The impacts of minimum alcohol pricing on alcohol attributable morbidity in regions of British Colombia, Canada with low, medium and high mean household income

Jinhui Zhao, PhD and Tim Stockwell, PhD
Centre for Addictions Research of BC (CARBC),
University of Victoria, BC, Canada

Address for correspondence:
Tim Stockwell
Director, CARBC and Professor, Department of Psychology
University of Victoria, PO Box STN 1700 CSC
Victoria, BC V8W 2Y2
CANADA
Telephone: 1 250 472 5445
Email: timstock@uvic.ca

31 March 2016

Acknowledgements:

The data utilised in these analyses and some descriptions of the methods used are adapted from an open access peer-reviewed journal article published by the same authors in the *American Journal of Public Health* [1]. This original research was funded by a Canadian Institutes for Health Research operating grant held by the second author. The unique contribution of the analyses presented here is to replicate the original analysis for regions stratified into low, medium and high average households income levels. The present report was made possible with funds from the Scottish Government.

Summary

Introduction: Minimum alcohol pricing involves setting a floor price below which a specified quantity of ethanol or alcoholic beverage cannot be sold. Research conducted in Canada has indicated that minimum pricing can reduce alcohol consumption and alcohol attributable mortality and morbidity. UK modelers predict greater impacts in low income areas. The aim of the present study is to investigate how the impacts of minimum pricing on acute alcohol attributable morbidity varied by income level.

Methods: A cross-sectional time-series panel study was designed to investigate the impacts of periodic increases to minimum prices of different alcohol beverages on acute alcohol attributable hospital admissions. We obtained quarterly alcohol attributable hospital admission data on 89 local health areas in British Columbia in 2002-2009. Multivariate mixed effect modelling was used to examine the relationship between the rates of acute alcohol attributable hospital admissions and minimum Canadian dollars per standard drink in regions with differing mean household income levels. We used covariates in the models to control for the confounding effects of alcohol outlet densities, trend and seasonality, social and demographic characteristics of regions, regional differences and temporal autocorrelation.

Results: A 10% increase in minimum alcohol prices was associated with a significant 17.13% decrease (t-test $P<0.05$) in the rate of acute alcohol attributable hospital admissions in the health regions with average annual family income of less than CA$65,000 and significant 11.6% decreases (t-test $P<0.01$) in the regions with average annual family income of CA$65,000 but less than CA$75,000; A 3.61% decreased effect was found in the regions with average annual family income of CA$75,000 or higher, which was not significant (t-test $P>0.05$). It was also shown that lower income regions had the highest overall levels of acute alcohol attributable morbidity and that the high income region had the lowest overall rates.

Conclusion: The results support the hypothesis that minimum alcohol pricing produces greater percentage reductions in acute alcohol attributable morbidity for populations with lower income. The significance of this effect is further emphasized by the other main finding that low income areas had the highest overall rates of alcohol attributable morbidity.

Key words: minimum alcohol price, alcohol attributable hospital admission, cross-section time-series study, mixed model

The impacts of minimum alcohol pricing on alcohol attributable morbidity in regions of British Colombia, Canada with low, medium and high mean household income

Introduction

Alcohol is the psychoactive substance with dependence-producing properties. The harmful use of alcohol ranks among the top five risk factors for disease, disability and death throughout the world [2, 3]. It is a causal factor in more than 200 disease and injury conditions as described in Statistical Classification of Diseases and Related Health Problems (ICD) 10 revision [4]. Globally, harmful use of alcohol causes approximately 3.3 million deaths every year or 5.9% of all deaths and 5.1% of the global burden of disease is attributable to alcohol consumption [5].

Several alcohol policies and interventions have been developed with the aim of reducing the harmful use of alcohol and the alcohol attributable health and social burden in a population and in society [5]. Pricing is a policy with a substantial body of literature indicating that higher prices and taxes can be highly effective in reducing harmful use of alcohol among drinkers. Studies show that as the price of alcohol increases, alcohol attributable morbidity and mortality decline [6-8]. In recent years, many attempts have been made to develop and test more specific varieties of pricing policies such as minimum prices [9]. Minimum alcohol pricing involves setting a floor price below which a specified quantity of ethanol or alcoholic beverage cannot be sold. Minimum alcohol pricing has been used in some Canadian provinces since the 1920s and it is now utilized in all 10 provinces, whether to set floor prices for alcohol sold for on premise or off premise consumption or both [10, 11]. Research conducted in Canada has found that minimum alcohol pricing policies can reduce alcohol consumption [12, 13], impaired driving offences [14] and alcohol-attributable mortality and morbidity [15, 16]. UK modelers predict greater impacts for low income drinkers [17]. It was estimated that low income drinkers would reduce their alcohol consumption the most and, as a group, demonstrate the greatest reductions in alcohol related harms. However, no studies have been conducted to confirm this in occurs in practice when minimum prices have been introduced or increased. The aim of the present study is to estimate how immediate impacts of minimum alcohol pricing on acute alcohol attributable hospital admissions vary by income level. Our earlier research found evidence of delayed effects of minimum pricing on chronic alcohol attributable morbidity [1]. These more complex relationships will be explored in a future paper. The opportunity to test this hypothesis is provided by a) the practice in British Columbia (BC) of only occasionally increasing levels of minimum alcohol pricing for products distributed by the government-owned liquor distribution authority and b) the availability of consistently made estimates of quarterly rates of alcohol attributable hospitalisations between 2002 and 2009 for all 89 local health areas of the province. Minimum alcohol pricing in BC is set as a dollar value per litre of beverage and is not adjusted the different strengths of beverage.

Method

Study design

We conducted a cross-sectional (89 Local Health Areas or LHAs) versus time-series (32 annual quarters, 2002–2009) panel study of quarterly acute alcohol attributable hospital admission rates and their association with CPI-adjusted mean minimum prices across all beverage types for a defined amount of alcohol (a Canadian “standard drink”, or 13.45 g of pure alcohol) [18]. Adjustments were made for density of different liquor outlets, trend, seasonality, sociodemographic characteristics, and regional and temporal autocorrelation. The LHAs are nested within 16 larger health service delivery areas (HSDAs). The analyses measured and corrected for the effect of correlation between LHA-level values of dependent variables within each HSDA. The analyses were performed by LHAs with three levels of annual family average income in 2006 CENSUS in order to investigate the effects differed by economic status.

Data sources

Alcohol-attributable hospital admissions

We estimated alcohol-attributable completed hospital admissions by applying population alcohol-attributable fractions (AAFs) to admission data for 60 categories of disease and injury [2]. For non-100% alcohol-attributable diseases, we calculated AAFs from the level of exposure to alcohol and the risk relations between consumption and different disease categories using the formula:

$$(1)\quad AAF=[\Sigma^{k}_{i=1} P_i(RR_i-1)]/[\Sigma^{k}_{i=0} P_i(RR_i-1) + 1],$$

where k=total levels of exposure; i=exposure category, with baseline exposure or no exposure i=0; RR_i=relative risk at exposure level i compared with no consumption; and P_i=prevalence of the i^{th} category of exposure.

We obtained relative risk estimates from published meta-analyses [19, 20] and prevalence data on drinking behaviors from the 2004 Canadian Addiction Survey [21]. For injuries attributable to alcohol, we based alcohol-attributable fractions on direct estimates of alcohol involvement from the published literature [19]. Alcohol-attributable fractions were multiplied with overall numbers of completed hospital admissions (i.e., those that had resulted in a discharge) for each International Classification of Diseases-10 (ICD-10) code [22] and summed to obtain the total burden of disease from alcohol by age and gender for each of the 89 LHAs.

The BC Ministry of Health provided hospital discharge data for the relevant ICD-10 codes using the most responsible diagnosis by 5-year age group, gender, LHA, and quarter

(Appendix A). (For simplicity, we refer to hospital discharges in this paper as hospital admissions or hospitalisations). We adjusted the survey-based estimates of alcohol exposure for underestimation by comparison with local per capita alcohol consumption for each of 5 BC health authorities [23]; the overall method is described in more detail elsewhere [24]. Rates of alcohol-attributable admissions were age and gender standardized with reference to the 2001 BC population [25].

Minimum alcohol prices

We obtained minimum alcohol prices from the Liquor Distribution Branch (LDB) of the BC Ministry of Public Safety and Solicitor General [13]. During the study, spirit minimum prices increased in 4 increments from CA$25.91 to CA$30.66 per liter of beverage (including sales taxes), and packaged and draft beer prices each increased in increments from CA$3.00 and CA$2.05 to CA$3.54 and CA$2.22 respectively. Other minimum prices were unchanged. We then recalculated mean minimum prices as dollar values per standard drink (17.05 ml ethanol) using precise estimates of mean percentage of alcohol content for each main beverage type, adjusted by the Consumer Price Index [13].

Alcohol outlet data

We obtained the number of restaurants, bars, government and private liquor stores from the BC LDB for each of the 89 LHAs and 32 time periods.

Population data

We obtained population data for each LHA from BC STATS [26] to calculate the quarterly rates of admissions per 100,000 population and alcohol outlet densities per 100,000 residents aged 15 years and older for these areas. The population data projected and estimated by

BC STATS combines information [27] from the 2006 Census of Canada along with population projections for non-census years.

Socioeconomic data

Sociodemographic variables likely to confound the relationships of interest were included in the models [28, 29]. We took from the 2006 Canadian census percentages of individuals who were aboriginal, were visible minorities, did not complete high school, and were in different household income brackets for each area. Population densities were calculated as total population divided by land area (km^2).

Spatial data

We obtained BC government data for LHA administrative areal units from DataBC [27]. The geometric center (centroid) of each area was computed and included in the models. We used the centroids from the LHAs to incorporate spatial dependence in the model by using the distance between centroids to develop the spatial covariance structure using a semivariogram function [27].

Statistical Analyses

A number of preparatory analyses were conducted by regions with three levels of family average income. We computed Moran's *I* for annual alcohol-attributable admission rates to test for spatial autocorrelation in these data and analyzed annual alcohol-attributable admission rates to examine trend changes using regression. We analyzed rates of age- and gender-standardized admissions using analysis of variance to examine seasonal differences. Bivariate regression was performed to examine the relationships between admissions and sociodemographic variables.

We then used mixed models [30], which provide straightforward but flexible methods for assessing spatial and temporal dynamics of longitudinal panels of data. Mixed models permit tests of fixed effects through either maximum likelihood or restricted maximum likelihood estimation. These methods are superior to traditional repeated-measures analysis of variance because they allow simultaneous inference about spatial and temporal factors through the use of fixed and random effects and they also apply to a wide variety of covariance (correlation) structures. Thus, more appropriate covariance data structures can be analyzed. We adjusted spatial and temporal autocorrelation effects in all models. Log transformations were applied when necessary to correct for significantly skewed distributions and make the variance stationary for dependent variables. Adjustments for temporal autocorrelation were made if it was detected by the Durbin-Watson statistic. The equation for the mixed models was as follows:

$$Y_{itk} = \beta_0 + \beta_1 X_{1itk} + \beta_2 X_{2itk} + \beta_3 X_{3itk} + \beta_4 X_{4itk} + \beta_5 X_{5itk} + \beta_6 X_{6itk} + \beta_7 X_{7itk} + \beta_8 X_{8itk} + \beta_9 X_{9itk} + \nu_k + u_i + \tau_{it} + \varepsilon_{itk}$$

where i (=1 to 89) each LHA, t (=1 to 32) each time period, and k (=1 to 16) indexes values for each HSDA; Y_{itk} is the rate of alcohol attributable admissions at the i^{th} LHA, k^{th} HSDA at the t^{th} annual quarter (natural log-transform); β_0 is the intercept; β_1 is the % change in rate of admissions due to a 1% increase in minimum price and X_{1itk} is CPI-adjusted minimum price (Canadian dollars) per standard drink (natural log-transform); coefficients β_2 to β_{10} represent the % change in rate of alcohol attributable admissions resulting from 1% increases in all other independent variables (i.e. the density of restaurants and bars, government stores, and private stores; percentages of the population that are aboriginal, visible minorities, high school completers and population density) the values for which are all represented by X_{2itk} to X_{8itk} (natural log-transform). In addition, β_9 is the estimated effect for the trend X_{9i} (i.e., year); ν_k is the variance component for HSDA; u_i is the variance component for LHA; τ_{it} is the spatial and temporal autocorrelation effect; ε_{itk} is the error term.

We conducted all statistical analyses using SAS version 9.3 and the SAS MIXED procedure was used to perform mixed-effect regression analyses (SAS Institute, Cary, NC) [31]. All significance tests assumed 2-tailed *P* values or 95% confidence intervals.

Results

Rates of alcohol attributable hospitalizations

During the study period, alcohol-attributable admissions numbered 142,615, of which 48.07% were acute and 51.93% were chronic. The analysis of variance identified significant variance in these rates by both HSDA and LHA ($P < 0.001$ in each case). Age-sex standardized acute alcohol-attributable admission rates showed significantly increasing trends over the study period ($P = 0.003$). Rates of alcohol-attributable admissions were significantly associated with the percentage of population that was aboriginal, was a visible minority, and had not completed high school. Lower population density and higher family income were also significant predictors ($P < 0.001$ in each case). Moran's *I* autocorrelation analyses identified significant spatial autocorrelation on rates at each centroid for each type of alcohol-attributable admission rate on the basis of a distance-defined neighborhood ($P < 0.001$ in each case). Durbin-Watson tests for rates of acute alcohol-attributable admissions were also significant, confirming the presence of fourth-order temporal autocorrelation, corresponding to consistent seasonal variation ($P < 0.01$).

Table 1 presents the mean age-sex standardized rate per annual quarter of acute alcohol attributable hospitalizations per 100,000 population in the LHAs of BC with three levels of income in 2002-2009. The mean rate for 89 LHAs in 2002-2009 was 61.72 acute chronic alcohol attributable hospitalizations per 100,000 population per quarter. The descriptive analysis shows a significant difference among the LHAs with three levels of average family income. The LHAs with low and medium income had a significantly higher morbidity rate compared to the LHAs with high income (both t-test Ps < 0.001); The LHAs with low income also had a significantly higher acute rate compared to the LHAs with medium income (t-test P < 0.01).

Table 1. Mean age-sex standardized rate per annual quarter of acute alcohol attributable hospitalizations per 100,000 population in the LHAs of British Columbia with three levels of income in 2002-2009

Average family income	N	Hospitalization rate and 95% CIs †	
Low income (CA$41678-<CA$65,000)	960 = 30X32	67.10	65.43 – 68.77
Medium income (CA$65000-<CA$75,000)	1,088 = 34X32	63.59	62.02 – 65.14
High income (CA$75,000-CA$18,434)	800 = 25X32	52.71	50.88 – 54.55
Total	2,848 = 89X32	61.72	60.73 – 62.71

Note: † Estimated 95% confidence interval of the quarter rates.

Acute alcohol attributable hospital admissions and minimum alcohol price

Table 2 presents the percent change in the rate of acute alcohol-attributable hospital admissions with a 1% change in minimum alcohol prices for the LHAs in BC, 2002-2009 by average family income. Mixed modeling shows that a 10% increase in minimum alcohol prices was associated with an immediate and significant 17.13% decreases (t-test P<0.05) in the rate of acute alcohol attributable hospital admissions in the local health areas with average annual family income of less than CA$65,000 and significant 11.60% decreases (t-test P<0.01) in the areas with average annual family income of CA$65,000 but less than CA$75,000; A 3.61% decreased effect was found in the areas with average annual family income of CA$75,000 or higher but not significant (t-test P>0.05).

Table 2. The percentage change in the rate of acute alcohol-attributable hospital admissions with a 1% change in minimum alcohol prices for the local health areas in British Columbia, 2002-2009 by average family income

Local health areas by average family income	Elasticity (% change due to 1% increase in minimum prices) †
<CA$65,000	–1.713 (–3.406, –0.021) *
CA$65,000–<CA$75,000	–1.160 (–1.879, –0.440) **
CA$75,000+	–0.361 (–1.172, +0.451) ns

Note: † Estimates using mixed models while controlling for the confounding effects of alcohol outlet densities, trend, seasonality, social and demographic characteristics of regions, regional differences and temporal autocorrelation. t-test: P>0.05 *P<0.05 **P<0.01, ns=not significant.

Discussion

These analyses confirm that the overall pattern of findings in our earlier [1] publication regarding minimum prices and alcohol attributable hospitalisations apply broadly across different regions of BC classified by level of mean household income. Using these same data, we previously reported that a 10% increase in minimum prices for all alcohol products was generally associated with a significant and immediate 8.9% decrease for acute alcohol attributable hospitalizations.

While we observed a similar pattern of results for areas classified as having low, medium or high average household income, there was also a tendency for effect sizes to be larger in the "low" income strata for acute alcohol attributable hospitalisations. Thus, these new analyses suggest that the regions of BC with lower income appear to experience the greatest health benefits when minimum prices increase. Conversely, low income areas are likely to experience the greatest increments in alcohol attributable hospitalisations when minimum prices decrease in value. The significance of this effect is magnified by the other main finding that low income areas already had significantly higher overall rates of alcohol attributable morbidity compared with both the medium and high income regions studied.

For rates of acute alcohol attributable morbidity (i.e. injuries, poisoning, acute illnesses), the immediate negative association with a 10% change in minimum alcohol price changes was almost four times greater in the low income (17.1%) compared with the higher income (3.6%) areas of the province. The medium household income areas evidenced an intermediate effect size (11.6%). Each of these negative associations was statistically significant.

A number of limitations of this study need to be borne in mind. Firstly, these are observational data and the associations identified, however statistically significant, could be caused by other unmeasured factors simultaneously influencing minimum prices and alcohol attributable hospital admissions to change in opposite directions. The effect sizes calculated mostly have quite wide confidence intervals. Thus, there is greater certainty regarding the statistical significance of the *direction* of the association (i.e. that it is negative) than it's precise *size*. It also needs to be acknowledged that this study examines ecological relationships at a broad aggregate level across quite large populations. Areas with a "low" mean a household income of less than CA$65,000 per annum will incorporate a wide range of household incomes from very low to very high. The intention of the study was to create broadly different areas which on average have contrasting overall levels of household income and to explore whether changes to minimum prices have different impacts on these broadly different regions.

Minimum alcohol pricing is likely to reduce rates of acute alcohol attributable hospitalizations [15] by reducing population levels of alcohol consumption [13]. Minimum alcohol pricing may have larger impacts in the regions with lowest income because alcohol is already less affordable in these communities. While it is known that there are more abstainers among people on low income [17], studies also show that expenditure on alcoholic beverages as a proportion of household income is twice as large in low income households as in high income households in countries like the United States and the United Kingdom [32]. However, Holmes et al [17] have modeled the impacts of minimum unit prices and concluded that for low income drinkers with heavy consumption, not only are there large reductions in their alcohol intake there is also no overall increase in expenditure when minimum prices are introduced i.e. in traditional economic parlance, minimum alcohol pricing may not be "regressive". Similar to Holmes et al [17], the present analyses suggest that even if minimum alcohol prices are in fact "regressive" to some degree (ie they have greater impacts on available income of low versus high income groups), these concerns may be offset by disproportionately large reductions in alcohol attributable morbidity for low versus high income groups when minimum alcohol prices are introduced or increased.

Minimum pricing aims to increase the price of very cheap alcohol, therefore limiting its affordability. Compared to taxation (e.g., sales and excise taxes), setting a minimum price may produce large effects on drinkers with heavier alcohol consumption patterns as they tend to purchase cheaper alcoholic beverages [32].

Conclusion

The results support the hypothesis that minimum alcohol pricing produces greater percentage impacts on acute alcohol attributable morbidity in populations with lower income. This is especially important for public health policy given that the lower income regions also had the highest rates of alcohol attributable morbidity.

References

1. Stockwell T, Zhao J, Martin G, Macdonald S, Vallance K, Treno A, Ponicki WR, Tu A, Buxton J: **Minimum alcohol prices and outlet densities in British Columbia, Canada:**

Estimated impacts on alcohol attributable hospitalisations. *American Journal of Public Health* 2013:e1-e7.

2. WHO: **Global status report on alcohol and health 2011**. In. Geneva: WHO Press. Available from URL: http://www.who.int/substance_abuse/publications/global_alcohol_report/msbgsruprofiles.pdf. Accessible 5 February 2016; 2011.

3. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, Amann M, Anderson HR, Andrews KG, Aryee M *et al*: **A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010**. *Lancet* 2012, **380**(9859):2224-2260.

4. WHO: **WHO Statistical Classification of Diseases and Related Health Problems (ICD) 10th revision**. Geneva: WHO; 1992.

5. WHO: **Global status report alcohol and health 2014**. L'IV Com Sàrl, Villars-sous-Yens, Switzerland: WHO; 2014.

6. Wagenaar AC, Salois MJ, Komro KA: **Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies**. *Addiction* 2009, **104**(2):179-190.

7. Wagenaar AC, Tobler AL, Komro KA: **Effects of Alcohol Tax and Price Policies on Morbidity and Mortality: A Systematic Review**. *American Journal of Public Health* 2010, **100**(11):2270-2278.

8. Elder RW, Lawrence B, Ferguson A, Naimi TS, Brewer RD, Chattopadhyay SK, Toomey TL, Fielding JE, Preventive TFC: **The Effectiveness of Tax Policy Interventions for Reducing Excessive Alcohol Consumption and Related Harms**. *American Journal of Preventive Medicine* 2010, **38**(2):217-229.

9. OECD: **Tackling harmful alcohol use: economics and public health policy**. In.: The Organization for Economic Co-operation and Development (OECD), Publishing. Accessible at: http//dx.doi.org/10.1787/9789264181069-en; 2015.

10. Thompson K, Stockwell T, Vallance K, Giesbrecht N, Wettlaufer A: **Reducing alcohol-related harms and a costs in British Columbia: a probably show a summary report**. In. Victoria, BC: Centre for addictions research of BC, University of Victoria; 2013.

11. Stockwell T, Hartford L, Paszkowski D, Thomas G, Westcott J, Wettlaufer A: **Social reference prices for alcohol: a tool for Canadian governments to promote a culture of moderation**. In. Ottawa, Ontario: Canadian Centre on Substance Abuse. Available from URL: http://www.ccsa.ca/Resource Library/CCSA-Social-Reference-Prices-for-Alcohol-Canada-Report-2015-en.pdf. Accessible February 17, 2016; 2015.

12. Stockwell T, Zhao J, Giesbrecht N, Macdonald S, Thomas G, Wettlaufer A: **The raising of minimum alcohol prices in Saskatchewan, Canada: impacts on consumption and implications for public health**. *American Journal of Public Health* 2012, **102**(12):e103-110.

13. Stockwell T, Auld MC, Zhao JH, Martin G: **Does minimum pricing reduce alcohol consumption? The experience of a Canadian province**. *Addiction* 2012, **107**(5):912-920.

14. Stockwell T, Zhao JH, Marzell M, Gruenewald PJ, Macdonald S, Ponicki WR, Martin G: **Relationships Between Minimum Alcohol Pricing and Crime During the Partial Privatization of a Canadian Government Alcohol Monopoly**. *Journal of Studies on Alcohol and Drugs* 2015, **76**(4):628-634.

15. Stockwell T, Zhao JH, Martin G, Macdonald S, Vallance K, Treno A, Ponicki W, Tu A, Buxton J: **Minimum Alcohol Prices and Outlet Densities in British Columbia, Canada: Estimated Impacts on Alcohol-Attributable Hospital Admissions**. *Am J Public Health* 2013, **103**(11):2014-2020.

16. Zhao J, Stockwell T, Martin G, Macdonald S, Vallance K, Treno A, Ponicki WR, Tu A, Buxton J: **The relationship between minimum alcohol prices, outlet densities and alcohol-attributable deaths in British Columbia, 200209**. *Addiction* 2013, **108**(6):1059-1069.

17. Holmes J, Meng Y, Meier PS, Brennan A, Angus C, Campbell-Burton A, Guo YL, Hill-McManus D, Purshouse RC: **Effects of minimum unit pricing for alcohol on different income and socioeconomic groups: a modelling study**. *Lancet* 2014, **383**(9929):1655-1664.

18. Beck N: **Time-series-cross-section data**. *Statistica Neerlandica* 2001, **55**(2):111-133.

19. Rehm J, Baliunas D, Brochu S, Fischer B, Gnam WH, Patra J, Popova S, Sarnocinska-Hart A, Taylor B: **The cost of substance abuse in Canada 2002**. In. Ottawa: Canadian Centre on Substance Abuse. Available from URL: http://koalicija.org/serveris/Metod_liter/Cost of substance abuse in Canada, 2002.pdf. Accessible 5 February 2016; 2006.

20. English DR, Holman CDJ, Milne E, Winter MJ, Hulse GK, Codde JP, Bower CI, Corti B, De Klerk N, Knuiman MW *et al*: **The quantification of drug caused morbidity and mortality in Australia**. In. Canberra: Commonwealth Department of Human Services and Health; 1995.

21. Adlaf E, Ialomiteanu A: **Canadian Addiction Survey 2004: Microdata eGuide**. In. Ottawa: Canadian Centre on Substance Abuse. Available from URL: http://www.ccsa.ca/2004 CCSA Documents/ccsa-005363-2004.pdf. Accessible 11 October 2012; 2005.

22. WHO: **International classification of diseases. 10th revision**. Geneva, Switzerland: WHO; 1980.

23. Stockwell T, Zhao J, Chikritzhs T, Greenfield TK: **What did you drink yesterday? Public health relevance of a recent recall method used in the 2004 Australian National Drug Strategy Household Survey**. *Addiction* 2008, **103**(6):919-928.

24. Buxton J, Stockwell T: **Tracking trends of alcohol, illicit drugs and tobacco use through morbidity data**. *Contemporary Drug Problems* 2009, **36**(3&4):13.

25. Lilienfeld DE, Stolley PD: **Foundations of epidemiology**, 3 edn. Oxford: Oxford University Press; 1994.

26. BC Stats: **Population Estimates**. In.: BC Stats. Available from URL: http://www.bcstats.gov.bc.ca/StatisticsBySubject/Demography/PopulationEstimates.aspx. Accessible 1 April 2012; 2012.

27. BC Stats: **Local Health Area Boundaries**. In., April 1, 2007 edn: BCGOV LCS BCStats. Available from URL: https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=49698&recordSet=ISO19115. Accessible 1 April 2012; 2007.

28. Stockwell T, Zhao J, Macdonald S, Pakula B, Gruenewald P, Holder H: **Changes in per capita alcohol sales during the partial privatization of British Columbia's retail alcohol monopoly 2003-2008: a multi-level local area analysis**. *Addiction* 2009, **104**(11):1827-1836.

29. Stockwell T, Zhao JH, Macdonald S, Vallance K, Gruenewald P, Ponicki W, Holder H, Treno A: **Impact on alcohol-related mortality of a rapid rise in the density of private liquor outlets in British Columbia: a local area multi-level analysis**. *Addiction* 2011, **106**(4):768-776.

30. Laird NM, Ware JH: **Random-Effects Models for Longitudinal Data**. *Biometrics* 1982, **38**(4):963-974.

31. SAS Institute: **SAS/STAT 9.3 user's guide**. Cary, NC: SAS Institute Inc. ; 2011.

32. Ludbrook A, Petrie D, McKenzie L, Farrar S: **Tackling alcohol misuse: purchasing patterns affected by minimum pricing for alcohol**. *Appl Health Econ Health Policy* 2012, **10**(1):51-63.

Appendix A

ICD-10 codes used to define alcohol attributable conditions	
Acute alcohol attributable conditions	**ICD-10 Code**
Unintentional injuries	
Motor vehicle accidents	V21-V892
Poisonings	X40-X49
Accidental poisoning & exposure to alcohol	X45
Falls	W00-W19
Fires	X00-X09
Drowning	W65-W74
Other unintentional injuries	Rest of V & W20-W64, W75-W99, X10-X39, X50-X59, Y40-Y86, Y88, Y89
Intentional injuries	
Self-inflicted injuries	X60-X84, Y87.0
Homicide	X85-Y09,Y87.1
Intentional self-poisoning by and exposure to alcohol	X65
Other intentional injuries	Y35
Chronic alcohol attributable conditions	
Malignant neoplasms	
Oropharyngeal cancer	C00-C14
Oesophageal cancer	C15
Liver cancer	C22
Laryngeal cancer	C32
Breast cancer	C50
Other neoplasm	D00-D48
Diabetes mellitus	E10-E14
Neuro-psychiatric conditions	
Alcoholic psychoses*	F10.0, F10.3-F10.9
Alcoholic dependence syndrome*	F10.2
Alcohol abuse*	F10.1
Unipolar major depression	F32-F33
Degeneration of nervous system due to alcohol*	F31.2
Epilepsy	G40-G41
Alcoholic polyneuropathy*	G62.1
Cardiovascular diseases	
Hypertensive disease	I10-I15
Ischaemic heart disease	I20-I25
Alcoholic cardiomyopathy*	I42.6
Cardiac arrhythmias	I47-I49
Heart failure & ill-defined complications of heart disease	I50-I52, I23, I25.0,I97.0,I97.1,I98.1
Cerebrovascular disease	I60-I69
Ischaemic stroke	I60-I62
Haemorrhagic stroke	I63-I66
Oesophageal varices	I85
Digestive diseases	
Alcoholic gastritis*	K29.2
Cirrhosis of the liver	K70,K74
Cholelithiasis	K80
Acute & chronic pancreatitis	K85,K86.1
Chronic pancreatitis (alcohol induced)*	K86.0
Skin diseases	
Psoriasis	L40
Conditions arising during the perinatal period (maternal use)	
Low birth weight & short gestation	P05-P07
Foetal alcohol syndrome (dysmorphic)*	Q86.0
Excess alcohol blood level*	R78.0
*Ethanol & methanol toxicity, undetermined intent**	Y15

*Conditions which are 100% alcohol attributable