equal to or greater than the (marginal) reservation wage unemployed workers would require to sacrifice leisure for work. Although determining the value of the marginal reservation wage for unemployed persons by empirical means is difficult (Shaw, 1992), its lower bound is the marginal value of leisure. Empirical estimation of the marginal value of leisure is complicated (Alvarez-Farizo, Hanley, & Barberan, 2001), and would require primary data collection that is beyond the scope of the current research. For this reason, in the Rehm et al. (2006) study we estimated the marginal reservation wage using a replacement wage approach, assigning values to household jobs that

replacement workers perform based upon Statistics Canada estimates of the value of housekeeping services (Statistics Canada, 1995), weighted over all household activities using time weights. The time weights were based upon Statistics Canada General Social Survey 1998 Cycle 2 data (Statistics Canada, 2005). The Rehm et al. (2006) study then aggregated the marginal reservation wages for all of the replacement workers across their expected productive lives, adjusted them for gender and age specific labour force participation rates, discounted them to present value using a 5% discount rate, and inflated them by 3% to reflect the projected productivity growth over time.

Productivity costs due to premature mortality

The cost of premature mortality due to alcohol abuse in the baseline (Rehm et al., 2006) study was calculated as the sum of the friction costs of replacing the deceased worker, plus the discounted present value of the projected future stream of the marginal reservation wage (for the worker who fills the vacant position), adjusted for sex and age-group-specific labour force participation rates and for the rate of productivity growth. The algebraic form of this cost equation has been published elsewhere (see for example, Gnam et al., 2006).

Once we applied the changes in the alcohol-attributable fractions (for all relevant alcohol-attributable conditions) associated with each intervention to determine the avoidable number of years of life lost (compared to the baseline scenario) by gender and age group, we calculated the avoidable productivity costs using the modified human capital approach described above. In order to facilitate comparisons with other research, we also calculated avoidable productivity costs due to the interventions using the traditional HC and the FC methods.

The productivity costs due to morbidity

Reduced productivity due to alcohol abuse or dependence could result from long-term disability, from increased rates of absenteeism (including short-term disability spells), or from reduced productivity for workers while on the job. To estimate the productivity costs for those Canadians on long-term disability due alcohol abuse or dependence in the Rehm et al. (2006) baseline

study, we first estimated the number of Canadians permanently disabled from working due to alcohol dependence using data from Canadian Community Health Survey, cycle 1.2 (CCHS c1.2) (Statistics Canada, 2002c). We used these estimates in conjunction with the age distribution of those permanently disabled to estimate the number of years of lost productive life. From these figures we then calculated productivity losses using the modified HC approach described above for premature mortality. In order to determine the impact of the interventions on long-term disability, we multiplied the costs of long-term disability by the estimated percentage change in the alcohol-attributable fraction for alcohol dependence that was determined for each intervention. Due to data limitations in the baseline study, our estimates of the interventions' impact on long-term disability are limited to their impact on alcohol dependence.

To estimate the baseline productivity losses due to short-term disability, absenteeism, and reduced productivity at work in the Rehm et al. (2006) study, we conducted a multivariate linear regression analysis of the personal income data recorded in the CCHS c1.2 for respondents aged 15 to 74 years who participated in labour force in 2002. The CCHS c1.2 survey asked respondents to report personal income from all sources, and to name all separate sources of income, but it did not record the amount of income from each source. Other sociodemographic and human capital variables included in the income equations were age, marital status, race, geographical residence, categorical variables for education, birth outside of Canada, and dummy variables for several chronic medical conditions. Once the regression models were fit, we took the difference between the predicted mean income of the survey respondents with and without alcohol dependence, controlling for other co-occurring mental disorders, as the final estimate of the productivity losses due to short-term disability and absenteeism attributable to alcohol. This approach assumes that worker productivity is readily observable to the employer; that wages adjust rapidly to reflect changes in productivity; and that the ill employee bears most of the costs of reduced productivity due to illness. Our econometric specification tests revealed that multiple linear regression models were an adequate specification, and that instrumental variables estimation (Angrist, Imbens, & Rubin, 1996; Greenland, 2000) in order to adjust for omitted variables or simultaneity bias was unnecessary. All analyses were performed on the CCHS c1.2 microdata at the Toronto Regional Data Centre (RDC) of Statistics Canada.

To estimate the impact of the interventions, for each intervention we multiplied the percent changes in the alcohol-attributable fraction for alcohol dependence due to the intervention by the baseline figures obtained in the regression analysis. The resulting costs represented the changes in indirect costs due to short-term disability, absenteeism and reduced at-work productivity that were attributable to the intervention. Due to data limitations the estimates represent only the impact of the interventions on workers with alcohol dependence, and do not include the potential impact of the interventions on other alcohol-attributable conditions that could cause absenteeism, reduced at-work productivity, or short-term disability.

Results

Avoidable Direct Health Care Costs

The productivity costs due to morbidity

Acute care hospital costs

The avoidable costs of the interventions related to acute care hospitals vary significantly, reflecting the fact that some interventions (increases in pricing and taxes, brief interventions, and privatization of alcohol sales) exert impact on most or all alcohol-attributable conditions, whereas other interventions (such as BAC, Zero tolerance, MLDA, or safer bars) only affect selected conditions –mainly unintentional and intentional injuries— for which acute care hospitalization might occur. For example, modifying BAC level, Zero tolerance and MLDA only impacted the number of acute care hospital days due to changes in the rates of alcohol-attributable motor vehicle accidents.

Our modelling indicates that brief interventions are the most effective measures to reduce the number of acute care hospital days and costs. These interventions would avoid 4.5% to 11.5% acute care hospital days, depending upon the magnitude of decrease in alcohol consumption (7.7% and 22.0%, respectively). In terms of avoidable costs, brief interventions that are associated with a reduction in alcohol consumption of 22.0% would result in cost savings of $168.1 million. Alternately, brief interventions that produced a reduction in alcohol consumption of 7.7% would lead to a $65.2 million reduction in costs. The second most effective cost-saving intervention would be increases in pricing and taxes by 25%, which would lead to cost savings of $34.0 million (2.3% relative to baseline).

The most consequential change in acute care hospital costs was associated with privatization of alcohol sales. We modelled privatization using two scenarios**:** an increase in alcohol consumption by 10%, and by 20% (holding relative risks constant). A 20% increase in alcohol consumption due to privatization would increase the number of alcohol-attributable acute care hospital days by 16.3%, which translates into $238.2 million in additional costs. A 10% rise in alcohol consumption due to privatization would result in an additional cost of $119.6 million.

These results indicate that substantial new health care costs related to acute care hospitalizations would occur following privatization of alcohol sales.

Tables 1 and 2 provide further details of the impact of the selected interventions and privatization on alcohol-attributable acute care hospital days and costs, respectively.

-Insert Tables 1 and 2 here-

Psychiatric hospital costs

Table 3 provides estimates of the avoidable costs of psychiatric hospitals due to three interventions: an increase in pricing and taxes, and brief interventions; privatization of alcohol sales is also modeled.

-Insert Table 3 here-

Our modeling indicates that the intervention with the largest impact on psychiatric hospital days and costs is brief interventions, under the assumption that they produce a reduction in alcohol consumption by 22%. Following these interventions 7,870 alcohol-attributable psychiatric hospital days would be avoided and $2.9 million would be saved, representing 14.5% of the baseline cost. Privatization of alcohol sales would lead to a substantial increase in psychiatric hospital costs. Our modelling indicates that privatization causing a 20% increase in alcohol consumption would result in additional 7,155 alcohol-attributable days in psychiatric hospitals, translating into $2.6 million of additional cost, a 13.2% increase over baseline costs.

Specialized outpatient care costs

Our results reveal that the most effective intervention for lowering the costs of outpatient specialized care would be brief interventions, assuming that such interventions produce a 22% reduction in alcohol consumption. The cost savings associated with this intervention would amount to $7.7 million or a 14.7% reduction from baseline. Also noteworthy was the impact of privatization. If privatization resulted in a 20% increase in alcohol consumption, our results indicate that specialized outpatient care costs would increase by almost $7.0 million, representing a 13.3% increase over the baseline cost (Table 4).

- Insert Table 4 here -

Specialized inpatient care costs

Based upon our modeling, brief interventions associated with a 22% reduction in alcohol consumption were found to be the most consequential intervention for avoidable inpatient specialized care costs, resulting in a $110.7 million of cost reduction, or 14.7% of baseline costs. Privatization causing a 20% rise in alcohol consumption would result in a $100.7 million increase in costs (Table 4).

Ambulatory care physician service costs

Privatization of alcohol sales proved to be the most consequential measure affecting ambulatory care physician service costs. Based upon the assumptions that privatization would increase alcohol consumption by 20%, our calculations indicate that costs would increase by $13.1 million, or 16.3% of the baseline cost (Table 4). Of the six interventions to reduce avoidable costs, brief interventions that result in a 22% reduction in alcohol consumption would have the largest effect, reducing costs by $9.2 million, a 11.5% reduction from baseline.

Family physician outpatient service costs

The most consequential measure affecting family physician outpatient service costs was privatization of alcohol sales. Privatization associated with a 20% increase in consumption was estimated to increase costs by $28.2 million. Of the six cost-saving interventions, brief

interventions had the largest effect. Brief interventions would result in a $19.9 million reduction (11.5% of the baseline cost) in costs, assuming that they are associated with a 22% decrease in alcohol consumption. However, according to our modeling, brief interventions would still produce $7.7 million in avoidable costs even if they resulted in only a 7.7% decrease in alcohol consumption. An increase in pricing and taxes would result in a $4.0 million decrease in costs, or 2.3% of baseline. Other interventions were associated with only small or negligible savings (Table 4).

Prescription drug costs

Based upon our calculations, brief interventions and increases in pricing and taxes would result in substantial decreases in alcohol-attributable prescription drug costs. Brief interventions resulting in a 22% decrease in consumption would result in a $88.4 million decrease in costs, and increase in pricing and taxes would result in a $17.9 million dollar decrease. Privatization that resulted in a 20% increase in alcohol consumption would increase prescription drug costs by $125.4 million (Table 4).

Avoidable indirect costs

Alcohol-attributable deaths

Table 5 presents the impact of the six selected interventions and privatization of alcohol sales on the number of alcohol-attributable deaths in Canada in 2002.

-Insert Table 5 here-

Brief interventions were the most effective intervention to reduce deaths, projected to avert 362 to 984 deaths (8.5 to 23.1% of the baseline rate, respectively), depending upon the magnitude of the resulting decrease in alcohol consumption (7.7% and 22%, respectively). Assuming that lowering the BAC level from 0.08% to 0.05% reduces motor-vehicle car accidents by 18%, 253 deaths would be averted – a 5.9% reduction compared to baseline.

Privatization has a large impact on deaths, and was estimated to result in an increase of 704 to 1,146 deaths (16.5 to 26.9% relative to baseline, respectively), depending upon the percentage increase in alcohol consumption that follows privatization (10% to 20%, respectively).

Alcohol-attributable potential years of life lost

Because the interventions affect distinct groups that have age distributions, their impact on years of life lost differs from their impact on mortality. Table 6 depicts the impact of the interventions on avoidable potential years of life lost.

-Insert Table 6 here-

The most consequential intervention saving potential years of life proved to be brief interventions. Assuming that brief interventions reduced alcohol consumption by 22%, the resultant years of life saved would be 20,094, or 13.6% of total years of life lost in the baseline scenario. Regulating MLDA to reduce alcohol consumption by 8% would lead to 4,974 (3.4% of baseline total) years of life saved, and lowering BAC level resulting in 18% fewer motor vehicle deaths would save 10,728 years of life, or 7.3% relative to the baseline. Finally, it should be

noted that privatizing alcohol sales also exerted significant effects. Assuming that privatization resulted in a 20% increase in alcohol consumption, 16,958 of additional years of life would be lost, representing 11.5% of the baseline total.

Premature mortality costs

Table 7 displays the effects of the six interventions and privatization of alcohol sales on the avoidable indirect costs due to premature mortality.

- Insert Table 7 here -

Using the modified HC approach, the largest reductions in mortality costs would be achieved by implementing brief interventions that reduce alcohol consumption by 22%. According to our estimates, implementing brief interventions would reduce the productivity losses associated with premature death by $101.2 million, constituting 11.0% of the baseline costs. If brief interventions reduced alcohol consumption by only 7.7%, then the total reduction in mortality costs would amount to $51.9 million, or 5.6% of baseline costs. A comparable magnitude of cost change would occur with lowering BAC level. Assuming that the intervention reduced deaths in motor vehicle accidents by 18%, the costs of premature mortality would be reduced by $63.1 million or 6.8% of the baseline cost. If raising the MLDA reduced fatal accidents by 8%, $29.3 million of costs (or 3.2% of the baseline cost) would be averted.

Privatizing alcohol sales would also have a significant effect on premature mortality costs. Assuming that privatization resulted in a 20% increase in consumption, the costs of premature mortality would increase by $64.8 million, or 7.0% of baseline costs. If privatization resulted in only a 10% increase in alcohol consumption, the increase in the costs of premature mortality is estimated to be $54.5 million (or 5.9% of baseline costs).

Long-term disability costs

As described in the methods section, the baseline costs of alcohol-attributable long-term disability were restricted to those persons who were permanently unable to work as a result of

alcohol dependence. As such, only those interventions that affected the number of persons with alcohol dependence had any impact on these costs.

The most consequential interventions reducing long-term disability costs were brief interventions, based on 22% reduction in alcohol consumption. In this scenario, $904.0 million dollars of long-term disability costs would be avoided. Privatization of alcohol sales that resulted in a 20% increase in alcohol consumption would lead to an increase in long-term disability costs of $821.9 million, or 13.3% of baseline costs. Further details are provided in Table 8.

-- Insert Table 8 here –

Short-term disability costs

As described in the long-term disability cost results, the baseline costs related to short-term disability (both absent days and days at work with reduced productivity) were restricted to those persons who had short-term disability as a consequence of alcohol dependence. Thus, the only interventions that have an impact on these costs are those that change alcohol consumption and thus affect the number of persons with alcohol dependence.

Tables 9 and 10 present the avoidable short-term disability costs related to the six interventions and the cost consequence of privatization of alcohol sales. Our results indicate that brief interventions – under the assumption that they produce a 22% reduction in alcohol consumption – have the largest avoidable costs of reduced productivity due to absenteeism ($2.3 million, or 14.7% relative to baseline) and reduced productivity at work (avoidable costs of $3.5 million, or 14.7% relative to baseline). An increase in alcohol prices through taxation would lead to moderate cost reductions. ($0.2 million in productivity losses due to absent days and $0.3 million in productivity losses due to reduced productivity at work). Privatization of alcohol sales would result in significant increases in short-term disability costs of $2.1 million due to absenteeism and $3.2 million due to reduced productivity while at work.

-Insert Tables 9 and 10 here-

Sensitivity analyses

Table 11 presents alternate estimates of the avoidable indirect costs related to premature mortality and long-term disability using the FC and HC methods. As expected, the magnitudes of the estimates vary widely depending upon the method, with the FC method producing the smallest figures.

The comparative cost consequences of the interventions also vary by method. The FC method is more sensitive to changes in number of deaths, while the HC method is responsive to changes in potential years of life lost. For example, compared to the FC method, privatization of alcohol sales is estimated to have a proportionally smaller cost consequence using the HC method because the intervention influences mortality primarily in older age groups.

-Insert Table 11 here-

Conclusion

In this report we have estimated the costs of health care and productivity losses that could be avoided following the implementation of six interventions. We also separately modeled the impact of privatization of alcohol sales, which are associated with cost increases and no avoidable costs. For many categories of direct health care costs, the largest savings are achieved by implementing brief interventions. Brief interventions and lowering the BAC from 0.08% to 0.05% are also associated with large avoidable indirect costs related to premature mortality. Brief interventions would also lead to a significant reduction of the indirect costs related to long-term and short-term disability, with price or taxation increases exerting a much smaller effect. In all of the results, the quantitative estimates of avoidable costs are sensitive to the magnitude of the effect the intervention has on reducing alcohol consumption.

Also noteworthy, however, is the effect of privatizing alcohol sales, which in most direct health care cost categories is associated with substantial increases in costs. These results indicate that provinces with a government monopoly on alcohol sales would incur substantial new health care costs by privatization. While the results also imply that those provinces with privatized alcohol sales may achieve substantial cost savings by reverting to a state monopoly, our study (due to lack of empirical data) could not provide a quantitative estimate of these costs.

For policy and planning purposes, our estimates of the avoidable costs associated with the interventions must be considered in conjunction with information on the costs of implementing the interventions. For example, in Canada it is likely that changing physician behaviour in order to implement brief interventions would have formidable costs, whereas the costs of implementing other interventions (such as lowering BAC or implementing taxation or price increases) would be far lower.

Overall, our results indicate that there are substantial costs related to alcohol-attributable health care utilization and productivity losses that could be avoided following the implementation of one or more of the six interventions modeled above. This study provides evidence that implementation of effective population-based interventions will reduce both direct health care costs and the indirect costs attributable to alcohol in Canada.

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Table 1. Alcohol-attributable acute care hospital days at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%				State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Acute Hospital Days	1,246,945	1,217,872	1,246,004	1,245,064	1,244,124	1,246,130	1,349,208	1,450,599	1,246,004	1,246,778	1,246,927	1,103,269	1,191,186
Difference between baseline and intervention	0	-29,073	-940	-1,881	-2,821	-814	102,264	203,654	-940	-166	-17	-143,675	-55,759
Relative change between baseline and intervention	0%	-2.33%	-0.08%	-0.15%	-0.23%	-0.07%	8.20%	16.33%	-0.08%	-0.01%	0.00%	-11.52%	-4.47%

Table 2. Alcohol-attributable acute care hospital costs at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	6% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Acute Hospital Costs (thousand dollars)	1,458,627	1,424,619	1,457,527	1,456,428	1,455,328	1,457,675	1,578,251	1,696,854	1,457,527	1,458,433	1,458,607	1,290,562	1,393,403
Difference between baseline and intervention (thousand dollars)	0	-34,008	-1,100	-2,200	-3,300	-953	119,624	238,227	-1,100	-194	-20	-168,066	-65,225
Relative change between baseline and intervention	0%	-2.33%	-0.08%	-0.15%	-0.23%	-0.07%	8.20%	16.33%	-0.08%	-0.01%	0.00%	-11.52%	-4.47%

Table 3. Alcohol-attributable psychiatric hospital days and costs at baseline and as a result of selected interventions in Canada 2002

			State monopoly on alcohol sales		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	Privatization 10% increase in alcohol consumption	Privatization 20% increase in alcohol consumption	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Psychiatric Hospital Days	54,114	53,380	57,691	61,268	46,244	51,359
Difference between baseline and intervention	0	-734	3,577	7,155	-7,870	-2,754
Relative change between baseline and intervention	0.0%	-1.4%	6.6%	13.2%	-14.5%	-5.1%
Psychiatric hospital costs (thousand dollars)	19,637	19,371	20,935	22,233	16,781	18,637
Difference between baseline and intervention (thousand dollars)	0	-266	1,298	2,596	-2,856	-1,000
Relative change between baseline and intervention	0.0%	-1.4%	6.6%	13.2%	-14.5%	-5.1%

Table 4. Alcohol-attributable direct health care costs of specialized, ambulatory care: physician fees and family physicians care as well as costs of prescription drugs at baseline and as a result of selected interventions in Canada 2002 (in thousands of dollars)

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	Privatization 10% increase in alcohol consumption	Privatization 20% increase in alcohol consumption	6% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Specialized inpatient care	754,919	744,602	0	0	0	0	805,247	855,575	0	0	0	644,198	716,167
Difference between baseline and intervention	0	-10,317					50,328	100,656				-110,722	-38,753
Relative change between baseline and intervention	0	-1.4%	0.0%	0.0%	0.0%	0.0%	6.7%	13.3%	0.0%	0.0%	0.0%	-14.7%	-5.1%
Specialized outpatient care	52,436	51,719	0	0	0	0	55,931	59,427	0	0	0	44,745	49,744
Difference between baseline and intervention	0	-717	0	0	0	0	3,496	6,991	0	0	0	-7,691	-2,692
Relative change between baseline and intervention	0.0%	-1.4%	0.0%	0.0%	0.0%	0.0%	6.7%	13.3%	0.0%	0.0%	0.0%	-14.7%	-5.1%
Ambulatory care physicians	80,200	78,330	80,139	80,079	80,018	80,147	86,777	93,298	80,139	80,189	80,199	70,959	76,614
Difference between baseline and intervention	0	-1,870	-60	-121	-181	-52	6,577	13,098	-60	-11	-1	-9,241	-3,586
Relative change between baseline and intervention	0.0%	-2.3%	-0.1%	-0.2%	-0.2%	-0.1%	8.2%	16.3%	-0.1%	0.0%	0.0%	-11.5%	-4.5%
Family physicians	172,821	168,792	172,691	172,561	172,431	172,709	186,995	201,047	172,691	172,798	172,819	152,909	165,093
Difference between baseline and intervention	0	-4,029	-130	-261	-391	-113	14,173	28,226	-130	-23	-2	-19,913	-7,728
Relative change between baseline and intervention	0.0%	-2.3%	-0.1%	-0.2%	-0.2%	-0.1%	8.2%	16.3%	-0.1%	0.0%	0.0%	-11.5%	-4.5%
Prescription Drugs	767,592	749,695	767,013	766,434	765,855	767,090	830,543	892,957	767,013	767,489	767,581	679,148	733,268
Difference between baseline and intervention	0	-17,896	-579	-1,158	-1,736	-501	62,951	125,365	-579	-102	-11	-88,443	-34,324
Relative change between baseline and intervention	0.0%	-2.3%	-0.1%	-0.2%	-0.2%	-0.1%	8.2%	16.3%	-0.1%	0.0%	0.0%	-11.5%	-4.5%

Table 5. Alcohol-attributable number of deaths at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Alcohol-attributable deaths	4,258	4,143	4,169	4,085	4,005	4,228	4,962	5,404	4,140	4,252	4,257	3,273	3,896
Difference between baseline and intervention	0	-115	-89	-173	-253	-30	704	1,146	-117	-6	-1	-984	-362
Relative change between baseline and intervention	0.0%	-2.7%	-2.1%	-4.1%	-5.9%	-0.7%	16.5%	26.9%	-2.8%	-0.1%	0.0%	-23.1%	-8.5%

Table 6. Alcohol-attributable years of life lost at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales (Privatization)		MLDA 19-21 years				Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	12% reduction in crashes	17% reduction in crashes	8% reduction in crashes	8% increase in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Alcohol-attributable deaths	147,571	144,833	143,810	140,234	136,843	145,925	159,959	164,529	140,234	137,395	142,597	152,873	147,331	147,546	127,476	138,589
Difference between baseline and intervention	0	-2,737	-3,761	-7,337	-10,728	-1,646	12,389	16,958	-7,337	-10,176	-4,974	5,302	-239	-25	-20,094	-8,982
Relative change between baseline and intervention	0.0%	-1.9%	-2.5%	-5.0%	-7.3%	-1.1%	8.4%	11.5%	-5.0%	-6.9%	-3.4%	3.6%	-0.2%	0.0%	-13.6%	-6.1%

Table 7. Alcohol-attributable indirect costs (productivity losses) due to premature mortality at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Indirect costs (thousand dollars)	922,951	907,702	900,813	879,763	859,802	904,688	977,422	987,780	893,675	921,508	922,800	821,754	871,004
Difference between baseline and intervention (thousand dollars)	0	-15,248	-22,138	-43,188	-63,148	-18,263	54,471	64,829	-29,276	-1,443	-151	-101,197	-51,947
Relative change between baseline and intervention	0.0%	-1.7%	-2.4%	-4.7%	-6.8%	-2.0%	5.9%	7.0%	-3.2%	-0.2%	0.0%	-11.0%	-5.6%

Table 8. Alcohol-attributable indirect costs (productivity losses) due to long-term disability at baseline and as a result of selected interventions in Canada 2002

			Lowering BAC from 0.08% to 0.05%				State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Indirect costs (thousand dollars)	6,163,939	6,079,698	-	-	-	-	6,574,868	6,985,797	-	-	-	5,259,895	5,847,523
Difference between baseline and intervention (thousand dollars)	0	-84,240	-	-	-	-	410,929	821,859	-	-	-	-904,044	-316,416
Relative change between baseline and intervention	0.0%	-1.4%	-	-	-	-	6.7%	13.3%	-	-	-	-14.7%	-5.1%

Table 9. Alcohol-attributable indirect costs (productivity losses) due to absent days at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%				State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Indirect costs (thousand dollars)	15,885	15,668	-	-	-	-	16,944	18,003	-	-	-	13,555	15,069
Difference between baseline and intervention (thousand dollars)	0	-217	-	-	-	-	1,059	2,118	-	-	-	-2,330	-815
Relative change between baseline and intervention	0.0%	-1.4%	-	-	-	-	6.7%	13.3%	-	-	-	-14.7%	-5.1%

Table 10. Alcohol-attributable indirect costs (productivity losses) due to days with reduced productivity while at work at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%					State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Indirect costs (thousand dollars)	23,633	23,310	-	-	-	-	25,208	26,784	-	-	-	20,167	22,420
Difference between baseline and intervention (thousand dollars)	0	-323	-	-	-	-	1,576	3,151	-	-	-	-3,466	-1,213
Relative change between baseline and intervention	0.0%	-1.4%	-	-	-	-	6.7%	13.3%	-	-	-	-14.7%	-5.1%

Table 11. Sensitivity analysis of alcohol-attributable indirect costs (productivity losses) due to premature mortality and long-term disability at baseline and as a result of selected interventions in Canada 2002

		Lowering BAC from 0.08% to 0.05%				State monopoly on alcohol sales (Privatization)		MLDA 19-21 years	Safer bars		Brief Interventions	
	Baseline (Cost Study Rehm et al 2006)	Increase in pricing and taxes by 25%	6% reduction in crashes	12% reduction in crashes	18% reduction in crashes	Zero BAC under age 21yrs	10% increase in alcohol consumption	20% increase in alcohol consumption	8% reduction in crashes	34% out of 10% reduction in homicides	34% out of 15% reduction in homicides	22% reduction in alcohol consumption	7.7% reduction in alcohol consumption
Indirect costs due to premature mortality (thousands dollars)													
Main Approach	922,951	907,702	900,813	879,763	859,802	904,688	977,422	987,780	893,675	921,508	922,800	821,754	871,004
Friction Cost Method	29,982	29,442	29,293	28,637	28,016	29,003	31,674	33,306	29,070	29,940	29,978	26,887	28,541
Human Capital Approach	1,822,746	1,805,459	1,776,622	1,732,766	1,691,179	1,785,307	1,935,891	1,944,333	1,761,751	1,820,002	1,822,460	1,655,357	1,752,465
Indirect costs due to long-term disability (thousands dollars)													
Main Approach	6,163,939	907,702	-	-	-	-	6,575	6,986	-	-	-	5,260	5,848
Friction Cost Method	133,076	131,257	-	-	-	-	141,947	150,819	-	-	-	113,558	126,244
Human Capital Approach	9,848,527	9,713,931	-	-	-	-	10,505,096	11,161,664	-	-	-	8,404,076	9,342,969

APPENDIX A

MODULE 2: INTERPRETATION AND TECHNICAL REPORT ON AVOIDABLE: ARCADIAN NORMAL APPROACH

Interpretation

The Arcadian approach (for short description see Collins et al., 2006; for more details see Armstrong, 1990) stipulates, that comparable countries should be looked for as comparators for "best feasible" disease rates. We operationalized comparable countries by countries with the same level of economic development and found surprisingly different rates of mortality (see spreadsheet).

Overall, if we assume that Canada could in principle achieve the lowest rate for each alcohol-related disease category, Canada could reduce standardized mortality rates by 177 per 100,000 for men and by 167 per 100,000 for women.

Major gains are possible in heart disease, diabetes and combined injury. Only a small but still substantial part of the gains could be made by alcohol. Of course, this gain would be larger for men compared to women. It is interesting to see that about 2/3 of the gain can be achieved by avoiding detrimental consequences of alcohol, and 1/3 by reaping the benefits of alcohol.

In total, the Arcadian normal proved to produce feasible minima in a way, which can influence our thinking about avoidable burden of alcohol. This approach should be continued to be explored , by using other summary measures of health (DALYs) and exploring their relationship to cost-relevant components, such as hospital days.

In addition, the Arcadian approach gives some hints to the nature of interventions to be conducted. For Canada, we should look at minimum at three interventions:

- Interventions to reduce alcohol-related acute consequences, especially injury. While some gains have been made, more can be achieved here.
- Interventions to reduce the overall negative impact related to volume.

- Interventions to improve patterns of drinking and allow more gains in alcohol-related benefits, especially coronary heart disease and diabetes.

Technical report

A comparison was made between the mortality rates, Years of Life Lost (YLL) rates, and Disability Adjusted Life Years (DALY) rates for a selection of causes of death known to be related to alcohol consumption (see table 1) for Canada 2002 and countries of similar economic strength. Those countries within plus or minus 10% of the Gross Domestic Product Purchasing Power Parity (GDP PPP) per capita 2002 of Canada (i.e. Australia, Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Italy, Japan, Netherlands, Sweden, United Kingdom) in addition to the United States were selected to be the comparison countries.

It would be inappropriate to compare crude mortality rates across countries with varying age structures. For example, the mortality rate in a country with a large proportion of elderly people would be expected to be higher than that of a country with a much smaller proportion of elderly people. Therefore, to allow the direct comparison of mortality rates across countries while controlling for different age structures, age-adjusted mortality rates were calculated by direct standardization. The age groups used in all procedures were 15-29, 30-44, 45-59, 60-69, 70-79, 80 plus.

The population of individuals aged 15 years and older in Canada in the year 2002 was used as the reference population. These data by sex and age-group were obtained from Statistics Canada. Mortality data for Canada 2002 was obtained from Statistics Canada and categorized according to Global Burden of Disease (GBD) cause of death categories. For each comparison country the following was obtained: 1) population by sex and age-groups, 2) number of deaths by sex, age-group, and GBD cause of death, 3) number of years lived with disability (YLDs) by sex, age-group, and GBD cause of death.

The GBD cause-specific standardized mortality rate for each country was calculated by direct standardization using the 2002 Canada population as a reference. This was done separately for each sex. For a given age-group the observed number of deaths was

divided by the population of the given country (in that age-group) and multiplied by 100,000 to obtain the observed mortality rate per 100,000 individuals. The observed mortality rate was multiplied by the 2002 Canadian population of that age-group, thus obtaining the expected number of deaths in that age group (if the population of the reference country had the same number of individuals in the age sex stratum) as Canada 2002. This was repeated for each age-group and the expected deaths were summed to provide the total number of deaths that would be expected if the population of the reference country had the same age structure as Canada 2002. The total number of expected deaths was then divided by the total population of Canada and this number was multiplied by 100,000 to obtain the standardized mortality rate per 100,000 individuals.

This exact procedure was repeated to calculate age-standardized YLLs and DALYs for men and women.

Table 1. Causes of death by Global Burden of Disease (GBD) category

Code	Description
W050	Low birthweight
W061	Mouth and oropharynx cancers
W062	Esophageal cancer
W064	Colon and rectal cancers
W065	Liver cancer
W069	Breast cancer
W078	Other neoplasms
W079	Diabetes mellitus
W082	Unipolar depressive disorders
W085	Epilepsy
W086	Alcohol use disorders
W106	Hypertensive heart disease
W107	Ischemic heart disease
W108	Cerebrovascular disease
W117	Cirrhosis of the liver
W150	Road traffic accidents
W151	Poisonings
W152	Falls
W154	Drownings
W155	Other unintentional injuries
W157	Self-inflicted injuries
W158	Violence
W160	Other intentional injuries

The results of the comparison can be seen in the following Tables 2, 3, 4, and 5.

Table 2. Age-standardized mortality rate per 100,000 (Men)

code	description	highest	2nd highest	Australia	Canada	Lowest	Difference Canada to lowest	Alcohol-attributable difference
W050	Low birthweight	Germany	USA	Australia	Canada	*rest are 0		
		0.00	0.00	0.00	0.00	0.00	0.00	0.00
W061	Mouth & oropharynx cancers	France	Austria	Australia	Canada	Iceland		
		17.60	10.99	6.48	6.01	3.77	2.23	0.73
W062	Oesophagus cancer	UK	Netherlands	Australia	Canada	Sweden		
		18.54	15.76	9.83	8.61	5.64	2.97	1.12
W064	Colon and rectum cancers	Denmark	Germany	Australia	Canada	Finland		
		48.64	41.23	37.00	29.87	24.31	5.56	0.30
W065	Liver cancer	Japan	Italy	Australia	Canada	Netherlands		
		35.64	22.36	7.07	7.15	4.60	2.55	0.81
W069	Breast cancer	Iceland	Germany	Australia	Canada	Sweden		
		0.76	0.73	0.33	0.44	0.07	0.37	N/A
W078	Other neoplasms	Italy	Denmark	Australia	Canada	Belgium		
		13.14	12.01	5.23	5.61	1.44	4.17	0.36
W079	Diabetes mellitus	Denmark	USA	Australia	Canada	Japan		
		32.89	31.89	21.81	31.47	10.26	21.21	-1.03
W082	Unipolar major depression	France	Denmark	Australia	Canada	Austria		
		1.24	0.46	0.25	0.32	0.00	0.32	0.03
W085	Epilepsy	Finland	France	Australia	Canada	Japan		
		3.15	3.08	1.77	1.11	0.54	0.57	0.28
W086	Alcohol use disorders	Denmark	France	Australia	Canada	Italy		
		17.76	11.04	3.02	4.51	0.71	3.79	3.79
W106	Hypertensive heart disease	Italy	Germany	Australia	Canada	Japan		
		23.9476	16.4195	5.5277	5.9254	3.3025	2.62	0.59
W107	Ischaemic heart disease	Finland	UK	Australia	Canada	Japan		
		290.24	236.22	171.45	176.00	79.05	96.95	-9.00
W108	Cerebrovascular disease	Japan	Italy	Australia	Canada	Canada		
		97.17	93.20	59.51	50.80	50.80	0.00	0.00
W117	Cirrhosis of the liver	Austria	Germany	Australia	Canada	Iceland		
		34.74	32.18	8.44	12.10	2.87	9.22	5.36
W150	Road traffic accidents	USA	France	Australia	Canada	Netherlands		
		26.19	25.30	14.64	14.24	11.51	2.73	1.08
W151	Poisonings	Finland	USA	Australia	Canada	Italy		
		19.86	8.59	7.29	5.52	0.69	4.83	1.16
W152	Falls	Finland	Denmark	Australia	Canada	Australia		
		25.73	24.39	4.35	7.27	4.35	2.92	0.52
W154	Drownings	Finland	Japan	Australia	Canada	UK		
		5.53	5.07	1.79	1.74	0.68	1.06	0.36
W155	Other unintentional injuries	France	Iceland	Australia	Canada	Canada		
		24.53	15.77	13.15	2.23	2.23	0.00	0.00
W157	Self-inflicted injuries	Finland	Japan	Australia	Canada	Italy		
		45.10	41.19	22.54	22.56	11.77	10.79	1.87
W158	Violence and homicide	USA	Finland	Australia	Canada	Japan		
		10.09	5.14	2.14	2.39	0.77	1.62	0.59
W160	Other intentional injuries	USA	Sweden	Australia	Canada	**rest are 0		
		0.29	0.12	0.07	0.06	0.00	0.06	0.02
	Total						176.55	18.96

Total gains by avoiding alcohol related harm **18.96**
Total gains by increasing alcohol-related benefits **10.03**
Total gains **28.99**

Table 3. Age-standardized mortality rate per 100,000 (Women)

code	description	highest	2nd highest	Australia	Canada	Lowest	Difference Canada to lowest	Alcohol-attributable difference
W050	Low birthweight	*rest are 0	*rest are 0	Australia	Canada	*rest are 0		
		0	0	0	0	0	0.00	0.00
W061	Mouth & oropharynx cancers	Denmark	Austria	Australia	Canada	Iceland		
		3.74	3.04	2.86	2.52	2.13	0.40	0.07
W062	Oesophagus cancer	UK	Netherlands	Australia	Canada	Italy		
		10.38	5.65	4.21	3.02	1.60	1.41	0.34
W064	Colon & rectum cancers	Denmark	Germany	Australia	Canada	Finland		
		47.32	36.33	31.31	25.16	20.23	4.92	0.06
W065	Liver cancer	Japan	Italy	Australia	Canada	Netherlands		
		14.87	11.30	3.20	4.06	2.82	1.24	0.27
W069	Breast cancer	Denmark	Netherlands	Australia	Canada	Japan		
		56.76	54.68	35.26	42.00	15.49	26.51	1.70
W078	Other neoplasms	Denmark	Italy	Australia	Canada	Belgium		
		9.83	9.64	4.70	5.82	1.88	3.94	0.20
W079	Diabetes mellitus	Italy	USA	Australia	Canada	Japan		
		34.32	34.26	19.13	30.11	8.52	21.58	-0.53
W082	Unipolar major depression	France	Sweden	Australia	Canada	Austria		
		1.97	1.01	0.48	0.63	0.00	0.63	0.02
W085	Epilepsy	France	Belgium	Australia	Canada	Japan		
		1.82	1.50	1.35	0.95	0.28	0.68	0.25
W086	Alcohol use disorders	Denmark	Germany	Australia	Canada	Japan		
		5.31	2.67	0.59	1.27	0.08	1.19	1.19
W106	Hypertensive heart disease	Italy	Germany	Australia	Canada	Japan		
		40.1811	27.6449	9.19	9.1525	5.14	4.01	0.31
W107	Ischaemic heart disease	Finland	USA	Australia	Canada	Japan		
		230.45	203.20	155.91	142.42	58.16	84.26	-4.10
W108	Cerebrovascular disease	Italy	UK	Australia	Canada	France		
		123.92	116.65	91.46	69.63	66.59	3.05	-0.20
W117	Cirrhosis of the liver	Italy	Austria	Australia	Canada	Iceland		
		14.23	13.92	3.38	6.11	2.44	3.67	1.68
W150	Road traffic accidents	USA	Austria	Australia	Canada	Iceland		
		7.97	5.95	5.65	4.66	2.21	2.45	0.45
W151	Poisonings	Finland	Iceland	Australia	Canada	Germany		
		6.00	3.90	3.17	2.09	0.28	1.81	0.39
W152	Falls	Denmark	France	Australia	Canada	Japan		
		35.49	19.15	3.72	6.45	3.38	3.07	0.18
W154	Drownings	Japan	Finland	Australia	Canada	UK		
		3.51	0.76	0.53	0.32	0.14	0.18	0.05
W155	Other unintentional injuries	France	Sweden	Australia	Canada	Canada		
		14.34	11.69	11.34	0.20	0.20	0.00	0.00
W157	Self-inflicted injuries	Japan	Belgium	Australia	Canada	Italy		
		12.46	11.14	6.01	4.81	2.83	1.98	0.27
W158	Violence and homicide	Finland	USA	Australia	Canada	Iceland		
		2.21	1.93	1.21	0.62	0.34	0.29	0.10
W160	Other intentional injuries	Netherlands	USA	Australia	Canada	**multiple 0		
		0.01	0.01	0.00	0.00	0.00	0.00	0.00
	Total						167.28	7.53
	Total gains by avoiding alcohol related harm							**7.53**
	Total gains by increasing alcohol-related benefits							**4.83**
	Total gains							**12.36**

Table 4. Age-standardized YLL rate per 100,000 (Men)

code	description	highest	2nd highest	Australia	Canada	Lowest	Difference Canada to lowest	Alcohol-attributable lowest difference	Difference Canada to lowest	Alcohol-attributable lowest difference
W050	Low birthweight	USA	Germany	Australia	Canada	*rest are 0				
		0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W061	Mouth & oropharynx cancers	France	Belgium	Australia	Canada	Iceland				
		222.96	137.18	62.31	56.36	33.40	22.96	9.34	22.96	9.34
W062	Oesophagus cancer	France	UK	Australia	Canada	Sweden				
		164.28	152.78	80.41	71.70	47.75	23.95	8.64	23.95	8.64
W064	Colon & rectum cancers	Denmark	Germany	Australia	Canada	Finland				
		338.93	297.15	287.08	219.74	177.64	42.10	3.37	42.10	3.37
W065	Liver cancer	Japan	Italy	Australia	Canada	Netherlands				
		299.22	176.93	60.20	60.24	37.05	23.19	7.94	23.19	7.94
W069	Breast cancer	Iceland	Germany	Australia	Canada	Sweden				
		8.02	5.93	3.31	3.53	0.70	2.83	N/A	2.83	0.00
W078	Other neoplasms	Italy	France	Australia	Canada	Iceland				
		86.95	78.75	30.98	39.18	7.49	31.69	3.21	31.69	3.21
W079	Diabetes mellitus	Denmark	USA	Australia	Canada	Iceland				
		264.52	258.64	145.06	209.84	64.48	145.36	-8.97	145.36	-8.97
W082	Unipolar major depression	France	Sweden	Australia	Canada	Austria				
		9.66	1.91	0.65	1.42	0.00	1.42	0.13	1.42	0.13
W085	Epilepsy	UK	Finland	Australia	Canada	Japan				
		57.99	50.95	35.12	19.67	10.81	8.86	4.94	8.86	4.94
W086	Alcohol use disorders	Denmark	Germany	Australia	Canada	Italy				
		240.97	172.95	39.43	52.05	10.11	41.94	41.94	41.94	41.79
W106	Hypertensive heart disease	USA	Italy	Australia	Canada	Japan				
		135.09	119.71	28.57	34.01	17.28	16.73	5.51	16.73	5.51
W107	Ischaemic heart disease	Finland	USA	Australia	Canada	Japan				
		1791.31	1617.73	1051.92	1110.59	583.14	527.44	-50.66	527.44	-50.66
W108	Cerebrovascular disease	Japan	Finland	Australia	Canada	Canada				
		605.23	528.79	287.52	257.77	257.77	0.00	0.00	0.00	0.00
W117	Cirrhosis of the liver	Austria	Germany	Australia	Canada	Iceland				
		424.25	418.46	101.59	132.48	39.86	92.62	59.04	92.62	59.04
W150	Road traffic accidents	France	USA	Australia	Canada	Netherlands				
		618.73	597.03	344.91	318.98	251.11	67.86	32.48	67.86	32.48
W151	Poisonings	Finland	Australia	Australia	Canada	Italy				
		376.76	197.30	197.30	120.12	12.36	107.76	31.92	107.76	31.92
W152	Falls	Finland	Austria	Australia	Canada	Netherlands				
		218.67	144.27	47.09	60.65	41.07	19.59	5.69	19.59	5.69
W154	Drownings	Finland	Japan	Australia	Canada	Belgium				
		97.42	58.50	39.36	36.44	12.28	24.15	10.54	24.15	10.54
W155	Other unintentional injuries	France	Iceland	Australia	Canada	Netherlands				
		295.44	249.58	169.12	46.92	41.99	4.93	1.85	4.93	1.85
W157	Self-inflicted injuries	Finland	Japan	Australia	Canada	Italy				
		941.95	756.34	488.96	474.10	207.08	267.02	51.34	267.02	51.34
W158	Violence and homicide	USA	Finland	Australia	Canada	Japan				
		271.81	105.96	48.74	59.46	14.87	44.59	16.56	44.59	16.56
W160	Other intentional injuries	USA	Sweden	Australia	Canada	*rest are 0				
		7.48	3.42	1.99	1.68	0.00	1.68	0.45	1.68	0.45
	Total						1518.67	235.26	1518.67	235.26
	Total gains by avoiding alcohol related harm							530.15		**530.15**
	Total gains by increasing alcohol-related benefits							-59.63		**-59.63**
	Total gains					-0.53		470.51		**470.51**

Table 5. Age-standardized YLL rate per 100,000 (Women)

code	description	highest	2nd highest	Australia	Canada	Lowest	Difference Canada to lowest	Alcohol-attributable lowest difference	Difference Canada to lowest	Alcohol-attributable lowest difference
W050	Low birthweight	*rest are 0	*rest are 0	Australia	Canada	*rest are 0				
		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W061	Mouth & oropharynx cancers	Austria	France	Australia	Canada	Iceland				
		34.77	34.13	25.57	20.04	5.22	14.83	2.92	14.83	2.92
W062	Oesophagus cancer	UK	Netherlands	Australia	Canada	Italy				
		65.09	41.00	25.20	19.69	11.90	7.78	2.02	7.78	2.02
W064	Colon & rectum cancers	Denmark	Netherlands	Australia	Canada	Finland				
		301.33	224.53	219.28	173.01	139.20	33.82	0.70	33.82	0.70
W065	Liver cancer	Japan	Italy	Australia	Canada	Iceland				
		96.05	72.52	24.97	29.31	21.19	8.12	1.91	8.12	1.91
W069	Breast cancer	Netherlands	Belgium	Australia	Canada	Japan				
		532.68	517.61	358.33	405.71	203.65	202.06	12.64	202.06	12.64
W078	Other neoplasms	Italy	France	Australia	Canada	Belgium				
		65.18	57.74	27.65	32.87	10.04	22.83	1.22	22.83	1.22
W079	Diabetes mellitus	USA	Denmark	Australia	Canada	Japan				
		235.79	162.30	110.83	158.65	46.23	112.42	-3.39	112.42	-3.39
W082	Unipolar major depression	France	Sweden	Australia	Canada	Austria				
		11.47	3.18	2.11	2.47	0.00	2.47	0.09	2.47	0.09
W085	Epilepsy	Australia	UK	Australia	Canada	Japan				
		20.69	18.28	20.69	9.96	3.85	6.11	2.09	6.11	2.09
W086	Alcohol use disorders	Denmark	Germany	Australia	Canada	Japan				
		70.13	40.04	8.39	15.25	1.35	13.90	13.90	13.90	13.83
W106	Hypertensive heart disease	Italy	USA	Australia	Canada	Japan				
		148.56	115.46	37.11	33.76	17.13	16.62	1.80	16.62	1.80
W107	Ischaemic heart disease	USA	Finland	Australia	Canada	France				
		977.23	896.47	643.69	607.57	262.00	345.58	-19.45	345.58	-19.45
W108	Cerebrovascular disease	UK	Finland	Australia	Canada	France				
		499.48	484.24	360.02	293.64	288.11	5.53	-0.46	5.53	-0.46
W117	Cirrhosis of the liver	Germany	Denmark	Australia	Canada	Iceland				
		173.47	168.35	40.41	66.08	18.74	47.34	26.63	47.34	26.63
W150	Road traffic accidents	USA	Austria	Australia	Canada	Iceland				
		120.98	119.90	114.01	66.13	15.58	50.55	10.04	50.55	10.04
W151	Poisonings	Finland	Australia	Australia	Canada	Germany				
		95.23	75.38	75.38	38.38	3.74	34.64	9.72	34.64	9.72
W152	Falls	Denmark	Finland	Australia	Canada	Japan				
		121.90	85.13	20.55	29.61	17.57	12.04	1.98	12.04	1.98
W154	Drownings	Japan	Austria	Australia	Canada	Belgium				
		23.97	12.28	9.97	4.96	1.92	3.03	1.47	3.03	1.47
W155	Other unintentional injuries	France	Australia	Australia	Canada	Canada				
		91.72	57.48	57.48	2.94	2.94	0.00	0.00	0.00	0.00
W157	Self-inflicted injuries	Finland	Belgium	Australia	Canada	Italy				
		192.68	187.69	130.54	89.74	43.20	46.53	6.69	46.53	6.69
W158	Violence and homicide	Finland	USA	Australia	Canada	Iceland				
		44.81	38.12	29.62	10.68	0.82	9.85	3.92	9.85	3.92
W160	Other intentional injuries	Netherlands	USA	Canada	Canada	*multiple 0				
		0.23	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total						996.06	76.43	996.06	76.43
	Total gains by avoiding alcohol related harm							99.74		**99.74**
	Total gains by increasing alcohol-related benefits							-23.30		**-23.30**
	Total gains							76.43		**76.43**

APPENDIX B

MODULE 3: LOWEST ATTRIBUTABLE FRACTION FROM COMPARATIVE RISK ANALYSIS (CRA) APPROACH. INTERPRETATION OF TABLE 1 AND 2 ON AAF COMPARISON

One of the potential means to construct a feasible minimum, which is outlined in the *International guidelines for the estimation of the avoidable costs of substance abuse* (Collins et al., 2006) is the use of the alcohol-attributable fractions (AAF) published by the Comparative Risk Analyses (Ezzati et al., 2004). The attached Excel spreadsheet summarizes the details of this comparison. Again, the comparison was restricted to developed countries regions, the so-called A-regions in the CRA document. These A regions comprise the following countries:

Americas A	Canada, Cuba, United States of America
Europe A	Andorra, Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
Western Pacific A	Australia, Brunei Darussalam, Japan, New Zealand, Singapore

The AAFs for Canada have been taken from the Canadian Cost study (Rehm et al., 2006a). It can be shown, that the Canadian AAFs are overall slightly higher than the AAFs for other regions, especially with respect to injury. Overall, however, the estimates are very close, reflecting the fact that the same risk relations had been used for these countries, and that adult per capita consumption is comparable (Table 1).

Using another outcome measure, years of life lost, yielded similar results (Table 2).

In terms of feasible minimum for an avoidable cost study, this approach does not seem to be very fruitful. The overall differences of drinking are small between larger regions of developed countries, and the methodologies of the Canadian Cost Study and the CRA do not allow for different risk relations.

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Table 1. Alcohol-attributable fractions (AAF) of mortality by sex in Canada, 2002 and WHO subregions, 2000

	Canada		AMR A		EUR A		WPRO A	
Diseases	**M**	**W**	**M**	**W**	**M**	**W**	**M**	**W**
Mouth and oropharynx cancers	32.7	18.6	28.6	19.0	42.4	30.7	32.0	23.8
Oesophagus cancer	37.6	24.1	37.2	26.4	47.5	39.2	41.8	34.5
Colon and rectum cancers	5.4	1.2	5.4	1.2	5.2	1.1	3.8	0.5
Liver cancer	31.7	22.0	31.2	19.5	38.0	31.8	30.8	23.9
Breast cancer	NA	6.4	NA	7	NA	12	NA	9.7
Other neoplasms	8.7	5.0	7.7	4.7	11.7	8.6	8.7	6.3
Diabetes mellitus	-4.8	-2.5	-4.1	-3.3	-4.2	-5.6	-1.5	-5.2
Unipolar major depression	8.4	2.8	**	**	**	**	**	**
Epilepsy	49.7	37.5	49.3	27.7	51.9	45.5	32.5	26.9
Mental and behavioural disorders due to use of alcohol	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Hypertensive heart disease	22.6	7.8	25.4	14.9	34.6	24.0	27.4	20.0
Ischaemic heart disease	-9.3	-4.9	-11.9	-7.1	-16.0	-12.8	-16.1	-12.2
Cerebrovascular disease	2.6	-6.6	6.4	-18.5	8.9	-34.6	6.7	-36.3
Cirrhosis of the liver	58.1	45.7	56.0	32.0	64.0	54.0	43.0	26.0
Road traffic accidents	39.4	18.2	31.5	14.7	37.9	18.6	26.4	12.4
Poisonings	24.0	21.5	19.2	16.3	25.2	18.3	18.9	15.8
Falls	17.9	5.9	16.3	5.4	20.8	6.8	15.8	5.2
Drownings	33.8	28.7	23.8	17.1	33.3	29.9	25.1	23.8
Other unintentional injuries	30.6	20.4	26.5	19.9	33.4	26.0	24.3	18.7
Self-inflicted injuries	17.3	13.7	13.2	9.4	16.4	11.4	11.6	7.8
Violence and homicide	36.7	34.0	28.2	27.2	35.0	34.5	25.6	24.9
Other intentional injuries	29.7	29.7	21.4	21.5	25.5	**	20.0	**

** The number of deaths (and hence YLL) coded to a number of diseases including "low back pain", "hearing loss", "unipolar depressive disorders", "osteoarthritis", and "mild mental retardation" is zero or very small in the GBD database. For other diseases, mortality or disease burden may be zero in some subregion-age-sex groups. In such cases, the population attributable fractions (PAF) would be undefined or unstable and were not estimated

Grey shading denotes proportional difference at least 10%

Sources: Rehm et al., 2006a, b; Rehm et al., 2004

Table 2. Alcohol-attributable fractions (AAF) of years of life lost (YLL) by sex in Canada, 2002 and WHO subregions, 2000

	Canada		AMR A		EUR A		WPRO A	
Diseases	**M**	**W**	**M**	**W**	**M**	**W**	**M**	**W**
Mouth and oropharynx cancers	40.7	19.7	31.9	21.7	44.2	33.3	33.4	25.8
Oesophagus cancer	36.1	26.0	39.7	28.8	49.0	41.2	42.8	36.5
Colon and rectum cancers	8.0	2.1	8.0	2.1	8.9	2.3	6.1	1.1
Liver cancer	34.2	23.6	33.9	21.6	39.7	33.5	31.8	25.0
Breast cancer	NA	6.3	NA	8.0	NA	12.9	NA	10.4
Other neoplasms	10.1	5.3	8.6	5.2	12.2	9.0	8.9	6.5
Diabetes mellitus	-6.2	-3.0	-5.3	-3.8	-5.3	-5.9	-1.8	-5.7
Unipolar major depression	9.4	3.5	**	**	**	**	**	**
Epilepsy	55.7	34.3	50.7	28.8	53.3	46.7	32.7	27.6
Mental and behavioural disorders due to use of alcohol	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Hypertensive heart disease	33.0	10.8	29.4	17.1	36.4	24.9	28.8	21.0
Ischaemic heart disease	-9.6	-5.6	-12.7	-8.1	-16.3	-13.4	-16.8	-13.1
Cerebrovascular disease	3.4	-8.2	9.1	-20.8	11.1	-34.6	8.5	-39.4
Cirrhosis of the liver	63.7	56.3	60.5	35.1	66.6	57.9	45.3	29.1
Road traffic accidents	47.9	19.9	34.8	15.2	42.4	19.5	32.0	13.3
Poisonings	29.6	28.1	20.3	17.4	27.9	22.1	20.9	17.7
Falls	29.1	16.4	20.0	8.4	25.4	10.1	18.4	8.2
Drownings	43.6	48.4	21.3	12.5	30.7	24.8	23.0	21.7
Other unintentional injuries	37.6	27.2	26.9	17.9	34.3	24.8	24.7	17.3
Self-inflicted injuries	19.2	14.4	14.8	10.0	18.9	12.8	13.0	8.8
Violence and homicide	37.1	39.8	28.0	26.5	34.6	33.6	24.7	23.3
Other intentional injuries	26.9	26.9	21.4	21.5	24.7	**	20.0	**

** The number of deaths (and hence YLL) coded to a number of diseases including "low back pain", "hearing loss", "unipolar depressive disorders", "osteoarthritis", and "mild mental retardation" is zero or very small in the GBD database. For other diseases, mortality or disease burden may be zero in some subregion-age-sex groups. In such cases, the population attributable fractions (PAF) would be undefined or unstable and were not estimated

Grey shading denotes proportional difference at least 10%

Sources: Rehm et al., 2006a, b; Rehm et al., 2004

APPENDIX C

MODULE 1: EPIDEMIOLOGICAL BASIS: TIME-DEPENDENT RELATIVE RISKS. EPIDEMIOLOGY OF ASSESSING EFFECTS FROM STOPPING OR REDUCING ALCOHOL CONSUMPTION

J. Rehm & S. Popova

Overview on alcohol-attributable disease in Canada

Based on the current epidemiological knowledge, alcohol causally impacts the following disease categories (see Table 1).

The current module is concerned with avoidable burden. In other words, it answers the question what happens to people, if alcohol consumption is stopped or reduced? The epidemiology of these consequences are laid out by category of disease. In our statistical modeling of the effects, we will not only base our analyses on individual-level literature, but will also include the literature on population drinking and mortality (Norstrom & Ramstedt 2005), i.e. on studies what happened with mortality rates, when societies increased or decreased their per capita consumption.

Summary of the literature overview and conclusions

Malignant neoplasm

Malignant neoplasms take years to develop. Thus, stopping consumption of alcohol does not reduce the risks for neoplasms to the risk of abstainers; it takes decades before this risk is reached again. Moreover, in modeling the risk of the neoplasms over time, the sick quitter effect has to be taken into consideration (Shaper 1990a; Shaper 1990b): the current epidemiological work shows in general higher risks for neoplasm in the first years after quitting compared to the year before stopping the consumption of alcohol,

because many people stopped drinking after they already experienced some of the negative health effects.

Based on the literature review below, the risk for cancer after cessation of drinking will be modeled by conducting neoplasm site-specific meta-analyses. The risk for reduction of drinking will be modeled based on the relative risks (RR) for the different categories from the meta-analyses shown in Table 1.

Diabetes

The effect of alcohol on diabetes is complicated and relatively small, e.g. (Avogaro & Tiengo 2005; Gutjahr et al. 2001). There are no good epidemiological studies what happens to the risk of diabetes when alcohol is stopped. We will thus model this effect relatively instantaneous based on the RR for different categories from the meta-analysis shown in Table 1.

Neuropsychiatric disorders

Alcohol use disorders (AUD) are chronic relapsing diseases. If alcohol consumption is stopped and if alcohol is no longer available, the effect on the risk of developing new AUD is instantaneous and lasting. However, these conditions are highly unrealistic. We will thus base our estimates on the effects of interventions on the assumption, that the overall level of consumption in a society influences the proportion of AUD (Skog, 1985). This assumption basically assumes that patterns of drinking are relatively stable, and we will conduct sensitivity analyses on this assumption. The effects on other neuropsychiatric disorders will be modeled as instantaneous based on the RR for different categories from the meta-analyses in Table 1.

Cardiovascular diseases

For all conditions except ischemic conditions we will model the RR based on a meta-analyses of the cessation studies referred to below. For ischemic heart disease and ischemic stroke, we will base our estimates on volume and patterns of drinking. We have started a meta-analyses on patterns of drinking in collaboration with Dr. Bagnardi

(University of Milano), who has contributed to the filed with his contributions to various meta-analyses (e.g. Corrao et al. 2000; Corrao et al. 2004).

Gastrointestinal diseases

Even though it takes several years to develop liver cirrhosis, the population effects of reducing alcohol are almost instantaneous (Leon et al. 1997; Mann et al. 2005; Ramstedt 2003). We will model liver cirrhosis and other gastrointestinal disease incidence with the exception of gallstone incidence based on this type of analyses. For gallstones, we assume instantaneous effects based on the RR described in the meta-analysis in Table 1.

Skin disease

The alcohol-attributable mortality of this disease category is not relevant in Canada.

Injury

Injury effects are instantaneous and mainly depend on the blood alcohol concentration at the time of the injury (Eckardt et al. 1998). Thus, all injury mortality will be modeled as instantaneous effects. The only exception is suicide which will be modeled based on time series analyses. The reason for this exception is based on the fact, that part of the causal mechanism for suicide is not instantaneous, but based on AUD and depression.

Overall we found sufficient literature to model the effects of cessation and reduction of drinking on all alcohol-attributable disease categories relevant for Canada.

Effect of mothers drinking on newborn

This effect is special and will be modeled based on the proportion of mothers consuming alcohol with heavy drinking occasions.

Malignant Neoplasms

Method

Search of the literature on time dependent relative risks after reduction/quitting of drinking for malignant neoplasms was performed from November 1-10, 2006. The following key search terms were used: ([“mouth and oropharynx cancer” OR “oesophageal cancer” OR “liver cancer” OR “laryngeal cancer” OR “breast cancer” OR “colorectal cancer” OR “other neoplasms”] AND “alcohol”) AND (“risk” OR “association”) AND (“cessation” OR “stopping drinking” OR “quitting drinking” OR “abstinence”). This search was performed in multiple electronic bibliographic databases, including: Ovid MEDLINE (1966-2006), PubMed (1980-2006), EMBASE (1980-2006), Web of Science (including Science Citation Index, Social Sciences Citation Index, Arts & Humanities Citation Index) and PsychINFO (1980-2006). In addition, manual reviews of the content pages of major epidemiology journals were conducted as well as citations in any of the relevant articles. The search was restricted to the English language.

A total of 387 studies were found in the initial broad search. Of these studies, only 112 contained topic matter on relative risks (RR). However, 97 of these studies were eliminated because they did not assess RRs after reducing/quitting of drinking in time. Therefore, the final list of included articles comprised 15 studies, which examine the effect of cessation of alcohol on the risk of malignant neoplasms.

Although ethanol per se has generally not been found to be carcinogenic in experimental animals (IARC, 1988), epidemiologic studies have consistently shown a strong association between alcohol consumption and cancers of the oral cavity, pharynx, larynx, esophagus, liver, breast cancer, and colorectal cancer. However, few epidemiological studies looked at the effect of stopping exposure on risk of malignant neoplasms.

According to different sources the latency period between exposure to the carcinogen and the development of signs and symptoms of cancer is from 15 to 30 years (Books@ovid 2006; Rothman & Greenland 1998). Research on the head and neck

cancer suggests that these cancers arise after six to ten independent genetic events, acquired over a 20- to 25-year latency period. During this time, the host is believed to have exposure to carcinogens, particularly tobacco, perhaps augmented by alcohol (Books@ovid 2006).

Oesophageal cancer (6 studies)

It is still unclear how alcohol causes cancer in the upper aerodigestive tract, although hypotheses have been made: action as a solvent for other carcinogens, irritation of mucosa increasing cell turnover, nutritional deficiencies, depression of immune state, presence of other carcinogens in beverages, and carcinogenicity of metabolites of ethanol (Day & Munoz 1982; IARC, 1988).

The study of (Cheng et al. 1995) examined the effect of the cessation of drinking on the risk of oesophageal cancer (adjusted for age, education, place of birth, smoking, and diet). Cases were 400 consecutive admissions of patients with histologically confirmed diagnosis of oesophageal cancer during a 21-month period in 1989-90. Controls were 1,598 patients selected from the same surgical departments as the cases and from the general practices from which the cases were originally referred.

The results showed that apart from an increased risk among those who recently stopped, there was a clear decrease in risk with longer periods of abstention (Table 2). The results also showed that light drinking (<200 g ethanol/week) was not associated with a significant increase in risk (Table 3). Among former drinkers risk fell more quickly in moderate (200-599 g/week) than heavy (>=600 g/week) drinkers. Even among heavy drinkers, however, risk had dropped substantially after five to nine years of not drinking. The results suggest that the time taken for risk to return to that in subjects who never drink was 10-14 years for moderate drinkers and 15 years or more, if ever, for heavy drinkers. Authors suggested that a rapid fall in risk on cessation among moderate drinkers indicates that the predominant action is likely to be on the late stage of carcinogenesis. This finding was supported by previous research (Armitage & Doll 1954; Day & Brown 1980). In heavy drinkers the large fall in risk after less than 10 years of cessation also indicates a strong effect of alcohol on the late stage of carcinogenesis, although one cannot be certain how long it will take for risk to return completely to that in those who never drink (Cheng et al. 1995).

Moreover, this study also found an increase in risk among recent abstainers. Authors explained that this was probably because of subjects who stopped drinking after diagnosis or developing symptoms. This result was similar to findings in prospective and case-control studies on the cessation of smoking and the risks of lung cancer (Shopland 1990).

(Cheng et al. 1995) concluded, that the risk of oesophageal cancer decreases fairly rapidly with time after abstaining from drinking. Authors also suggested that alcoholic beverages have a strong effect on the late stage of carcinogenesis.

Castellsague et al. (2000) also explored the effectiveness of alcohol drinking cessation in reducing esophageal cancer risk. Data from a series of five hospital-based case-control studies of incident squamous-cell carcinoma of the esophagus conducted in Brazil, Uruguay, Argentina and Paraguay were combined and analyzed by multivariate logistic regression procedures. A total of 2,063 men (655 case patients and 1408 control subjects) were included in the pooled analysis.

Figure 1 summarizes the overall effect of drinking cessation on reducing esophageal cancer risk after adjusting for the effect of the amount of alcohol consumed. The risk of esophageal cancer decreased rapidly, strongly and significantly with longer periods of abstention. For former drinkers the required minimum quitting time for a statistically significant risk reduction was 19 years, although after 10 years of drinking cessation the risk estimate already fell within the risk interval of never-drinkers. The data show that the risk reduction was statistically significant regardless of the intensity and duration of alcohol consumption and the type of alcoholic beverage consumed. Thus, the inverse trend associated with drinking cessation was marginally significant for drinkers of less than 62 ml of pure ethanol/day ($p = 0.05$), and highly significant for heavier drinkers ($p = 0.009$). As shown in Figure 2, the inverse trend with time since quitting was statistically significant for subjects who had been exposed to the habit for 40 years or less ($p = 0.005$), as well as for subjects who had been exposed for a longer period of time ($p = 0.04$). The type of drink consumed did not influence the overall effectiveness of cessation (Figure 2). Thus, the inverse trend was statistically significant for drinkers of spirits ($p = 0.005$), and for drinkers of other combinations of drinks ($p = 0.009$).

Observed rapid and steady decrease in risk and the relatively short lag time before risk is significantly reduced among ex-drinkers (Figure 1), suggesting that the predominant action of ethanol is in the late stages of carcinogenesis (cancer promotion). This study estimated that, in the South American populations represented by this analysis, 64% of esophageal cancer cases would be avoided by quitting alcohol drinking.

Another previous work of the same authors (Castellsague et al. 1999) presented the effects of alcohol cessation, the amount of alcohol, duration, and the type of beverage consumed, on the risk of esophageal cancer by gender (Table 4). Very strong effects for all measures of amount, duration, cessation and the type of beverage consumed were identified in men. Among women, the magnitudes of the effects were much smaller than the corresponding ones for men, although none of the interaction terms with gender were statistically significant. In men, a statistically significant decrease in risk was observed with years since stopping the habit ($p< 0.02$). When alcohol abstainers were excluded, the strong dose-response effects remained statistically significant for all alcohol-related variables.

Bosetti et al. (2000) also evaluated the pattern of risk after ceasing drinking, on oesophageal carcinogenesis. Data of the present analysis were derived from two case-control studies of oesophageal cancer conducted between 1992 and 1999 in northern Italy and in the Swiss Canton of Vaud. Cases were subjects admitted to the general hospitals with newly-diagnosed histologically confirmed squamous cell cancer of the oesophagus. A total of 404 subjects (356 men and 48 women) were included, whose median age was 60 years (range, 34–77). Controls were subjects admitted to the same hospitals as the cases for a wide spectrum of acute, non-neoplastic conditions excluding those related to smoking or alcohol consumption. The control group comprised a total of 1,070 subjects, 878 men and 192 women, whose median age was 60 years (range 32–77 years).

This study indicated that quitting alcohol drinking leads to a reduced oesophageal cancer risk after 10 or more years (Table 5). Authors found that the pattern of risk after stopping drinking does not seem to be linear, and, after allowance for time since smoking cessation, the RR for ex-drinkers was similar or above that of current drinkers for at least 10 years since stopping. Authors suggested that this could be due to some

characteristics of people who have recently stopped drinking. Most former drinkers were, in fact, heavy drinkers and the cessation of drinking may therefore, have been influenced by health-related conditions. From a biological viewpoint, the persistence of an excess risk several years after stopping drinking indicates that alcohol is probably not a late-stage carcinogen (Day & Brown 1980) in this disease, as previously observed for oral and pharyngeal cancers (Franceschi et al. 2000).

Similar results were found in Martinez study in Puerto Rico: a decrease in the risk of cancers of the oesophagus, mouth, and pharynx after alcoholic beverages had been discontinued for 10 years or more (Martinez 1969). Victora et al. (1987) reported an adjusted relative risk of 0.78 (90% CI = 0.36 to 1.69) of oesophageal cancer after stopping cachaca (a popular alcoholic beverage in southern Brazil) for 10 or more years. However, no information on the relation with amount consumed or duration of habit was reported.

Laryngeal cancer (3 studies)

To examine an effect on laryngeal cancer risk of time after drinking cessation, Altieri et al. (2002) analyzed data from a multicentric case – control study of cancer of the larynx. This study was conducted between 1992 and 2000 in two areas of northern Italy (the provinces of Pordenone and the greater Milan area), and in the Swiss Canton of Vaud (Talamini et al. 2002). Cases were 527 patients (478 men and 49 women, median age 61 years, range 30 – 79) admitted to the major teaching and general hospitals in the areas under study with histologically confirmed squamous-cell carcinoma of the larynx, diagnosed no longer than 1 year before the interview. Laryngeal cancer cases included 271 glottis, 117 supraglottis, and 139 other or unspecified laryngeal cancers. Controls were 1297 subjects (1052 men and 245 women, median age 61 years, range 30 – 79) frequency-matched with cases by 5-year age groups, sex and study centre, selected among patients admitted to the same hospitals as cases for a wide spectrum of acute, nonneoplastic conditions, not related to smoking, alcohol consumption or long-term modifications of diet.

Table 6 demonstrates results of this study in relation to the time since stopping alcohol drinking. No consistent pattern of risk was observed up to 20 years, and some risk

reduction was evident only 20 years since stopping the habit. The ORs for ex-drinkers, as compared to current drinkers, were 1.24 for 1-5 years since drinking cessation, 1.29 for 6 – 19 years. The OR was 0.53 among the few subjects who had stopped drinking for 20 or more years, i.e., similar to that of never drinkers (OR=0.56). None of these estimates, nor the trend in risk, was significant.

Authors suggested that some favourable impact of stopping drinking may become apparent in the long term, but it was difficult to estimate on account of the small number of subjects who had stopped drinking for 20 years or more. They argued that the persistence of an excess risk up to several years after stopping drinking indicates that alcohol is probably not only a late stage carcinogen (Day & Brown 1980), as previously observed for oral, pharyngeal (Franceschi et al. 2000), and oesophageal (Bosetti et al. 2000) cancers. Furthermore, the persistence of exposure to tobacco among ex-drinkers may play an important role in limiting the benefits of drinking cessation. This pattern of risk after drinking cessation may be also due to certain characteristics of the selected group of people who had stopped drinking (8% of control subjects). Most former drinkers had, in fact, higher alcohol consumption than current drinkers (median number of drinks per week was 42 in ex- and 28 in current drinkers), and it is possible that health related conditions had affected the decision to stop alcohol consumption, though this aspect was not investigated. In any case, it is unlikely that early symptoms of cancer of the larynx had accounted for drinking cessation, since the excess risk persisted up to 20 years prior to cancer diagnosis (Altieri et al. 2002).

Cancer of oral cavity and pharynx (2 studies)

Case-control study included 754 individuals with incident cancer of the oral cavity and pharynx (median age 57) and 1,775 controls (median age 57) in the hospital for acute, non-neoplastic diseases who were interviewed in 2 Italian areas and in the Swiss Canton of Vaud between 1992 and 1997 (Franceschi et al. 2000).

Results of this study demonstrated that ORs increased with the increase of weekly alcoholic drinks (overall OR for >= 91 *vs.* never drinkers = 11.6; 95% CI: 6.3–21.5) (Table 7). At each level of alcohol intake, ORs tended to be somewhat more elevated for former than current drinkers, except for 91 drinks or more per week (OR: 16.7 in current

and 11.1 in former drinkers). Authors reported that after allowance for the number of drinks, former drinkers showed an OR of 1.9 (95% CI: 1.3–2.7) compared with current drinkers (not shown on the table 6). Drinkers of 20 drinks/week or less showed an OR not significantly different from never drinkers.

No clear influence of age at starting or duration of drinking was found for current or former drinkers or overall. In no time interval since cessation of habit were former drinkers at lower risk than current drinkers. Risk in former drinkers seemed to peak at 7–10 years after cessation (OR = 3.3; 95% CI: 1.5–7.3) but declined thereafter (OR = 1.9; 95% CI: 1.0 –3.8) (Table 7). A lack of influence of age at starting drinking or duration of habit is also consistent with a few previous studies (Franceschi et al. 1990; Blot et al. 1988; Merletti et al. 1989) and points to the possibility that an elevated alcohol intake acts as a late-stage carcinogen (Day & Brown 1980).

Authors also reported that although the reason(s) for stopping drinking had not been elicited, some diseases were reported near the time of habit change by 16 (13%) cases and 21 (19%) controls.

Similarly to the study of Franceschi et al. (2000) another case-control study from Puerto Rico (Hayes et al. 1999), a clear decline in the risk of cancer of the oral cavity and pharynx was not found, at least up to 10 years after ceasing drinking.

Colorectal cancer (2 studies)

A direct relationship between alcohol consumption and colorectal cancer has been demonstrated by epidemiologic studies from different population groups. The association is often moderate with odds ratios of below 1.5 (Franceschi & La Vecchia 1994).

A hospital-based case-control study was conducted from April 1998 to March 2000 in Hong Kong (Ho et al. 2004). Newly diagnosed colorectal adenocarcinoma (822 cases) and sex- and age-matched inpatient 926 controls without gastrointestinal and malignant conditions were included.

An increased risk of colorectal cancer was found in current drinkers (adjusted OR = 1.42; 95% CI = 1.09–1.85) and in those who drank >= 4 days (current and ex-drinkers) or > 4 units (ever and ex-drinkers) weekly.

For ex-drinkers, increasing duration, in tertiles, of alcohol abstention was associated with progressive reduction in colorectal cancer risk in a dose-response manner. Using the lowest tertile as a reference, the adjusted odds ratios for colorectal cancer decreased with increasing duration of abstention with a significant *p* trend at 0.006 (Table 8). Similar results were obtained for the subsites of colon and rectal cancers. Adjustment for the weekly frequency and amount of alcohol consumed did not alter the association for colorectal cancer (when adjusted for drinking frequency, adjusted OR = 0.48, 95% CI of the highest tertile = 0.26–0.90, *p* trend = 0.015; when adjusted for drinking amount, adjusted OR = 0.50, 95% CI of the highest tertile = 0.28–0.96, *p* trend = 0.024). However, only insignificant trends for reduced risk were obtained for the subsites of colon and rectal cancers after such adjustments (data not shown). The ex-drinkers were further stratified according to the weekly frequency and amount of drinking and a significant negative association between the duration of abstention and colorectal cancer risk was obtained for those who drank > = 4 days per week as well as those who drank <= 4 units of alcohol per week (*p* trend = 0.032 and 0.006, respectively).

The data were reanalyzed using the current drinker as the reference (Table 8). Again, the risk decreased with longer periods of abstention (*p* trend 0.002). The cessation of drinking for > 180 months (15 years) resulted in a colorectal cancer risk similar to that of never drinkers.

Authors pointed out that individuals might have stopped drinking due to symptoms from the underlying malignancy. However, when the data concerning the current habit and the extent of exposure were reanalyzed by including subjects who had quit drinking within 12 months as current drinkers, similar results were obtained (data are not shown).

One previous Italian study found no association between colorectal cancer risk and drinking cessation (Tavani et al. 1998). However, it is important to note that the study failed to demonstrate any relationship between drinking and colorectal cancer.

Other findings (4 studies)

A study on pancreatic cancer in England found a higher risk among former drinkers than current drinkers and attributed this to the cessation of habit after the development of symptoms (Cuzick & Babiker 1989).

In the three studies on breast cancer, there was a suggestion of a lower risk among former drinkers, but no further details were given (Byers & Funch 1982; Hiatt et al. 1988; Rosenberg et al. 1982).

Hypertension (19 studies)

The method of searching the literature on time dependent relative risks after reduction/quitting of drinking for hypertension was similar to the malignant neoplasms method, with the exception of key search terms: (“hypertension“ AND “alcohol”) AND (“risk” OR “association”) AND (“cessation” OR “stopping drinking” OR “quitting drinking” OR “abstinence”).

A total of 265 studies were found in the initial broad search. Of these studies, only 19 examined the effect of cessation of alcohol drinking on blood pressure.

Many epidemiologic studies associate regular alcohol consumption with elevated blood pressure (Chobanian et al. 2003; Puddey et al. 1987a); . Alcohol-induced hypertension may be an important contributing factor for other potentially fatal or permanently disabling cardiovascular diseases, including stroke, myocardial infarction, and cardiomyopathy.

A recent study (Ceccanti et al. 2006) examined hypertension in early alcohol withdrawal (AW) in chronic alcoholics. Blood pressure (BP) was assessed daily for 18 days in a series of chronic alcoholics on early AW, while also assessing the severity of their alcohol withdrawal symptoms (AWS) on the CIWA-Ar scale. A sharp and sustained decrease in BP was observed after AW; 56.5% of the alcoholics during the early stages of abstinence were hypertensive (mild and moderate hypertension in most cases) at T_0, but only 21.8% were hypertensive at the end of the observational period (Table 9). The variation of BP is partially explained by years of at-risk drinking and AWS severity.

Authors suggested that hypertension in 'detoxified' alcoholics (21.8%) may be related to alcohol-independent hypertension or to a long-lasting alcohol-induced derangement of the BP regulating mechanisms. Authors concluded that complete alcohol abstinence must be recommended to all hypertensive alcoholics, as AW-induced transient hypertension was found to be harmless in all subjects, and abstinence leads to a complete recovery from hypertension in most cases.

Results of this study were similar to the findings of (Aguilera et al. 1999) where about 28% of the patients were hypertensive after 30 days of proven abstinence from alcohol on the 24-hour BP profile in heavy alcohol drinkers (42 men). After 1 month of proven alcohol abstinence, BP and heart rate significantly decreased. The proportion of alcoholic patients considered hypertensive on the basis of 24-hour BP criteria fell from 42% during alcohol drinking to 12%, after 1 month of complete abstinence. Authors concluded that heavy alcohol consumption has an important effect on BP, and thus cessation of alcohol consumption must be recommended as a priority for hypertensive alcohol drinkers.

In other studies the prevalence of hypertension was also similar to the study of (Ceccanti et al. 2006) and ranged from 12 to 29% (Angelico et al. 2003; Capuano et al. 2001; Cricelli et al. 2003; La Torre et al. 2001; Sega et al. 2001) despite the bias with respect to BP assessment procedures and the chosen cut-off between normal and hypertensive subjects in these earlier studies.

Several intervention studies (Potter & Beevers 1984; Malhotra et al. 1985; Puddey et al. 1985; Puddey et al. 1987b; Ueshima et al. 1993; Saunders et al. 1981; Howes 1985) performed in moderate or heavy alcohol drinkers also showed a significant decrease of BP with alcohol reduction or abstinence. Saunders et al. (1981) performed a study with 132 alcoholic patients and demonstrated that the prevalence of hypertension fell from 51.5% during alcohol drinking to 9% after detoxification. Potter & Beevers (1984) in a crossover study performed in hypertensive drinkers, found a significant reduction of BP after 4 days of abstinence and a significant rise in BP after 4 days of alcohol reintroduction. These results were confirmed in treated or untreated hypertensive subjects (Malhotra et al. 1985; Puddey et al. 1987b; Ueshima et al. 1993) in

normotensive subjects (Puddey et al. 1985) and in more moderate alcohol drinkers (Howes 1985).

However, more recent studies that examined the effects of alcohol consumption on BP, using ambulatory BP monitoring have found negative results. Howes and colleagues found no significant change in 24-hour BP during 4 days of alcohol consumption or abstinence in healthy volunteers (Howes et al. 1990; Howes et al. 1992). Abe et al. (1994) found that BP fell prominently during the first 6 hours after drinking and rose during the next 8 hours, after 7 days of regular alcohol consumption at dinner and none of this had an effect on the average 24-hour BP. O'Callaghan et al. (1995) found no significant effect of alcohol in the office or 24-hour BP in normotensive light drinkers. Maiorano et al. (1995) stated a minor, insignificant decrease in systolic BP after 1 week of abstinence in heavy alcohol drinkers.

Table 1. Alcohol-related disease categories and sources for determining risk relations including alcohol-attributable fractions (AAFs)

Condition	*ICD-10 Code*	*Source for meta-analysis or AAF*
Malignant neoplasms		
Mouth and oropharynx cancers	C00 - C14	(Gutjahr et al. 2001)
Oesophageal cancer	C15	(Gutjahr et al. 2001)
Liver cancer	C22	(Gutjahr et al. 2001)
Laryngeal cancer	C32	(Gutjahr et al. 2001)
Breast cancer	C50	(Ridolfo & Stevenson 2001)
Other neoplasms	D00-D48	(Rehm et al. 2004)
Diabetes		
Diabetes mellitus	E10 - E14	(Gutjahr et al. 2001)
Neuro-psychiatric conditions		
Alcoholic psychoses	F10.0, F10.3 - F10.9	100% AAF per definition
Alcohol abuse	F10.1	100% AAF per definition
Alcohol dependence syndrome	F10.2	100% AAF per definition
Unipolar major depression	F32 - F33	(Rehm et al. 2004)
Degeneration of nervous system due to alcohol	G31.2	100% AAF per definition
Epilepsy	G40 - G41	(Gutjahr et al. 2001)
Alcoholic polyneuropathy	G62.1	100% AAF per definition
Cardiovascular diseases		
Hypertensive disease	I10 - I15	(Corrao et al. 1999)
Ischaemic heart disease	I20 - I25	(Corrao et al. 2000; Rehm et al. 2004)
Alcoholic cardiomyopathy	I42.6	100% AAF per definition
Cardiac arrhythmias	I47 - I49	(Gutjahr et al. 2001)
Heart failure and ill-defined complications of heart disease	I50 - I52, I23, I25.0, I97.0, I97.1, I98.1	This is an unspecific category with no identification of underlying pathology. Therefore, the relationship between average volume of consumption cannot be determined by usual meta-analysis.
Cerebrovascular disease	I60 - I69	
Ischaemic stroke	I60 - I62	(Reynolds et al. 2003)
Haemorrhagic stroke	I63 - I66	(Reynolds et al. 2003)
Oesophageal varices	I85	(Gutjahr et al. 2001)
Digestive diseases		
Alcoholic gastritis	K29.2	100% AAF per definition
Cirrhosis of the liver	K70, K74	(Rehm et al. 2004)
Cholelithiasis	K80	(Gutjahr et al. 2001)
Acute and chronic pancreatitis	K85, K86.1	(Corrao et al. 1999)
Chronic pancreatitis (alcohol induced)	K86.0	100% AAF per definition
Skin diseases		
Psoriasis	L40	(Gutjahr et al. 2001)
Conditions arising during the perinatal period		
Low birth weight – as defined by the global burden of disease study*	P05 - P07	(Gutjahr et al. 2001)
Foetal alcohol syndrome (dysmorphic)	Q86.0	100% AAF per definition

Excess alcohol blood level	R78.0	100% AAF per definition
Unintentional injuries		
Motor vehicle accidents	[§]	(Traffic Injury Research Foundation of Canada 2004; Transport Canada, 2004)
Poisonings	X40 - X49	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Falls	W00 - W19	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Fires	X00 - X09	Council of Canadian Fire Marshals and Fire Commissioners, 2003.
Accidental poisoning & exposure to alcohol	X45	100% AAF per definition
Drowning	W65-W74	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Other unintentional injuries	[†] Rest of V & W20 - W64, W75 - W99, X10 -X39, X50 - X59, Y40 -Y86, Y88, Y89	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Intentional injuries		
Self-inflicted injuries	X60 - X84, Y87.0	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Intentional self-poisoning by and exposure to alcohol	X65	100% AAF per definition
Homicide	X85 -Y09, Y87.1	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Other intentional injuries	Y35	(Rehm et al. 2004); adjusted to Canada by AAF for traffic accidents
Ethanol and methanol toxicity, undetermined intent	Y15	100% AAF per definition

* Relative risk refers to drinking of mothers

[§] V021-V029, V031-V039, V041-V049, V092, V093, V123-V129, V133-V139, V143-V149, V194-V196, V203-V209, V213-V219, V223-V229, V233-V239, V243-V249,V253-V259, V263-V269, V273-V279, V283-V289, V294-V299, V304-V309, V314-V319, V324-V329, V334-V339, V344-V349, V354-V359, V364-V369, V374-V379, V384-V389, V394-V399, V404-V409, V414-V419, V424-V429, V434-V439, V444-V449, V454-V459, V464-V469, V474-V479, V484-V489, V494-V499, V504-V509, V514-V519, V524-V529, V534-V539, V544-V549, V554-V559, V564-V569, V574-V579, V584-V589, V594-V599, V604-V609, V614-V619, V624-V629, V634-V639, V644-V649, V654-V659, V664-V669, V674-V679, V684-V689, V694-V699, V704-V709, V714-V719, V724-V729, V734-V739, V744-V749, V754-V759, V764-V769, V774-V779, V784-V789, V794-V799, V803-V805, V811, V821, V830-V833, V840-V843, V850-V853, V860-V863, V870-V878, V892.

[†] Rest of V = V-series MINUS [§].

Table 2. Years since stopping drinking and risk of oesophageal cancer

Years of drinking	Cases	Controls	Odds ratio (95% confidence interval)*
Current drinkers	207	675	1.0
0-1 Year	47	55	2.5 (1.4 to 4.4)
1-4 Years	36	96	1.5 (0.9 to 2.6)
5-9 Years	22	139	0.5 (0.3 to 0.9)
10-14 Years	20	89	0.8 (0.4 to 1.5)
>/=15 Years	11	128	0.2 (0.1 to 0.6)
Never drinkers	53	407	0.6 (0.4 to 1.0)

*Adjusted for average weekly alcohol consumption and other non-alcohol variables in the final model.

Source: (Cheng et al. 1995) (Hong Kong)

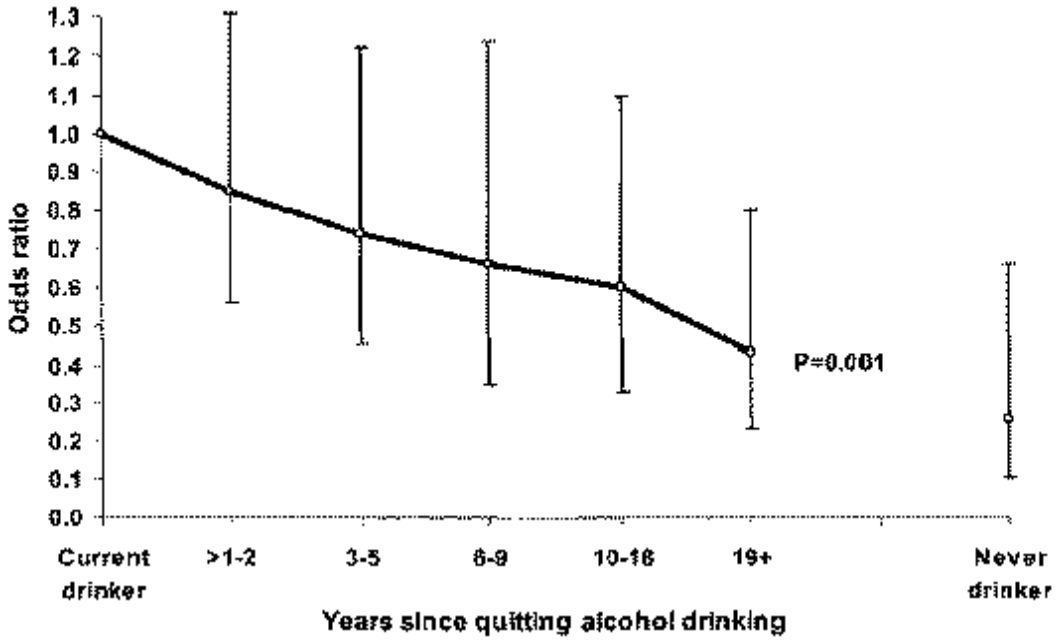
Table 3. Average amount of alcohol used, years since stopping, and risk of oesophageal cancer (odds ratios and 95% confidence interval*)

Years since stopping	Weekly consumption (in g ethanol)		
	1-199	200-599	>/=600
Current drinkers	1.0[&]	3.4 (2.0 to 5.9)	11.1 (6.0 to 20.4)
0-1 Year	3.7 (1.2 to 11.6)	7.3 (2.9 to 18.0)	8.7 (3.2 to 23.8)
1-4 Years	2.0 (0.9 to 4.6)	4.8 (1.5 to 15.1)	11.8 (3.6 to 38.0)
5-9 Years	0.7 (0.3 to 1.6)	1.9 (0.6 to 5.6)	3.1 (0.8 to 11.1)
10-14 Years	1.2 (0.5 to 3.2)	0.4 (0.07 to 3.1)	6.4 (1.5 to 27.0)
>/=15 Years	0.4 (0.1 to 1.3)	0.2 (0.02 to 2.5)	1.4 (0.2 to 7.9)

*Adjusted for other non-alcohol variables in the final model.

[&] Risk for never drinkers relative to this category was 1.1 (0.7 to 1.8).

Source: (Cheng et al. 1995) (Hong Kong)



ALCOHOL DRINKING[b]	No. of cases (N=550)	No. of controls (N=1195)	OR[a] (95% CI)
Current drinker	365	551	1.0 (reference)
Ex-drinker	135	247	**0.7 (0.5 – 0.9)**
Years since quitting: >1-2	46	68	0.8 (0.6 – 1.3)
3-5	31	55	0.7 (0.4 – 1.2)
6-9	21	32	0.7 (0.3 – 1.2)
10-18	20	43	0.6 (0.3 – 1.1)
≥19	17	46	**0.4 (0.2 – 0.8)**
Never drinker	50	400	**0.3 (0.1 – 0.7)**
Trend OR per cessation year[c]			**0.96 (0.94 – 0.98)**
P for trend[c]			***0.001***

Figure 1. Effect of drinking cessation on esophageal cancer risk.

[a] Odds ratios are adjusted for age group, hospital, years of schooling, average amount of pure ethanol consumed per day. Figures in bold type indicate statistical significance at the 0.05 level. [b] Subjects from Uruguay-2 (105 cases and 210 controls) were excluded from this analysis because data on alcohol drinking cessation were not collected. Three control subjects who were ex-drinkers did not provide information on years since quitting. [c] Trend test performed among subjects ever exposed to that habit. Vertical lines in graphs indicate 95% confidence limits. Source: (Castellsague et al. 2000) (Brazil, Uruguay, Argentina and Paraguay)

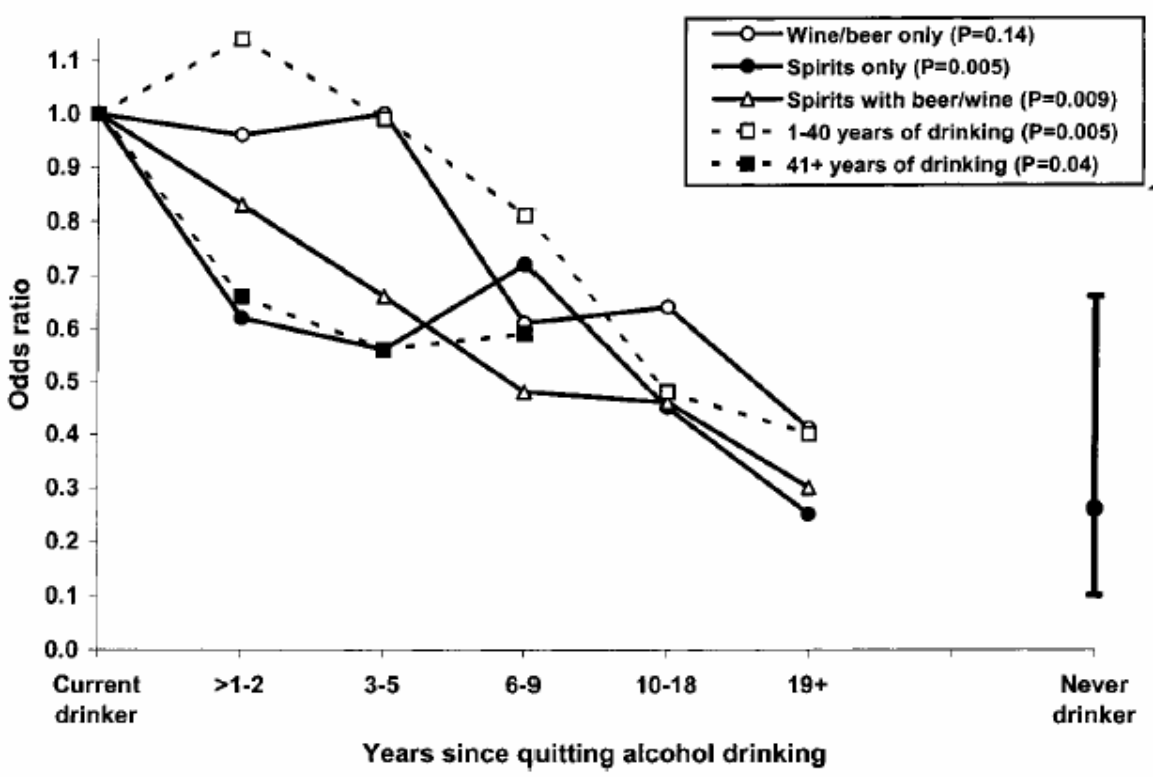


Figure 2. Effects of drinking cessation on esophageal cancer risk by duration and type of alcohol consumed.

Odds ratios are adjusted for age group, hospital, years of schooling, average amount of pure ethanol consumed per day; p-values are two-sided and they refer to the statistical significance of the trend test between risk and years since quitting among subjects in that exposure category. Vertical lines in unexposed groups indicate 95% confidence limits.
Source: (Castellsague et al. 2000) (Brazil, Uruguay, Argentina and Paraguay)

Table 4. Odds ratios (OR) for esophageal cancer according to selected alcohol-related exposure characteristics and gender[1]

Variables	Men		Women	
	Cases/controls	OR[2] (95% CI)	Cases/controls	OR[2] (95% CI)
Total	655/1408		175/371	
Alcohol drinking status				
Never-drinker	69/487	1.0	110/289	1.0
Ever-drinker	586/921	**3.7 (2.7–4.9)**	65/82	**2.1 (1.3–3.3)**
Never-drinker[3]	50/400	1.0	84/233	1.0
Ex-drinker	134/247	**3.4 (2.3–5.0)**	20/25	1.9 (0.9–3.8)
Current drinker	365/551	**4.4 (3.1–6.2)**	40/51	**2.2 (1.3–3.9)**
p value for trend		*<0.00001*		*0.004*
Average amount of pure ethanol/day (ml)				
0	69/487	1.0	110/289	1.0
1–24	82/272	**1.8 (1.2–2.6)**	23/31	**2.1 (1.1–3.9)**
25–49	102/182	**3.0 (2.1–4.4)**	18/22	**2.3 (1.1–5.0)**
50–149	195/305	**4.1 (3.0–5.8)**		
150–249	85/74	**6.9 (4.5–10.6)**		
250+	114/66	**11.5 (7.4–17.6)**	20/22	**2.0 (1.0–4.2)**
p value for trend		*<0.00001*		*0.008*
Years of alcohol drinking				
0	69/487	1.0	110/289	1.0
1–29	119/244	**2.9 (2.0–4.2)**	24/22	**2.9 (1.4–5.9)**
30–39	153/187	**4.6 (3.2–6.5)**	11/14	2.0 (0.8–5.0)
40–49	179/281	**3.6 (2.6–5.1)**	10/15	1.6 (0.6–4.1)
≥50	130/188	**4.0 (2.7–5.9)**	18/25	**2.1 (1.0–4.3)**
p value for trend		*<0.00001*		*0.018*
Age at starting drinking				
≤16	136/210	1.0	17/25	1.0
17–19	117/158	1.1 (0.8–1.5)		
20–24	169/270	0.9 (0.7–1.3)	20/26	1.1 (0.4–3.0)
≥25	159/262	0.9 (0.7–1.3)	26/25	1.1 (0.4–3.4)
p value for trend		*0.51*		*0.80*
Age at quitting drinking				
<47	30/70	1.0		
48–57	39/57	**2.2 (1.1–4.6)**	8/10	1.0
58–65	40/60	2.2 (1.0–5.0)		
≥66	26/57	1.0 (0.4–2.6)	12/15	1.8 (0.2–14.4)
p value for trend		*0.76*		
Years since quitting drinking				
Current drinkers	365/551	1.0	40/51	1.0
1–4	69/105	0.9 (0.7–1.3)	12/8	1.3 (0.4–4.4)
5–9	29/50	0.8 (0.5–1.4)		
≥10	37/89	**0.6 (0.4–0.9)**	8/17	0.6 (0.2–1.8)
p value for trend		*0.02*		*0.56*
Type of drink				
Never-drinker	69/487	1.0	110/289	1.0
Ever beer	100/203	**2.6 (1.8–3.8)**	9/4	**5.5 (1.6–19.5)**
Ever wine	374/600	**3.5 (2.6–4.8)**	45/72	**1.6 (1.0–2.7)**
Ever spirits	415/506	**4.5 (3.3–6.1)**	17/5	**8.0 (2.7–23.9)**

[1]Figures in bold type indicate statistical significance at the 0.05 level. [2]Adjusted for age group, hospital, years of schooling and average number of cigarettes smoked per day. [3]Subjects from Uruguay-2 are excluded from this analysis, information on alcohol cessation not being available.
Source: (Castellsague et al. 1999) (Brazil, Uruguay, Argentina and Paraguay)

Table 5. Odds ratios[a] (OR) and corresponding 95% confidence interval (CI) of oesophageal cancer according to smoking and drinking status and time since cessation, among 404 cases and 1070 controls, Italy and Switzerland, 1992–1999

	Cases	Controls	OR (95% CI)
Tobacco smoking			
Current smokers	238	320	1[c]
Ex-smokers			
Time since cessation (years)			
1–2	16	19	1.37 (0.64–2.96)
3–5	27	36	1.10 (0.60–2.04)
6–9	21	52	0.58 (0.31–1.07)
10–14	18	85	0.31 (0.17–0.56)
≥ 15	42	182	0.31 (0.20–0.49)
χ^2_1 for trend			48.76 $P < 0.0001$
Never smokers	42	376	0.23 (0.15–0.35)
Alcohol drinking[b]			
Current drinkers	347	870	1[c]
Ex-drinkers			
Time since cessation (years)			
1–5	20	25	0.85 (0.41–1.75)
6–14	24	19	1.72 (0.83–3.57)
≥ 15	5	22	0.53 (0.15–1.85)
χ^2_1 for trend			0.03 $P = 0.87$
Never drinkers	7	133	0.31 (0.14–0.69)

[a]Estimates from unconditional logistic regression models, including terms for age, sex, study centre, education, alcohol and tobacco consumption;
[b]The sum does not add up to the total because of some missing values;
[c]Reference category
Source: (Bosetti et al. 2000) (Italy and Switzerland)

Table 6. Odds ratios (OR) and corresponding 95% confidence intervals (CI) of laryngeal cancer according to smoking and drinking status and time since cessation, among 527 cases and 1297 controls. Italy and Switzerland, 1992 – 2000

	Cases	Controls	OR[a] (95% CI)
Tobacco Smoking			
Current smokers	349	352	1[b]
Ex-smokers	159	460	
Time since cessation (years)			
1 – 2	29	23	1.30 (0.70 – 2.40)
3 – 5	22	38	0.65 (0.36 – 1.17)
6 – 9	33	59	0.60 (0.37 – 0.98)
10 – 14	25	89	0.28 (0.17 – 0.46)
14 – 19	18	76	0.23 (0.13 – 0.40)
⩾20	32	175	0.17 (0.11 – 0.27)
χ^2_1 for trend			62.49 ($P<0.001$)
Never smokers	19	485	0.05 (0.03 – 0.08)
Alcohol drinking			
Current drinkers	448	1075	1[b]
Ex-drinkers	60	87	
Time since cessation[c] (years)			
1 – 5	30	39	1.24 (0.69 – 2.24)
6 – 19	24	33	1.29 (0.68 – 2.47)
⩾20	5	15	0.53 (0.15 – 1.94)
χ^2_1 for trend			0.05 (P=0.82)
Never drinkers	19	135	0.56 (0.31 – 0.99)

[a]Estimates from unconditional logistic regression models, including terms for age, sex, study centre, education (plus alcohol and tobacco consumption for time since cessation).
[b]Reference category.
[c]The sum does not add up to the total because of one missing value.
Source: (Altieri et al. 2002) (Italy and Switzerland)

Table 7. Distribution of 754 cases of oral cavity and pharynx and 1,775 controls[1], odds ratios (ORs) and corresponding 95% confidence intervals (CIs)[2] according to selected aspects of drinking habit in Italy and Switzerland, 1992–1997

	Current drinkers			Former drinkers			Total	
	Ca:Co	OR	(95% CI)	Ca:Co	OR	(95% CI)	OR	(95% CI)
Total drinks/week								
Never	32:224	1		32:224	1		1	
1–20	82:746	0.71	(0.44–1.15)	14:52	1.16	(0.51–2.65)	0.70	(0.44–1.11)
21–62	271:608	2.59	(1.60–4.21)	29:34	3.71	(1.66–8.28)	2.39	(1.48–3.85)
63–90	145:61	8.89	(4.96–15.94)	35:8	13.95	(4.74–41.05)	8.04	(4.56–14.17)
≥ 91	98:26	16.73	(8.55–32.73)	48:16	11.07	(4.49–27.28)	11.64	(6.31–21.45)
χ^2_1 (trend)		160.54			34.09		167.38	
		$p < 0.001$			$p < 0.001$		$p < 0.001$	
Age at starting[3]								
≤ 16	149:371	1		39:27	1		1	
17–19	125:268	1.12	(0.78–1.62)	25:18	1.62	(0.50–5.29)	1.16	(0.82–1.63)
20–22	178:381	1.35	(0.96–1.90)	40:35	1.31	(0.49–3.48)	1.36	(0.99–1.87)
≥ 23	130:351	1.08	(0.75–1.55)	21:28	0.84	(0.27–2.58)	1.04	(0.74–1.46)
χ^2_1 (trend)		0.63			0.07		0.42	
		$p = 0.43$			$p = 0.80$		$p = 0.52$	
Duration of drinking (years)[3]								
≤ 27	105:329	1		60:46	1		1	
28–35	159:325	1.00	(0.64–1.59)	36:29	0.58	(0.21–1.60)	1.00	(0.67–1.48)
36–44	171:349	1.08	(0.63–1.86)	21:23	0.63	(0.19–2.07)	1.06	(0.66–1.69)
≥ 45	147:368	0.91	(0.49–1.68)	8:10			0.87	(0.50–1.52)
χ^2_1 (trend)		0.07			0.74		0.15	
		$p = 0.79$			$p = 0.39$		$p = 0.70$	
Years since drinking cessation[3]								
1–3	—	—	—	27:35	1		1.21[4]	(0.61–2.38)
4–6	—	—	—	37:26	1.70	(0.61–4.80)	1.82	(0.96–3.46)
7–10	—	—	—	36:15	2.26	(0.69–7.45)	3.29	(1.49–7.27)
≥ 11	—	—	—	26:34	1.32	(0.41–4.21)	1.91	(0.95–3.84)
χ^2_1 (trend)		—			0.43		1.55	
					$p = 0.51$		$p = 0.21$	

Ca:Co = Cases:Controls.
[1]Some figures do not add up to the total because of some missing values.
[2]Estimates from logistic regression equations including terms for age, gender, centre, interviewer, education, smoking habits and drinking status, when appropriate.
[3]Adjusted also for total drinks/week.
[4]596 cases and 1,441 controls who were current drinkers as reference category.

Note: One drink corresponded to 125 ml of wine, 330 ml of beer and 30 ml of spirit (*i.e.,* 10–12 g of ethanol). Never drinkers were individuals who had abstained from any alcoholic beverage lifelong, whereas former drinkers were those who had stopped drinking any type of alcoholic beverage for at least 12 months at cancer diagnosis or hospital admission (for controls).
Source: (Franceschi et al. 2000) (Italy and Switzerland)

Table 8. Association of the duration of drinking abstention (in tertiles) with colorectal cancer risk

	Colorectal cancer (95% CI)			Colon cancer (95% CI)			Rectal cancer (95% CI)		
	Number	Crude OR	Adjusted OR[1]	Number	Crude OR	Adjusted OR[1]	Number	Crude OR	Adjusted OR[1]
Duration in tertiles									
< 66 months	79	1.0	1.0	37	1.0	1.0	39	1.0	1.0
66–180 months	40	0.52[2] (0.31–0.87)	0.54[2] (0.30–0.97)	21	0.56 (0.30–1.06)	0.61 (0.30–1.26)	39	0.47[2] (0.45–0.90)	0.50 (0.23–1.0)
> 180 months	34	0.45[3] (0.26–0.76)	0.44[2] (0.24–0.82)	19	0.56 (0.30–1.07)	0.48 (0.22–1.05)	14	0.35[3] (0.17–0.7)	0.41[2] (0.71–0.98)
			p trend 0.006			*p* trend 0.056			*p* trend 0.030
Alternative analysis[4]									
Current drinker	247	1.0	1.0	133	1.0	1.0	111	1.0	1.0
< 66 months	79	1.29 (0.88–1.90)	1.37 (0.91–2.06)	37	1.12 (0.71–1.79)	1.13 (0.69–1.87)	39	1.42 (0.89–2.26)	1.63 (0.99–2.68)
66–180 months	40	0.65 (0.42–1.02)	0.66 (0.42–1.06)	21	0.64 (0.37–1.10)	0.62 (0.35–1.11)	39	0.65 (0.37–1.16)	0.73 (0.40–1.36)
> 180 months	34	0.56[2] (0.35–0.88)	0.52[2] (0.31–0.86)	19	0.58 (0.33–1.01)	0.50[2] (0.31–0.86)	14	0.57[2] (0.27–0.95)	0.54 (0.28–1.08)
Never drinker	385	0.77[2] (0.62–0.97)	0.72[2] (0.55–0.94)	219	0.81 (0.62–1.06)	0.68[2] (0.49–0.95)	161	0.72[2] (0.54–0.96)	0.79 (0.56–1.12)
			p trend 0.002			*p* trend 0.007			*p* trend 0.044

[2] $p < 0.05$.
[3] $p < 0.01$.
[4] Results were similar if analysis was performed with exclusion of never drinkers.
Source: (Ho et al. 2004) (Hong Kong)

Table 9. Normotensive and hypertensive subjects on alcohol withdrawal

	Normal BP (%)	Hypertension			Total hypertension (%)
		Mild (%)	Moderate (%)	Severe (%)	
T_0	43.5	33.3	16.9	6.3	56.5
T_3	63.3	31.2	3.4	2.1	36.5
T_5	70.1	23.8	5.4	0.7	29.9
T_{10}	76.2	20.3	3.5	–	23.8
T_{18}	78.2	19.7	1.4	0.7	21.8

Source: (Ceccanti et al. 2006) (Italy)

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LIMITATIONS OF THE STUDY

Although we tried to estimate avoidable costs as best as possible, the current study has some limitations. The time aspect of change due to interventions was not well captured. Over what periods of time would these benefits in burden and cost be achievable? In this study all effects were modeled as if they occurred instantaneously. While this modeling is reasonable for most effects on acute disease conditions and criminality, it overestimates the effect on chronic health conditions (except liver cirrhosis) attributable to alcohol. For example, if some drastic intervention could reduce alcohol consumption to zero at a certain point in time, alcohol-related disease burden would not be zero immediately thereafter. Instead, some burden of disease would persist due to previous alcohol consumption. For instance, there will be some people already having alcohol-attributable mouth cancer and some people may even develop new mouth or other cancer in future based on their past alcohol exposure.

In our aggregate costs estimates (baseline; Rehm et al., 2006), protective effect of low or moderate consumption of alcohol on cardio-vascular diseases and diabetes was taken into account and was, therefore, incorporated in current avoidable cost estimates. However, policies aimed at minimizing the costs of alcohol abuse, such as increasing taxes on alcohol, may reduce the number of low or moderate alcohol consumers and thus reduce the total protective effect of low or moderate alcohol consumption. This effect of interventions on possible reduction of protective effect of alcohol over time was not captured in avoidable estimates.

Due to data unavailability, the impact of selected interventions for prescription drugs, ambulatory care and physicians' services was assumed to be the same as for acute care hospitals.

Also, the impact of some interventions was not modeled stratified by sex and age. For example, economic theory would predict, that impact of taxation would be stronger for people with less disposable income such as young adults.

Avoidable productivity costs due to the interventions were calculated by using the modified Human Capital (HC) approach, introduced in the Canadian cost of substance abuse study (Rehm et al., 2006, 2007). However, to facilitate comparisons with other

research, we also calculated avoidable productivity costs using the traditional HC and the Friction Cost (FC) methods. The magnitude of the avoidable indirect cost estimates varied substantially depending upon the method and underlying labor market assumptions, with the FC method producing the smallest figures. This is because FC method is more sensitive to changes in number of deaths, while the HC method is responsive to changes in potential years of life lost.

These presented estimates of avoidable cost of alcohol abuse do not reflect the rates of return that the society might achieve. To compute the potential rates of return on expenditure it is necessarily to conduct a cost benefit analysis. Our first estimates of avoidable cost of alcohol abuse in Canada might serve as a basis for conducting a meaningful cost benefit analysis, which would facilitate a complete evaluation and comparison of the most effective and cost effective interventions.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH

Conclusion from the approach based on the outcome of proven effective major interventions

By implementing cost-effective policies, some portion of alcohol-attributable burden and its costs could be avoided. Under conservative assumptions and using interventions generally supported by public opinion, one billion dollars per year could be saved in Canada.

The potential gains to Canadian society may be even higher, as sensitivity analyses on three of the six interventions resulted in a doubling of the avoidable alcohol-attributable burden and cost.

The largest impact would come from comprehensive interventions affecting the overall level of drinking, such as brief interventions and increasing alcohol taxation. However, the greatest cost avoidance would be achieved when multiple rather than single effective and cost-effective alcohol policies are implemented. Thus, the results clearly indicate that substantial decreases in alcohol-attributable harm and costs to society can only be made if an alcohol strategy is implemented that comprises several policies. The recommendations for a National Alcohol Strategy, as laid out by the National Alcohol Strategy Working Group about one year ago (http://www.nationalframework-cadrenational.ca/uploads/files/FINAL_NAS_EN_April3_07.pdf), would outline the right direction. However, substantial decreases in alcohol-attributable costs will only be possible if such a strategy is seen as a priority, and if it includes several broad areas of action, including measures to reduce the availability of alcohol.

Recommendations for feasible minimum (other approaches):

The Arcadian approach

The results revealed surprisingly different rates of mortality in different countries with similar economic development (see Appendix A). These substantial differences in mortality rates could be explained by the fact that countries are very different with respect to confounding factors, such as genetic, cultural, and environmental, all of which

determine disease conditions and relative risks. Based on this, it would not be possible to know why one specific country has the lowest rate on some specific disease.

We recommend continuing to explore this approach by using other summary measures of health, i.e. Disability Adjusted Life Years (DALYs), and their relationship to cost-relevant components, such as hospital days. However, the above issues have to be acknowledged when using this approach.

The lowest attributable fraction in economically comparable regions

The results revealed that the estimates of AAFs for mortality and PYLL are very close due to using the same relative risks and similar adult per capita consumption in developed countries regions (A-regions in the CRA, Rehm et al., 2004). Therefore, in terms of feasible minimum for an avoidable cost study, this approach was not very fruitful.

Recommendations for future research

Future research studies on the avoidable cost of substance abuse should not ignore the element of time. The time dimension is very important, as we would need to know the period of time over which positive changes to health, criminality and other outcomes are achievable. These changes may vary for different conditions. For example, for acute conditions such as most injuries and criminality, the effect of reducing/stopping drinking could be observed almost immediately. For mixed conditions, such as coronary heart disease and liver cirrhosis, some effects could be observed within one year. The longest waiting period to observe effect is for neoplasms. For example, our recent meta-analysis demonstrated that stopping drinking reduced the risks of head and neck and oesophagus cancers but it took 15-20 years, before the risks were as low as for lifetime abstainers (Rehm et al., 2007).

Another example is a natural Gorbachev's experiment in Russia - the anti-alcohol campaign of 1985–1991. After introducing a "dry law", all major causes of death, with the exception of neoplasms showed decline. The largest declines were observed for alcohol–related deaths, accidents and violence (Leon et al., 1997).

Overall, it is hard to judge the effectiveness of the interventions based on changes in health care outcomes, especially for chronic diseases and within a short time frame. Therefore, it is much more common in our society to measure the effectiveness of alcohol policies and programs through alcohol-related acute consequences such as injuries (e.g., drinking and driving) and criminality, which are fastest and easiest to observe. This tendency may also be influenced by the generally short time windows considered in politics. There is a need for studies which would look at avoidable burden and its cost over the next 25 years rather than for a specific year.

Recommendations for the *Guidelines for the Estimation of the Avoidable Cost of Substance Abuse*

This study found that the most valuable approach recommended by the *Guidelines* (Collins et al., 2006) is based on the policy effectiveness. This approach allows modelling the effect of both existing and desirable (non-existing) interventions, which is very valuable from the policy implication perspective. However, this approach should not only look at avoidable burden and costs at one time, but also take the future time dimension into consideration, and thus predict future developments. As a consequence, avoidable burden should be considered in larger time spans rather than one year.

Furthermore, we found that all other approaches, recommended by the *Guidelines*, were of limited utility for reasons outlined above. Based on these results, and perhaps results from future avoidable cost studies from other countries (for example, Australia is currently conducting a similar study), we believe that the *Guidelines for the Estimation of the Avoidable Cost of Substance Abuse* should be substantially revised.

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