Meta-analysis shows that binge drinking, but not over guideline drinking, has increased substantially from 1996 to 2013 in Canada

Running head: Binge drinking in Canada 1996-2013

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ABSTRACT

Background: Heavy drinking is a major factor in worldwide morbidity and mortality. Little information is available on trends in Canada regarding alcohol abuse and here we performed meta-analyses to estimate abstinence, binge drinking and over guideline drinking in the Canadian population during 1996-2013.

Methods: The data sources were a series of cross sectional national health surveys of the Canadian population carried out by Statistics Canada during 1996-2013. These were cross-sectional files from the National Population Health Surveys (NPHS) of 1996 and 1998, plus the Canadian Community Health Surveys (CCHS) from 2000 to 2013; the respondents were 18 years and older.

Results: The proportion of binge drinkers increased steadily from 13.7% (95% confidence interval [CI], 13.2-14.2%) in 1996 to 19.7% (CI 19.1-20.3%) in 2013. In terms of gender the corresponding proportions for males were 20.8% (CI 19.9-21.7%) in 1996, and 25.7% (CI 24.7-26.6%) in 2013; for females these proportions were 6.9% (6.4-7.5%) in 1996, and 13.8% (CI 13.1-14.5%) in 2013. No significant increases were observed in the proportion of over guideline drinkers or abstainers during the same time period.

Interpretation: The proportion of binge drinkers in the Canadian population has steadily increased during the period of 1996 to 2013, relatively more so in females than males. No evidence of an increase in the proportion of over guideline drinkers or abstainers was observed during the same time period. These results suggest that binge drinking is of particular concern regarding intervention strategies aimed at improvement of public health.

Introduction

Abuse of alcohol contributes substantially to morbidity and mortality worldwide. For example, on a global basis, alcohol is estimated to cause 4.6% of disability adjusted-life years lost and 3.8% of all deaths [1]. Alcohol abuse is associated with liver cirrhosis, cardiovascular disease, diabetes, psychiatric disorders, cancer and significant social problems [2,3] as well as increased risk of suicide ideation and suicide attempts [4,5]. Intervention strategies at improving public heath require sound epidemiological data on alcohol use over time, this being the goal of the current study of the Canadian general population.

Binge drinking is known to be a particularly dangerous form of alcohol abuse [6]. One of the first population estimates of binge drinking was for American college students [7], although the definition of binge drinking can be traced back at least to 1969 [8]. This measure is not without its critics, for example blood alcohol content may be a more sensitive measure of problem drinking [9], although not a practical approach in epidemiological surveys.

Previous studies have estimated the prevalence of binge drinking in a number of countries. There has been a tendency to focus on alcohol abuse in children and adolescents [10, 11] and college students [12], however binge drinking is also an adult problem and can extend into later years [13]. A study of Chinese adults living in Hong Kong reported a 9.0% prevalence of binge drinking [14], whereas a corresponding estimate for Brazilians is 11.4% [15] and for Africans it is 9.6% [16]. In the USA an older study of data from 19 states showed that the prevalence of binge drinking decreased from 16.9% in 1985 to 13.6% in 1999

[17]. However in more recent large nationally representative survey of adults in the USA binge drinking was found to have increased from 21.5% to 25.8% between 2001-2002 and 2012-2013 [18]. In all studies the prevalence of binge drinking is higher in men than women, and highest in young age groups. The goal of the present study was to estimate binge and over guideline drinking in the Canadian population by meta-analysis of data from multiple health surveys over the period from 1996 to 2013. Meta-regression was then used to examine trends over time.

Methods

This study used the cross-sectional data files collected in two early cycles of the NPHS (1996 and 1998), the general health surveys of the CCHS (2000, 2003, 2005, 2007/2008, 2009/2010, 2011/2012 and 2013), plus the two mental health CCHS surveys of 2002 (CCHS 1.2) and 2012 (CCHS-MH) (Table 1). These surveys used a complex multistage sampling procedure to obtain a representative sample of the Canadian population. First geographical clusters were selected, then households were selected within the clusters and finally one respondent per household was selected.

Alcohol consumption was measured by estimating several variables in the Alcohol Module. Abstainers were identified based on the results of one question "During the past 12 months, have you had a drink of beer, wine, liquor or any other alcoholic beverage?" For above guideline drinking a 7-day diary of alcohol consumption was used to identify respondents who exceeded moderate guideline drinking (14 and 9 drinks per week for men and women respectively) [19]. Finally binge drinking was defined as consumption of five or more drinks at least once a

month in the past year, the usual definition of binge drinking used in Statistics Canada surveys.

Variables included as potential confounders and effect modifiers included age and gender. Although data is available for 12-17 year olds, the data presented here are for 18+ years old only, i.e., those of minimum legal drinking age in most Canadian provinces.

We initially examined the data with forest plots of frequency estimates with 95% confidence intervals for each survey (these plots are not shown). Appropriate sampling weights and bootstrap variance estimation procedures were employed as recommended by Statistics Canada. Heterogeneity was first examined using the I^2 statistic that represents the residual variation due to heterogeneity. Subsequently random effects meta-regression was used to quantify changes over time (i.e., time was a variable included in the models) and to adjust for study level co-variates. These results are shown as graphs. Goodness of fit was assessed by the associated I^2 value and the R^2 value (proportion of between study variance explained). These analyses used the "metan" command in Stata version 13 and were conducted in the Prairie Regional Data Centre of Statistics Canada at the University of Calgary. This research was approved by the Ethics Review Board of the University of Calgary.

Results

The surveys used in the current study and the total number of available observations are shown in Table 1. As is typical of Statistics Canada surveys missing data were minimal (<2%).

Inspection of the raw data for binge drinking shows an increase from 1996 to 2013 from 13.7% (95% CI 13.2-14.2) to 19.7% (95% CI 19.1-20.3) overall. As expected the proportion of male binge drinkers was higher than that for females, the increase for males being from 20.8% (95% CI 19.9-21.7) to 25.7% (24.7-26.6), whereas as for females it was from 6.9% (95% CI 6.4-7.5) to 13.8% (95% CI 13.1-14.5). A preliminary inspection of a forest plot (not shown) gave a visual impression that the proportion of male and female binge drinkers increased from 1996 to 2013 in a linear fashion, the I^2 values being 95.2% and 97.8% respectively. The linear meta-regression model shown in Figure 1 shows a very good visual fit for both males and females whose fitted lines appear to be parallel, the fit being better for females than males. This visual impression is supported by a lower I^2 values of 90.2% and 83.7% for males and females, the R^2 values being 57.6% and 91.6% for males and females respectively. Time was significant in the models for both males (beta =0.003, t = 3.49, p = 0.007) and females (beta = 0.003, t = 8.99, p < 0.001). It is notable that the slope values (beta values) are the same for males and females which confirms the visual impression that the two fitted lines are parallel.

Inspection of the raw data and a forest plot (not shown) for above guideline drinking showed no clear trend between 1996 and 2013 (Figure 2). The overall proportion of above guideline drinkers in 1996 and 2013 was 5.3% (95% CI 4.9-5.6) and 4.9% (95% CI 4.6-5.2) respectively. Again as expected the proportion of males was greater than that of females, the proportions in 2013, for example, being 5.9% (5.5-6.3) for males and 3.9% (95% CI, 3.5-4.3) for females. Compared to the binge drinking data, the above guideline data showed surprising heterogeneity, for example note the relatively low values for males in 2007/2008

and 2013 (Figure 2). Also as expected linear meta-regression models for both males and females showed poor fits, time was not significant, I^2 values were > 97% and R^2 values were negative.

The raw data and forest plot (not shown) for abstainers from 1996 to 2013 was dissimilar to both of the binge and above guideline data and suggestive of a curvilinear trend. The prevalence data appears to decrease from 1996 to about 2005-2006 and increase thereafter (Fig 3). The overall proportion of abstainers in 1996 and 2013 was 22.4% (95% CI 21.8-23.1) and 20.3% (19.7-20.9). Abstinence was higher in females, for example the proportions in 2013 were 24.6% (95% CI 23.7-25.6) for females and 15.8% (95% CI 15.0-16.7) for males. As expected linear meta-regression models showed poor fits for both genders, I^2 and R^2 values being >90% and <20%. However addition of a time squared variable to the model gave a very good visual fit for both genders (Figure 3). This visual impression is supported by the statistics, the I^2 values decreasing to 79.4 % and 86.4% for males and females. Also the R^2 values increased to 55.4% and 52.8% for males and females respectively. Time was significant in the models for both males (beta = -0.005, t = -3.08, p = 0.018) and females (beta = -0.008, t = -2.81, p = 0.026). Time squared was significant for males (beta = 0.0003, t = 2.73, p = 0.030), but was not significant for females (beta = 0.0003, t = 2.32, p = 0.053).

Interpretation

A clear linear increase in binge drinking by both males and females was observed from 1996 to 2013 (Figure 1). Visual impressions of these linear trends were confirmed by the statistics accompanying the linear meta-regression analyses in

which time was highly significant. Residual heterogeneity was higher in males than females as apparent in the graphs (Figure 1). Another visual impression that the fitted regression lines are parallel for males and females is confirmed by the slope coefficients (beta values) that were the same. In contrast to the binge drinking data the above guideline data was highly heterogeneous and showed no clear trend with time (Figure 2). It is unknown, for example, why the estimates for males in 2007/2008 and 2013 were low and close to those for females in these surveys. Attempts to fit linear meta-regression models were unsuccessful as expected. In terms of abstainers, prevalence estimates showed an apparent curvilinear trend (Figure 3) and quadratic equations with a time squared variable gave very good visual fits and time was significant for both genders. Time squared was significant for men (p=0.030) but not for women (p=0.053). Based on these statistics we conclude there is suggestive, but not conclusive, evidence that favors a quadratic model, with abstinence levels dipping to a low in 2005-2006 and increasing thereafter. To summarize our data, the prevalence binge drinking has increased steadily from 1996 to 2013 from about 14% to 20% overall. The prevalence of above guideline drinking was about 5-8% during this period with no clear trend over time. Abstinence may have reached a low point in 2005 – 2006 and was in the range of 18-22% during 1996 to 2013.

Our data on estimates of the prevalence of binge drinking are somewhat lower than two estimates for the USA that overlap our study period. In two large nationally representative survey of adults in the USA binge drinking was found to have increased from 21.5% to 25.8% between 2001-2002 and 2012-2013 [18]. Our estimates for 2002 and 2013 were 17.0% and 19.7%. Given the many

similar socioeconomic factors in common between Canada and the USA it would be expected that the extent of binge drinking would be similar in the two countries, and the closeness of the estimates helps to reaffirm their probable accuracy. Also the increase of binge drinking in the USA is apparently part of a longer trend since earlier estimates for 1991 and 2001 (combined) were in the 14.7-21.6% range [20]. Our data are also in line with estimates of increased binge drinking in England from 2001 to 2009 which rose from a prevalence of 21.7% to 37.9 % during this period [21]. It should be noted that UK definition of binge drinking is 8/6 drinks (males/females) on the heaviest drinking day of the past week. So although direct comparison of binge drinking prevalence in Canada/USA to the UK is difficult, all 3 countries showed a steady increase in overlapping time periods. In contrast to Canada, the USA and the UK, estimates of binge drinking prevalence in Africa, Brazil, and Hong Kong are much lower in the 9-12 % range (see Introduction). Whether these lower values are underestimates for these nations is unknown. It has been observed that binge drinking is subject to age, period and cohort effects [22], factors beyond the scope of the present study.

In Canada alcohol abuse is monitored by the Canadian Alcohol and Drug Use Monitoring Survey (CADUMS) since 2008 [23]. This survey uses its own definitions of at risk drinking and does not report binge drinking using the 5 drink measure as such. We used the original data from the Public Use files and estimate the prevalence of binge drinking in 2008 and 2012 to be 16.7% (CI 15.5-17.9%) and 14.8% (CI 13.6-16.2%) respectively, with no evidence of a trend during this period. Inspection of our data shows an apparent increase in prevalence in females, but not males, during 2008-2012 (Fig 1). Our period of data collection

(18 years) is much longer than the CADUMS (6 years), and has the capability to reveal longer term trends. Another difference between these studies is that the CADUMS population was 15+ whereas we used 18+.

Limitations

Limitations of the study lie in its reliance of self- report with no independent measures, for example, of blood alcohol concentration. Limitations of the five drink definition of binge drinking were discussed in the Introduction.

Strengths

We were able to examine drinking trends over an unusually long study period of 18 years (1996-2013). This was made possible by a meta-analysis of eleven Statistics Canada health surveys during this period. Another strength is the large sample sizes (ranging from about 14,000 to 120,000 over the 11 surveys). Further the surveys used consistent questions to determine alcohol use.

Conclusion

That one fifth of the Canadian population are currently binge drinkers is of considerable concern for public health and provides data for evidence based health regulations and policies. Binge drinking is known to be a particularly dangerous form of alcohol abuse that is strongly related to myocardial infarction, unsafe sex, violence and injuries [6]. A number of focused interventions and public health policies have been implemented [2], but the observed steady increase of binge drinking poses a major challenge for current and future public health provision.

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Contributors: Ms Williams and Ms Lavorato conducted the statistical analyses. The first draft of the paper was written by Dr Bulloch. Dr Patten, Ms Williams and Ms Lavorato provided critical feedback on drafts of the paper. Dr Patten was the primary investigator, and Dr Bulloch was co-investigator, on the

grant from CIHR. All authors have read and approved the final version of the paper and have agreed to its submission and publication.

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Disclaimer: The authors have no conflicts of interest regarding the integrity of the reported findings. This research and analysis were based on data from Statistics Canada, but the opinions expressed do not represent the views of Statistics Canada.

Survey	Respondents 18+ years
NPHS 1996	68,282
NPHS 1998	14,150
CCHS 1.1 (2000)	118,336
CCHS 1.2 (2002)	35,236
CCHS 2.1 (2003)	121,300
CCHS 3.1 (2005)	120,559
CCHS 2007/2008	120,838
CCHS 2009/2010	113,796
CCHS 2011/2012	115,131
CCHS 2012 Mental Health	23,846
CCHS 2013	59,224

Table 1. Sample size availability from NPHS and CCHS surveys

Figure 1: estimated proportion of binge drinking by gender 1996 to 2013. Men (upper), women (lower).

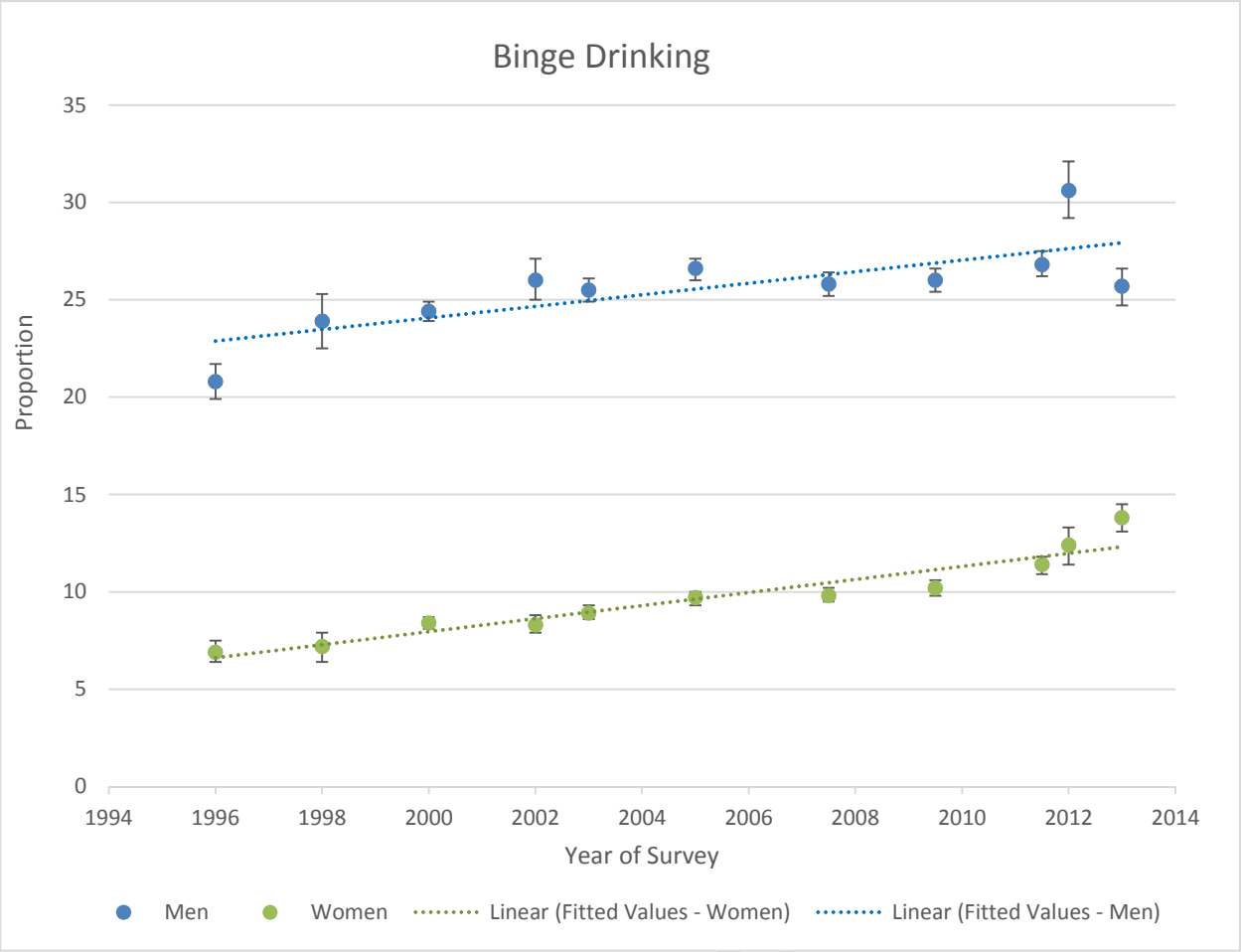


Figure 2: estimated proportion of over guideline drinking by gender 1996 to 2013. Men (upper), women (lower).

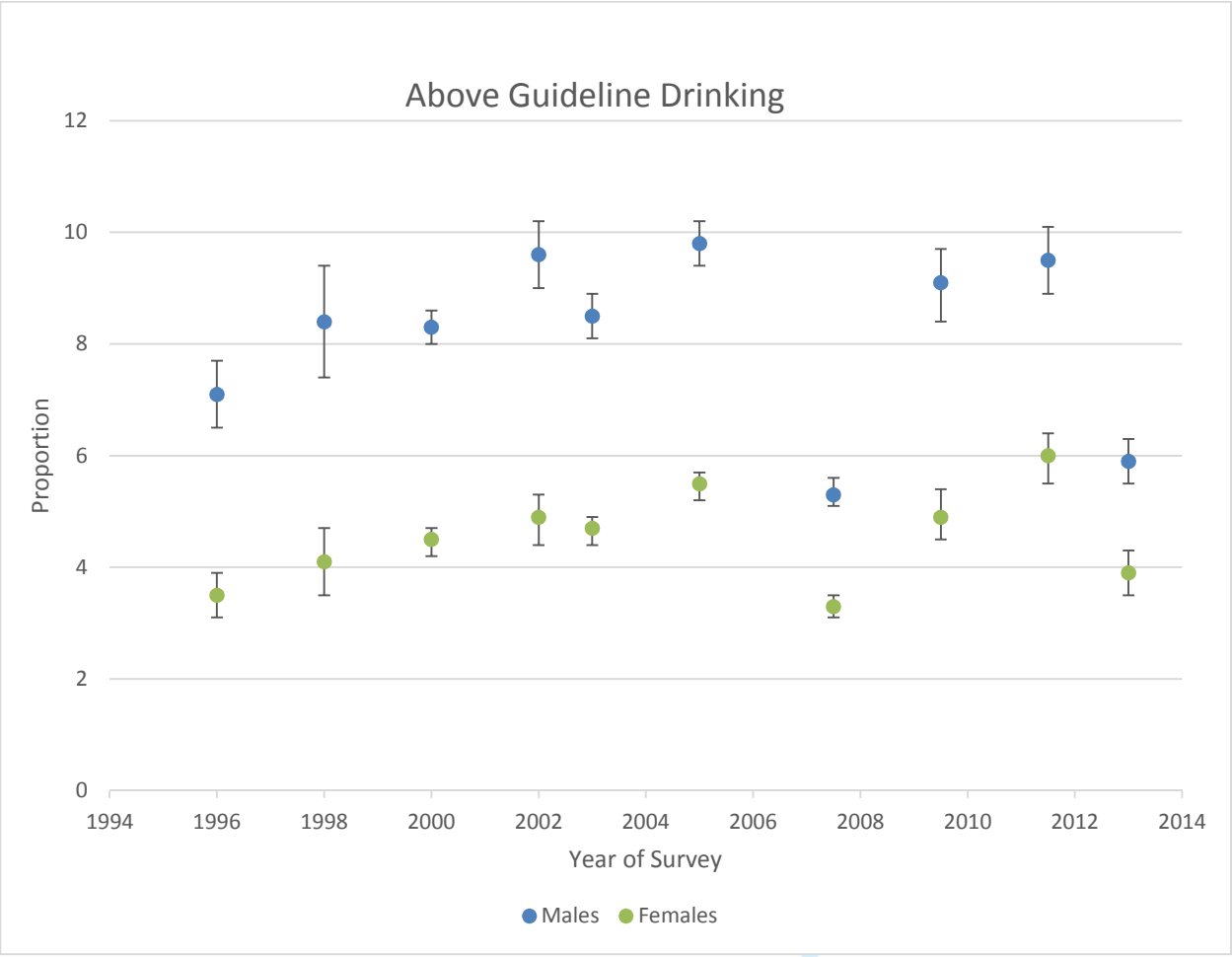
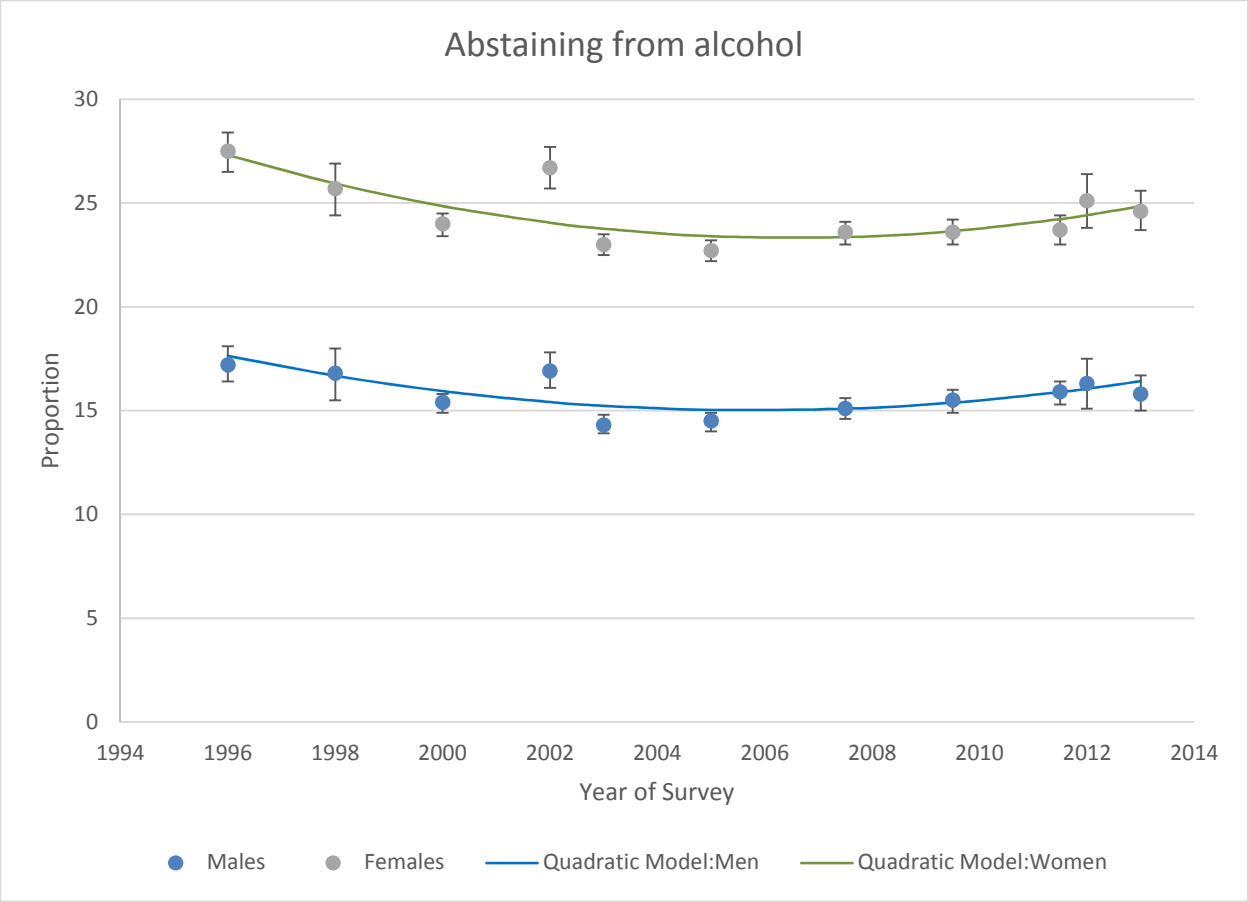


Figure 3: estimated proportion of abstaining by gender 1996 to 2013. Men (lower), women (upper).



PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3-4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Methods
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	N/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	N/a
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	N/a
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4-5
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	N/a
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	5
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/a
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	5
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. (Table 1)	5
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. (Table 1)	5
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	5-7
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	5-7
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/a
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	5-7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	10
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	13

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097