Alcohol and Alcoholism Vol. 48, No. 6, pp. 729–736, 2013
Advance Access Publication 5 July 2013
doi: 10.1093/alcalc/agt066

ORIGINAL ARTICLE

Alcohol-Attributable Mortality and Years of Potential Life Lost in Chile in 2009

Álvaro Castillo-Carniglia[1,2,*], Jay S. Kaufman[3] and Paulina Pino[4]

[1]Doctoral Program in Public Health, University of Chile, Santiago, Chile, [2]Research Department, National Service for Prevention and Rehabilitation of Drug and Alcohol (SENDA), Santiago, Chile, [3]Department of Epidemiology, Biostatistics and Occupational Health, McGill University, Montreal, Canada and [4]Epidemiology Division, School of Public Health, University of Chile, Santiago, Chile

*Corresponding author: School of Public Health, University of Chile, Av. Independencia 939, Santiago, Chile. Tel.: +52-2-25100879; E-mail: alvacasti@gmail.com

(*Received* 29 *October* 2012; *first review notified* 30 *March* 2013; *in revised form* 10 *June* 2013; *accepted* 12 *June* 2013)

Abstract — Aims: The aim of the study was to estimate mortality and years of potential life lost (YPLL) attributable to alcohol consumption in 2009 in Chile. **Methods:** The population considered for this study included those 15 years and over. Exposure to alcohol in the population was estimated by triangulating the records of alcohol per capita consumption in Chile with information from the Eighth National Study of Drugs in the General Population (2008). The effect of alcohol consumption on each cause of death (relative risk) was extracted from previously published meta-analyses. With this information we estimated the alcohol-attributable fraction (AAF) and deaths and YPLL due to alcohol consumption. The confidence intervals for the AAF were estimated with Monte Carlo sampling using the estimated variances of the exposure prevalence and relative effect. **Results:** The estimated total number of deaths attributable to alcohol consumption was 8753 (95% CI: 6257, 11,584) corresponding to 9.8% (95% CI: 7.01%, 12.98%) of all deaths in Chile in 2009. The total estimated YPLL attributable to alcohol were 195,475 (95% CI: 164,287, 227,726), corresponding to 21.5% (95% CI: 18.1%, 25.0%) of total YPLL for that year in Chile. **Conclusion:** Alcohol consumption is a major risk factor and accounts for nearly one of ten deaths in Chile. These results may be used to guide the design of public health policies and evaluations.

BACKGROUND

Alcohol consumption is a global public health problem and is a major cause of morbidity and mortality worldwide (World Health Organization, 2011). According to the World Report on Alcohol and Health of the World Health Organization, alcohol causes about 2.5 million deaths each year and 4.5% of the global burden of disease (World Health Organization, 2011). Many causes of death have been related to alcohol consumption. Among these, there are diseases where alcohol is a necessary cause, which the literature has defined as 'wholly attributable to alcohol' (Rehm *et al*., 2010d). For other diseases, alcohol consumption is a sufficient component cause, meaning that these are diseases that are causally affected by alcohol but for which alcohol explains only some fraction of the events (Rehm *et al*., 2010d). In both cases, the estimation of alcohol-attributable mortality assumes that in the counterfactual scenario the proportion of deaths attributable to alcohol would be null (Steenland and Armstrong, 2006).

The relationship between consumption and the occurrence of a disease (and later death) depends on several factors, including the amount of alcohol consumed, the patterns of consumption and the quality of alcohol consumed (Rehm *et al.*, 2010b,d). The interaction of these elements becomes clear when we analyze the volume and temporal patterns of consumption in some countries. For example, in some Mediterranean countries where the volume of alcohol consumed is high, the prevalence of alcohol dependence is relatively low, which contrasts with other countries with similar amounts of alcohol consumed but with higher rates of dependence (Heath, 2009; World Health Organization, 2011). Health and social consequences associated with alcohol consumption depend not only on the level of consumption or the presence of hazardous patterns, but also on biological aspects of the drinker that could increase or decrease individual susceptibility (IARC, 2010; Linneberg *et al.*, 2010), or the possibility to prevent or treat alcohol-related health consequences (Sussman and Ames, 2008). In this sense, the effect of similar levels and patterns of consumption may have different results depending on economic development, and even within countries the results may vary based on racial, cultural and access to quality health-care differences (Mäkelä *et al.*, 1997; Maki and Martikainen, 2009; Nolasco *et al.*, 2009).

In Chile, the reported last month prevalence of any alcohol consumption in 2008 was 49.8% among people of 12–64 years, with the group between 19 and 34 reporting the highest percentage (60.8%). In terms of the long-term time trend, the last month prevalence increased from 1994 until 2002 (from 40.4 to 59.6%, the highest point of the trend) but then declined to current levels (Consejo Nacional para el Control de Estupefacientes, 2008). Regarding alcohol abuse, in the Eighth National Drug Survey (DSM-IV criteria), 10.5% of people who reported consumption in the past year have probable alcohol abuse, a percentage that doubles in people between 19 and 25 years (Consejo Nacional para el Control de Estupefacientes, 2008). In addition, in the Second National Health Survey of 2009, the prevalence of hazardous alcohol consumption (8 or more points in the Alcohol Use Disorders Identification Test (Gmel *et al*., 2005)) was 10.9% in the population over 15 years of age (Ministerio de Salud, 2009–2010).

Despite these conditions, there is still scarce information in Chile and other middle-income countries generally regarding the health and social consequences of alcohol consumption, which limits the development of policies and programs and their evaluation. Mortality has been a key indicator for different organizations, such as the Pan American Health Organization, the Inter-American Drug Abuse Control Commission and the Cooperation Program between Latin America and the European Union on Drug Policies. Nevertheless, only a few countries in the region have reported improvements in this field. For example, Argentina (Barriviera *et al*., 2012) has estimates of alcohol and other drug-attributable mortality, but the estimates in other countries only

consider causes completely attributable, which only explains a small fraction of the total alcohol burden.

In Chile there is a 2008 government study that analyzed alcohol mortality and burden of disease, but there are some issues that can be substantially improved. For example, there has been extensive publication in the past few years that summarizes the epidemiological evidence regarding the effect of alcohol consumption and mortality (see Table 2). Additionally, the 2008 study did not include some important causes of death related to alcohol such as tuberculosis, pneumonia, pancreatitis and laryngeal, colon, rectal and colorectal cancers. And it only included aggregated Latin American statistics for alcohol consumption instead of actual Chilean data (Ministerio de Salud, 2008).

The aim of the current study was to estimate the total mortality and years of potential life lost (YPLL) attributable to alcohol consumption, using the latest information available. With this article we expect to contribute to the generation of national policies based on evidence that show the health impact of alcohol consumption in a middle-income country such as Chile.

METHODS

Population

We use as the reference population for this study people 15 years of age and over, based on the information available for alcohol per capita consumption in Chile. For 2009, this corresponds to 13,066,251 people (Instituto Nacional de Estadísticas, 2010).

Estimated volume of alcohol consumption in Chile

To determine the level of alcohol exposure, four categories of volume in grams per day of ethanol for men and women were constructed (see Table 1). It has been suggested that the best source of information for the population consumption is the volume of alcohol per capita estimated from statistics of production, imports and exports in each country, plus an estimate of unrecorded alcohol or alcohol produced outside of the legal system (Rehm *et al.*, 2005, 2010a) available at the Global Information System on Alcohol and Health of the World Health Organization for the population ages 15 and over (Rehm *et al*., 2007b). However, this information is only available at the national level as a per capita average consumption (in Chile, 8.81 l per capita of pure alcohol estimated for 2008), which prevents us from knowing the distribution by sex or age of the volume consumed (World Health Organization, 2013). Thus, to estimate this distribution we used the Eighth National Drug Survey in General Population (NDS-VIII).

Table 1. Average consumption of pure alcohol (g) per day for men and women according to consumption categories

	Women	Men
Abstinence	0 g/day	0 g/day
Category 1	0.1–19.9 g/day	0.1–39.9 g/day
Category 2	20–39.9 g/day	40–59.9 g/day
Category 3	≥40 g/day	≥60 g/day

The NDS-VIII has been conducted every 2 years since 1994, and it represents the urban population (communities >30,000 inhabitants) between 12 and 65 years of age at the national and regional levels. This is a three stage randomly sampled study, with face-to-face interviews carried out on

Table 2. Causes related to alcohol consumption and corresponding ICD-10 codes

Causes	ICD-10 codes
Causes wholly attributable to alcohol (AAF = 1)	
Alcoholic cardiomyopathy	I426
Alcoholic gastritis	K292
Alcohol-induced chronic pancreatitis	K860
Degeneration of nervous system due to alcohol	G312
Mental and behavioral disorders due to alcohol	F10
Alcohol polyneuropathy	G621
Intentional self-poisoning by and exposure to alcohol	X65
Accidental poisoning by and exposure to alcohol	X45
Poisoning by and exposure to alcohol, undetermined intent	Y15
Causes partially attributable to alcohol (AAF < 1)	
Cardiac arrhythmias (Samokhvalov *et al*., 2010a)	I48X
Ischemic stroke (Patra *et al*., 2010)	I60–I62
Hemorrhagic and other non-ischemic stroke (Patra *et al*., 2010)	I63–I66
Non-insulin-dependent diabetes mellitus (Baliunas *et al*., 2009)	E11
Hypertensive disease (Taylor *et al*., 2009)	I10–I15
Ischemic heart disease (Roerecke and Rehm, 2010; Roerecke *et al*., 2011)	I20–I25
Mouth and oropharynx cancers (Corrao *et al*., 2004)	C00–C14
Laryngeal cancer (Corrao *et al*., 2004)	C32
Esophageal cancer (Corrao *et al*., 2004)	C15
Breast cancer (Corrao *et al*., 2004)	C50
Liver cancer (Corrao *et al*., 2004)	C22
Colon cancer (Corrao *et al*., 2004)	C18
Rectal cancer (Corrao *et al*., 2004)	C20
Colorectal colorectal (Cruz *et al*., 2007)	C19X
Pneumonia (Samokhvalov *et al*., 2010b)	J12–J18
Tuberculosis (Lonnroth *et al*., 2008)	A15–A19
Cirrhosis of the liver (Rehm *et al*., 2010c)	K70, K74
Acute and chronic pancreatitis (Irving *et al*., 2009)	K85, K861
Epilepsy (Samokhvalov *et al*., 2010c)	G40–G41
Motor vehicle accidents (Taylor *et al.*, 2008, 2010)	–[a]
Accidental poisoning (Taylor *et al.*, 2008, 2010)	X40, X46–X49
Falls (Taylor *et al.*, 2008, 2010)	W00–W19
Fires (Taylor *et al.*, 2008, 2010)	X00–X09
Drowning (Taylor *et al.*, 2008, 2010)	W65–W74
Other Unintentional injuries (Taylor *et al.*, 2008, 2010)	–[b]
Self-inflicted injuries (Taylor *et al.*, 2008, 2010)	X60–X64, X66–X84, Y87.0
Homicide (Taylor *et al.*, 2008, 2010)	X85–Y09, Y87.1
Other intentional injuries (Taylor *et al.*, 2008, 2010)	Y35

[a]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.

[b]W20-W64, W 75-W99, X10-X39, X50-X59, Y40-Y86, Y88, Y89 and V series except for the codes listed in footnote a.

2008 and with a response rate of 77%. Methodological details and main results of the survey can be found elsewhere (Consejo Nacional para el Control de Estupefacientes, 2008). For the purposes of this article, we included only people between 15 and 65 years of the NDS-VIII, corresponding to 16,422 observations, of which 12,757 answered all the items used to estimate the daily volume of alcohol. Since the survey does not include those 65 years and over, we extrapolated the prevalence of the people between 60 and 65, to people of 65 and over. In the Second Chilean National Health Survey the weekly alcohol prevalence and volume observed in the group 45–64 years old were similar to the group of 65 and over, which supports the assumption we made with the NDS-VIII (Ministerio de Salud, 2009–2010).

To estimate the volume of alcohol consumption with the survey information we followed the method proposed by Stahre *et al*., which includes an adjustment for binge drinking (Stahre *et al*., 2006). To estimate the number of drinks from typical days of consumption we use the formula $V1_i = (F1_i - F2_i) \times Q_i$, where $V1$ is the number of days consumed in a typical month, $F1$ is the number of days in the last month with alcohol consumption, $F2$ is the number of days with binge drinking episodes (third item of the Alcohol Use Disorder Identification Test [AUDIT]) and Q is the amount of drinks consumed in a typical day (second item of AUDIT). The subscript i denotes each observation in the survey (i…12,757).

To consider the number of drinks from binge episodes we use the formula $V2_i = F2_i \times 6$. The sum of $V1$ and $V2$ divided by 30 is equal to the average number of drinks per day. This, multiplied by 13 or 16, depending on the assumption of alcohol per drink, is the volume of alcohol consumption per day, in grams (V_{survey}). For the triangulation of both sources, we use the following formula $V_{triangulated} = V_{survey} \times P$, where P is a weighting factor obtained from the inverse of the coverage rate of the survey. The coverage rate is the proportion of the per capita consumption, considering a 10% factor of spilled or wasted alcohol following the recommendation of Rehm *et al*., measured by the survey (Rehm *et al*., 2010a). In the case of NDS-VIII, this percentage ranged from 17.7%, when the content of a standard drink was defined as 13 g of pure alcohol, to 21.8% when 16 g were assumed as recommended by the Ministry of Health of Chile. The alcohol categories defined for the alcohol-attributable fraction (AAF) estimation are presented in Table 1 and were selected to be consistent with previous studies (Rehm *et al*., 2004; Grant *et al*., 2009).

Alcohol effect

The effect of alcohol consumption for each cause of death (relative risks for all causes except for tuberculosis, for which the pooled estimates were odds ratios) was provided by the Department of Social and Epidemiological Research of the Centre for Addiction and Mental Health (CAMH) in Canada. Each relative risk (RR) was estimated from the quantitative synthesis of available evidence and estimated as a function of risk for each cause of death, sex and volume of alcohol consumed (Table 2). Since in this article we follow a categorical approach for estimating the AAF, we extracted from the continuous RR function for each cause of death the median for each exposure category, except for category 3, where we used as a point estimate 1.5 times the amplitude of the previous range (70 g/day for women and 90 g/day for men) (Rehm *et al*., 2007a).

The criteria to select the causes of death were based on causal criteria of temporality, consistency, strength of the association and biological plausibility (Rehm *et al*., 2010d). The causes that included 'alcohol' or 'alcoholic' in their ICD-10 description were classified as wholly attributable to alcohol (AAF = 1). The partially attributable causes of death (AAF < 1), their respective ICD-10 codes and the source references of their RR's are presented in Table 2.

Estimating the AAF and 95% confidence intervals

The AAF was estimated for each cause of death and separately for men and women in four age categories (15–29, 30–44, 45–59 and 60 and over). The formula used for this was

$$\mathrm{AAF} = \frac{\sum_{i=0}^{k} p_i(\mathrm{RR}_i - 1)}{\sum_{i=0}^{k} p_i(\mathrm{RR}_i - 1) + 1}$$

where p is the prevalence for each category of alcohol consumption (i=0 ... 3) and RR_i is the relative risk for each level of exposure, relative to abstainers (0 = abstainers) (Fischer *et al*., 2005). This scheme was the same for all causes of death except for ischemic heart disease (IHD), which included the proportion of people who reported binge drinking in the past year, defined as the consumption of six or more drinks in one occasion. This was done because the relative risk for IHD has a J-shaped function. However when people have heavy episodes of alcohol consumption, even at moderate levels of average consumption, this function becomes linear (Roerecke *et al*., 2011).

YPLL were estimated using the formula $\sum_i^k$ (reference_age − age_at_death) with i to k being the number of deaths attributable to alcohol consumption in people equal or younger to the reference life expectancies at birth in Chile in 2005–2010, which is 75.5 years for men and 81.5 for women (Departamento de estadísticas e información de salud (DEIS)).

To estimate the 95% confidence intervals (95% CI) of the AAF we used the estimated standard errors (SE) of the prevalence and RR estimates. The SE of the prevalences were directly estimated from the database of the NDS-VIII considering the sample design of the survey. The SE of the RR were extracted from the log-transformed 95% confidence intervals available for each RR in the published literature. With this information, we used Monte Carlo sampling of 10,000 AAF for each cause of death and for each sex and age category, from which we extracted the median as a point estimate and the 2.5 and 97.5 percentiles as empirical confidence limits.

All analyses were conducted in Stata 11.2 (StataCorp, 2009).

RESULTS

Table 3 shows the crude and triangulated prevalences and the 95% confidence intervals for each category of alcohol consumption by age and sex. The prevalence of consumption is

Table 3. Crude and triangulated prevalence of alcohol consumption in Chile by age group, 2009

	15–29 years of age		30–44 years of age		45–59 years of age		60–65 years of age	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Crude prevalences								
Abstainers								
Men	25.0	(21.0–28.9)	20.9	(18.1–23.8)	30.0	(24.1–35.9)	38.0	(31.6–44.5)
Women	39.1	(34.8–43.4)	48.0	(44.1–51.8)	49.2	(44.6–53.7)	62.2	(54.9–69.4)
Category 1								
Men	73.9	(69.8–77.9)	77.8	(74.9–80.7)	67.8	(61.9–73.7)	59.9	(53.4–66.4)
Women	60.1	(55.8–64.4)	51.6	(47.8–55.4)	50.6	(46.1–55.2)	37.7	(30.5–45.0)
Category 2								
Men	0.9	(0.3–2.7)	0.9	(0.3–1.6)	1.0	(0.4–1.7)	0.2	(0.1–0.8)
Women	0.2	(0.0–0.5)	0.2	(0.0–0.4)	0.1	(0.0–0.2)	0.0	.
Category 3								
Men	0.3	(0.0–0.5)	0.3	(0.1–0.5)	1.2	(0.5–1.8)	1.8	(0.7–4.7)
Women	0.5	(0.0–1.1)	0.2	(0.0–0.4)	0.1	(0.0–0.3)	0.1	(0.0–0.7)
Triangulated prevalences								
Abstainers								
Men	25.0	(21.0–28.9)	20.9	(18.1–23.8)	30.0	(24.1–35.9)	38.0	(31.6–44.5)
Women	39.1	(34.8–43.4)	48.0	(44.1–51.8)	49.2	(44.6–53.7)	62.2	(54.9–69.4)
Category 1								
Men	49.3	(44.8–53.9)	56.9	(53.0–60.9)	50.9	(44.7–57.0)	44.3	(38.0–50.6)
Women	45.9	(41.0–50.9)	44.3	(40.3–48.2)	44.6	(39.8–49.4)	32.5	(25.2–39.9)
Category 2								
Men	12.0	(8.9–15.1)	10.2	(8.0–12.4)	9.1	(4.6–13.5)	6.3	(3.5–9.1)
Women	9.2	(6.8–11.5)	4.6	(3.2–6.0)	3.8	(2.6–5.1)	1.9	(0.8–3.1)
Category 3								
Men	13.8	(10.2–17.4)	12.0	(9.0–14.9)	10.1	(7.1–13.1)	11.4	(7.4–15.3)
Women	5.8	(4.3–7.3)	3.2	(2.1–4.4)	2.4	(1.6–3.1)	3.4	(1.2–5.5)

highest in men and generally follows a decreasing trend with age. In the highest category of consumption, relative differences between men and women increase, and they are more than four times higher in the group between 45 and 59 years of age.

The total number of deaths attributable to alcohol in Chile in 2009 was 8753 (95% CI: 6257–11,584) corresponding to 9.8% (95% CI: 7.01–12.98) of the total deaths in that year. Table 4 shows the number of deaths by cause, sex and age group. The largest number of attributable deaths occurred in men, mainly due to injury and cirrhosis. In the younger age groups in both men and women, self-inflicted injuries, traffic accidents and homicide contributed almost all of the deaths. In the older age groups deaths by cirrhosis were considerably more common, as were deaths from IHD, hypertension and some types of cancers. For diabetes in men and ischemic stroke in women there were 21 and 30 prevented deaths by alcohol consumption, respectively.

In terms of percentages, deaths attributable to alcohol showed a clear decrease with age and a significant difference between men and women (Fig. 1). For men between 15 and 29 years of age, alcohol-attributable deaths are almost 50% of all deaths in that group, almost entirely explained by traffic accidents and other intentional and accidental injuries.

Finally, total YPPLs attributable to alcohol were 195,475 (95% CI: 164,287–227,726), corresponding to 21.5% (95% CI: 18.1–25.0) of total YPLL for that year in Chile. When we stratified the results by gender, we found that men had the greatest number of YPLL with 167,300 (95% CI: 144,881–189,139), corresponding to 31.4% (95% CI: 27.2–35.5) of the total male YPLL, whereas women reached 28,175 (95% CI: 19,405–38,587), corresponding to 7.5% (95% CI: 5.1–10.2).

DISCUSSION

Alcohol-attributable deaths for 2009 in Chile totaled 8753, corresponding to 9.8% of all deaths for that year. The proportion of deaths was greater in men, especially in younger age groups. The cause of death that contributes the largest number of cases was cirrhosis, followed by self-inflicted injuries and motor vehicle accidents. These results confirm the great effect of alcohol consumption in Chile and the need to reinforce public health policies aimed at reducing alcohol consumption and its adverse consequences.

Comparing these results with those estimated for other countries, the percentage of alcohol-attributable deaths in Chile was higher than most of the other settings. Grant *et al*. estimated that 5% of all deaths in Scotland were attributable to alcohol (6.8% in men and 3.3% in women) and found that in young adults this estimate was 24% (Grant *et al*., 2009). Schneider *et al*. estimated that alcohol accounted for 7.1% the deaths in South Africa for 2000 (Schneider *et al*., 2007), while in the native population of Alaska the estimate came to 11.7% (Naimi *et al*., 2008). In South America, only Argentina has published estimates for alcohol-attributable deaths, which account for 2.6% of all deaths (Barriviera *et al*., 2012). Using a similar methodology to the one used in our study, Rehm and Monteiro found that 4.8% of all deaths in people of 15 years and over in the Americas were attributable to alcohol consumption in 2000 (Rehm and Monteiro, 2005), a bigger percentage than the 3.8% estimated worldwide (World Health Organization, 2009). Recently, Shield *et al*., following a similar methodology to that used in this article, estimated that 7.7% of deaths were attributable to alcohol in the population between 0 and 64 years of age in Canada (Shield *et al*.,

Table 4. Deaths attributable to alcohol consumption in Chile by sex and age group, 2009

	Men					Women					
	15–29 years	30–44 years	45–59 years	≥60 years	Men total	15–29 years	30–44 years	45–59 years	≥60 years	Women total	Row total
Cardiac arrhythmias	0	0	3	37	40	0	0	0	16	16	56
Hemorrhagic stroke	4	14	50	128	196	3	8	28	97	136	332
Ischemic stroke	0	0	0	2	3	0	−1	−2	−26	−30	−27
Diabetes mellitus	0	0	−3	−17	−21	0	0	−4	7	3	−18
Alcoholic cardiomyopathy	0	1	2	2	5	0	0	0	1	1	6
Hypertensive disease	1	4	16	192	213	0	1	3	121	125	338
Ischemic heart disease	1	9	45	131	186	0	2	20	295	317	503
Mouth and oropharynx cancers	0	1	12	39	51	0	0	1	7	9	60
Laryngeal cancer	0	0	6	37	44	0	0	0	1	2	46
Esophageal cancer	0	1	10	120	130	0	0	2	23	25	156
Breast cancer	0	0	0	0	0	1	7	26	51	85	85
Liver cancer	1	2	12	64	78	0	1	3	18	22	100
Colon cancer	0	1	3	19	24	0	0	1	7	9	33
Rectal cancer	0	0	3	15	18	0	0	1	4	5	23
Colorectal colorectal	0	2	2	10	13	0	0	0	1	1	15
Pneumonia	3	11	19	158	190	0	1	2	52	55	245
Tuberculosis	1	11	14	29	55	0	1	1	6	7	63
Cirrhosis of the liver	6	161	554	781	1501	3	15	55	165	238	1740
Alcoholic gastritis	0	1	3	1	5	0	0	0	0	0	5
Acute and chronic pancreatitis	1	5	8	26	40	0	0	0	4	5	45
Alcohol-induced chronic pancreatitis	0	0	0	0	0	0	0	0	0	0	0
Epilepsy	9	12	8	16	46	3	2	2	3	9	55
Degeneration of nervous system due to alcohol	0	1	4	15	20	0	0	0	5	5	25
Mental and behavioral disorders due to alcohol	0	44	87	92	223	0	0	6	13	19	242
Alcohol polyneuropathy	0	0	0	0	0	0	0	0	0	0	0
Motor vehicle accidents	235	253	245	214	947	20	10	8	17	55	1002
Intentional self-poisoning by and exposure to alcohol	0	0	1	0	1	0	0	0	0	0	1
Accidental poisoning by and exposure to alcohol	10	48	86	41	185	1	6	13	3	23	208
Poisoning by and exposure to alcohol, undetermined intent	0	0	0	0	0	0	0	0	0	0	0
Accidental poisoning	13	13	10	13	49	6	3	4	3	16	65
Falls	19	34	54	138	245	2	1	3	119	125	370
Fires	8	12	14	33	66	1	1	4	7	14	80
Drowning	75	57	61	42	235	3	4	4	4	15	250
Other unintentional injuries	102	139	169	238	647	12	13	16	59	100	747
Self-inflicted injuries	356	333	262	197	1148	71	51	41	17	180	1328
Homicide	245	163	87	41	536	15	11	7	4	37	573
Column total	1090	1331	1846	2855	7123	142	137	245	1103	1628	8750

2012a). Regarding the 2009 Chilean Burden of Disease Study, the number and percentage of deaths attributable to alcohol consumption were similar to our results. In that study, 8366 deaths, corresponding to 9.7% of all deaths in Chile in 2004, were attributed to alcohol (Ministerio de Salud, 2008).

However, not all studies are strictly comparable, so the differences in percentages do not necessarily respond to greater alcohol consumption in the population or the higher incidence of related deaths. First, there are differences in the populations included. For example, Shield *et al*. considered people between 0 and 64 years of age, Grant *et al*. included the population aged 16 and over, Schneider *et al*. population aged 15 and over, while the Argentinean study and the Chilean Burden of Disease Study considered all ages (Schneider *et al.*, 2007; Ministerio de Salud, 2008; Grant *et al.*, 2009; Barriviera *et al.*, 2012; Shield *et al.*, 2012a). This can be very important because there are causes that occur more frequently in some age groups, such as motor vehicle accidents, IHD or strokes, so truncating the lower or the upper age limit can significantly impact the final results. Also, there are methodological differences in the AAF estimates, for example modeling the alcohol exposure or including the RR as a continuous function (Shield *et al*., 2012a). Another element to consider is the set of causes of death included in the analysis. For example, the Argentinean study did not include epilepsy, some types of cancers or tuberculosis (Barriviera *et al*., 2012); the former Chilean study also did not consider tuberculosis, some types of cancers, pneumonia and pancreatitis, and Grant *et al*. included causes such as Cholelithiasis, Mallory–Weiss syndrome or Wernicke's encephalopathy in the estimation of alcohol-attributable mortality in Scotland, based primarily on clinical criteria (Grant *et al*., 2009). These last three causes are very rare in Chile, so they would make almost no difference in our estimates. Finally, in our study we included the RR from the latest meta-analysis available, which may not necessarily be the same used in other studies.

Another possible difference between countries is the system of classification of the causes of death or registration procedures and transcription on the death certificates. In Chile, the quality of mortality statistics was studied by Nuñes and Icaza, exploring the distribution of ill-defined causes (ICD-10 codes R00-R99) between 1997 and 2003. The authors found that

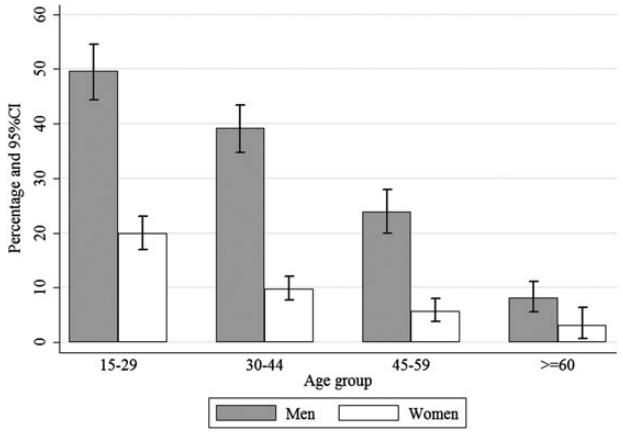

Fig. 1. Percentage and 95% CI of deaths attributable to alcohol consumption by age group and sex, Chile 2009

misdefined causes were strongly correlated with physician-diagnosed causes of death ($r = -0.98$), and this occurred mainly in rural areas and in deaths of people over 75 years of age. The authors concluded that the overall quality of Chilean mortality statistics is reasonably good and has improved over time (Núñez and Icaza, 2006).

Using the same methodology, the 2010 Global Burden of Disease study (GBD) estimated the burden of disease attributable to alcohol for almost 200 countries for 21 regions of the world, finding important differences between them. For example, in Chile >6% of total disability adjusted lost years (DALYs) were attributable to alcohol, while in countries with similar epidemiological and demographic profiles such as Uruguay, Cuba or Argentina this percentage is around 3 or 4%, similar to the estimates for Canada, the United States, Italy or Spain (Institute for Health Metrics and Evaluation, 2013). The GBD provides valuable information that can be compared across countries, but not necessarily with the results of other studies that have estimated the same indicators (Shield *et al*., 2012b). The reasons for this are diverse and beyond the scope of this article, but are related to methodological differences, the reference population used, data and year considered and the assumptions made to calculate the estimates (Watts and Cairncross, 2013).

There are several advances in our estimate in relation to the studies conducted in other countries. First, we incorporated into the estimates of AAF all the sampling variability in the RR and the prevalence of consumption. This allowed us to obtain a distribution of AAF for each cause, by sex and age group, from which we could estimate 95% confidence intervals. Second, we included the most recent information available on the effect of alcohol for each cause of death and exposure category. Finally, the inclusion of the proportion of people who reported binge episodes made it possible to incorporate information on the consumption pattern in the estimation of IHD, which corrected the overestimation of preventable deaths and gave more accurate estimation of attributable deaths.

Additional considerations

The triangulation of the volume of alcohol consumption using the method described in this article assumes that the coverage of the survey is equally distributed throughout the population, which is not necessarily true. Even though we have no reports on this in Chile, it is reasonable to hypothesize that there are groups, such as those with higher alcohol consumption (e.g. young people), which would tend to underestimate the amount and/or frequency of alcohol consumption more than subjects with low or moderate consumption (Shield *et al*., 2012c). Such difference in reporting could also be influenced by other factors such as age, sex or socioeconomic status. That could be particular important considering the low coverage rate of the survey used in our study and therefore the impact of triangulation in the estimates of the alcohol consumption prevalences. There are several possible explanations regarding this low coverage rate that has been discussed in previous studies. One is that the population covered by the household surveys like NDS-VIII, excluded heavy drinkers from the estimates (e.g. homeless or people in drug and alcohol treatment) affecting the general estimates (Mäkelä and Huhtanen, 2010). For example, in USA the top 20% of drinkers account for the 90% of the total alcohol consumed and in Switzerland the top 11% account for the 50% for the total reported alcohol consumption (Gmel and Rehm, 2004). Another explanation is that the questionnaire of the NDS-VIII might not be sensitive enough to provide accurate estimates of daily alcohol consumption. There are different instruments to quantify alcohol consumption which, for example, distinguish between type of alcohol beverage, week days from weekends or days with heavy drinking episodes from typical consumption days, observing significant differences between them (Gmel *et al*., 2006). Another hypothesis is that the mode of data collection (face-to-face in NDS-VIII compared with self-administered or telephone) differentially misclassifies the true level of alcohol consumption. Additionally, the exclusion of the rural population (13% in Chile) from the sample frame could also be consequential, despite the fact that there is no convincing evidence for Chile that indicates higher or lower consumption levels in either group (Ministerio de Salud, 2009–2010). Overall, the coverage rate for most surveys accounts for ~30 to –60% of the alcohol per capita estimates from sales statistics (Jansen *et al*., 2008).

Another point to note is that the causal effect estimates used are mainly from studies that were carried out in developed countries. The assumption behind this is that the effect of alcohol consumption can be extrapolated to the Chilean population, which is reasonable for those causes that are the result of prolonged exposure to alcohol, such as cirrhosis or cancer, but not necessarily with other causes such as motor vehicle accidents, as infrastructure standards and security policies of each country are different.

Limitations

This study did not include former alcohol consumers. This means that the overall death rate may be underestimated since the abstinent category includes a proportion of former drinkers whose prior exposure may have increased the risk for certain diseases. Unfortunately we have no information that allows us to estimate the volume consumed in the past. Another limitation is the availability of data on alcohol consumption. The NDS-VIII only includes people up to 65 years of age; thus we extrapolated the prevalence of the group between 60 and 65–65 and over. Finally, unlike other similar studies, we did not

include perinatal causes of death such as fetal alcohol syndrome or low birth weight, because we did not include the population of ages <15 years. The reasons for this decision were as follows: (a) statistics for per capita consumption were only available for population of 15 years and over and (b) the level of alcohol consumed during pregnancy and lactation—needed for estimating the AAF on perinatal causes—has not been measured in a nationally representative sample in Chile.

Implications

In Chile, the reduction of alcohol consumption is part of the 2011–2014 National Drug and Alcohol Strategy (Servicio Nacional para la Prevención y Rehabilitación de Drogas y Alcohol (SENDA), 2011), of the National Alcohol Strategy (Ministerio de Salud, 2010) and of the 2011–2020 National Health Strategy of the Ministry of Health (Ministerio de Salud, 2011). While each of these documents has a specific focus, the main goal is to decrease the burden of death and disease due to alcohol consumption. For this objective, there are specific actions designed to reduce alcohol consumption such as increased taxes, increases on alcoholic beverages and restricting the places and hours for selling. This is combined with strategies for prevention and early detection implemented in various settings, such as workplaces, schools, primary health center and police stations. Also, an amendment to the law that regulates alcohol and driving has recently been approved. This amendment includes lowering the criteria that define driving under the influence of alcohol and drunk driving from 0.5 to 0.3% blood alcohol concentration and 1.0 to 0.8%, respectively. Our method permits accurate assessment of alcohol consumption and its impact on mortality over time, which is necessary for the evaluation of such efforts.

CONCLUSIONS

Alcohol is responsible for 1 in 10 deaths in Chile and about 20% of total YPLL. These results confirm that alcohol is a major risk factor, especially in the young male population. These results can be used for the design of public policies based on evidence and as an indicator for retrospective evaluation of existing interventions and policies, which is especially relevant in the context of Latin America and other developing countries.

Acknowledgements — We thank Dr Jürgen Rehm and Gmel Gerrit from the Department of Social and Epidemiological Research of the Centre Addiction and Mental Health (Canada), for their valuable contribution on the design of this study and the information provided, Esteban Pizarro from the Research Department, National Service for Prevention and Rehabilitation of Drug and Alcohol (Chile) for his help on the statistical programing and Richard F. Maclehose from the Division of Epidemiology and Community Health and the Division of Biostatistics, University of Minnesota (USA) for his contribution in the planning.

AUTHORS' CONTRIBUTIONS

A.C.C., J.S.K. and P.P.Z. were involved in the design, interpretation of results and final revision of the article. A.C.C. performed the data analysis and wrote the manuscript.

Funding — This work was supported by the National Commission for Scientific and Technological Research of Chile (CONICYT). J.S.K. received support from the Canada Research Chairs program.

Conflict of interest statement. None declared.

REFERENCES

Baliunas DO, Taylor BJ, Irving H *et al*. (2009) Alcohol as a risk factor for type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care* **32**:2123–32.

Barriviera G, Sisti L, Ahumada G *et al*. (2012) Mortalidad relacionada al consumo de drogas en Argentina 2004–2010, Buenos Aires, Secretaría de Programación para la Prevención de la Drogadicción y la Lucha contra el Narcotráfico.

Consejo Nacional para el Control de Estupefacientes. (2008) Octavo Estudio Nacional de Drogas en Población General, Santiago, Chile.

Corrao G, Bagnardi V, Zambon A *et al*. (2004) A meta-analysis of alcohol consumption and the risk of 15 diseases. *Prev Med* **38**:613–9.

Cruz MF, Patra J, Fischer B *et al*. (2007) Public opinion towards supervised injection facilities and heroin-assisted treatment in Ontario, Canada. *Int J Drug Policy* **18**:54–61.

Departamento de estadísticas e información de salud (DEIS). *Esperanza de vida al nacer (en años) por periodo y sexo*. [Online]. Santiago: Ministerio de Salud. Available: http://deis.minsal.cl/deis/ev/esperanza_de_vida/index.asp (25 June 2012, date last accessed).

Fischer B, Rehm J, Brissette S *et al*. (2005) Illicit opioid use in Canada: comparing social, health, and drug use characteristics of untreated users in five cities (OPICAN study). *J Urban Health* **82**:250–66.

Gmel G, Rehm J. (2004) Measuring alcohol consumption. *Contemp Drug Probl* **31**:467–540.

Gmel G, Heeb JL, Rezny L *et al*. (2005) Drinking patterns and traffic casualties in Switzerland: matching survey data and police records to design preventive action. *Public Health* **119**:426–36.

Gmel G, Graham K, Kuendig H *et al*. (2006) Measuring alcohol consumption—should the 'graduated frequency' approach become the norm in survey research? *Addiction* **101**:16–30.

Grant I, Springbett A, Graham L. (2009) *Alcohol Attributable Mortality and Morbidity: Alcohol Population Attributable Fractions for Scotland*. Edinburgh: ISD Scotland Publications, NHS National Services Scotland.

Heath DB. (2009) History of drinking (international). In Korsmeyer P, Kranzler HR (eds). *Encyclopedia of Drugs, Alcohol, & Addictive Behavior*, 3rd edn. Farmington Hills, MI: Macmillan Reference.

IARC. (2010) *IARC Monographs on the Evaluation of Carcinogenic Risk to Humans. Alcohol Beverage Consumption and Ethyl Carbamate (urethane)*. Lyon: International Agency for Research on Cancer.

Institute for Health Metrics and Evaluation. (2013) Global Burden of Disease: Country Profiles [Online]. Seattle, WA. Available: http://www.healthmetricsandevaluation.org/gbd/country-profiles (20 April 2013, date last accessed).

Instituto Nacional de Estadísticas. (2010) Chile: estimaciones y proyecciones de la población. [Online]. Santiago. Available: http://deis.minsal.cl/deis/proyec/menprincok.xls (24 July 2011, date last accessed).

Irving HM, Samokhvalov AV, Rehm J. (2009) Alcohol as a risk factor for pancreatitis. A systematic review and meta-analysis. *JOP* **10**:387–92.

Jansen H, Lahaut V, Garretsen H *et al*. (2008) Measuring the year consumption of alcohol: the development of a questionnaire. *Subst Use Misuse* **43**:880–94.

Linneberg A, Gonzalez-Quintela A, Vidal C *et al*. (2010) Genetic determinants of both ethanol and acetaldehyde metabolism influence alcohol hypersensitivity and drinking behaviour among Scandinavians. *Clin Exp Allergy* **40**:123–30.

Lonnroth K, Williams BG, Stadlin S *et al*. (2008) Alcohol use as a risk factor for tuberculosis—a systematic review. *BMC Public Health* **8**:289.

Mäkelä P, Huhtanen P. (2010) The effect of survey sampling frame on coverage: the level of and changes in alcohol-related mortality in Finland as a test case. *Addiction* **105**:1935–41.
Mäkelä P, Valkonen T, Martelin T. (1997) Contribution of deaths related to alcohol use to socioeconomic variation in mortality: register based follow up study. *BMJ* **315**:211–6.
Maki N, Martikainen P. (2009) The role of socioeconomic indicators on non-alcohol and alcohol-associated suicide mortality among women in Finland. A register-based follow-up study of 12 million person-years. *Soc Sci Med* **68**:2161–9.
Ministerio de Salud. (2008) Estudio de carga de enfermedad y carga atribuible, Santiago, Pontificia Universidad Católica de Chile.
Ministerio de Salud. (2009–2010) Segunda Encuesta Nacional de Salud, Santiago, Subsecretaria de Salud Pública.
Ministerio de Salud. (2010) Estrategia Nacional sobre Alcohol: reducción del consumo de riesgo y sus consecuencias sociales y sanitarias, Santiago, Chile.
Ministerio de Salud. (2011) Estrategia Nacional de Salud: metas 2011–2020. Santiago, Chile.
Naimi TS, Cobb N, Boyd D *et al*. (2008) Alcohol-attributable deaths and years of potential life lost among American Indians and Alaska Natives: United States, 2001–2005. *MMWR* **57**:938–41.
Nolasco A, Melchor I, Pina JA *et al*. (2009) Preventable avoidable mortality: evolution of socioeconomic inequalities in urban areas in Spain, 1996–2003. *Health Place* **15**:702–11.
Núñez L, Icaza G. (2006) Calidad de las estadísticas de mortalidad en Chile, 1997–2003. *Rev Méd Chile* **134**:1191–6.
Patra J, Taylor B, Irving H *et al*. (2010) Alcohol consumption and the risk of morbidity and mortality for different stroke types—a systematic review and meta-analysis. *BMC Public Health* **10**:258.
Rehm J, Monteiro M. (2005) Alcohol consumption and burden of disease in the Americas: implications for alcohol policy. *Rev Panam Salud Publica* **18**:241–8.
Rehm J, Room R, Monteiro M *et al*. (2004) Alcohol use. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL (eds). *Comparative Quantification of Health Risks Global and Regional Burden of Disease Attributable to Selected Major Risk Factors*. Geneva: World Health Organization.
Rehm J, Room R, van den Brink W *et al*. (2005) Alcohol use disorders in EU countries and Norway: an overview of the epidemiology. *Eur Neuropsychopharmacol* **15**:377–88.
Rehm J, Sulkowska U, Manczuk M *et al*. (2007a) Alcohol accounts for a high proportion of premature mortality in central and eastern Europe. *Int J Epidemiol* **36**:458–67.
Rehm J, Klotsche J, Patra J. (2007b) Comparative quantification of alcohol exposure as risk factor for global burden of disease. *Int J Methods Psychiatr Res* **16**:66–76.
Rehm J, Kehoe T, Gmel G *et al*. (2010a) Statistical modeling of volume of alcohol exposure for epidemiological studies of population health: the US example. *Popul Health Metr* **8**:3.
Rehm J, Kanteres F, Lachenmeier DW. (2010b) Unrecorded consumption, quality of alcohol and health consequences. *Drug Alcohol Rev* **29**:426–36.
Rehm J, Taylor B, Mohapatra S *et al*. (2010c) Alcohol as a risk factor for liver cirrhosis: a systematic review and meta-analysis. *Drug Alcohol Rev* **29**:437–45.
Rehm J, Baliunas D, Borges GL *et al*. (2010d) The relation between different dimensions of alcohol consumption and burden of disease: an overview. *Addiction* **105**:817–43.
Roerecke M, Rehm J. (2010) Irregular heavy drinking occasions and risk of ischemic heart disease: a systematic review and meta-analysis. *Am J Epidemiol* **171**:633–44.
Roerecke M, Greenfield TK, Kerr WC *et al*. (2011) Heavy drinking occasions in relation to ischaemic heart disease mortality—an 11–22 year follow-up of the 1984 and 1995 US National Alcohol Surveys. *Int J Epidemiol* **40**:1401–10.
Samokhvalov AV, Irving HM, Rehm J. (2010a) Alcohol consumption as a risk factor for atrial fibrillation: a systematic review and meta-analysis. *Eur J Cardiovasc Prev Rehabil* **17**:706–12.
Samokhvalov AV, Irving HM, Rehm J. (2010b) Alcohol consumption as a risk factor for pneumonia: a systematic review and meta-analysis. *Epidemiol Infect* **138**:1789–95.
Samokhvalov AV, Irving H, Mohapatra S *et al*. (2010c) Alcohol consumption, unprovoked seizures, and epilepsy: a systematic review and meta-analysis. *Epilepsia* **51**:1177–84.
Schneider M, Norman R, Parry C *et al*. (2007) Estimating the burden of disease attributable to alcohol use in South Africa in 2000. *S Afr Med J* **97**:664–72.
Servicio Nacional para la Prevención y Rehabilitación de Drogas y Alcohol (SENDA). (2011) Estrategia Nacional de Drogas y Alcohol 2011–2014, Santiago.
Shield KD, Taylor B, Kehoe T *et al*. (2012a) Mortality and potential years of life lost attributable to alcohol consumption in Canada in 2005. *BMC Public Health* **12**:91.
Shield KD, Kehoe T, Taylor B *et al*. (2012b) Alcohol-attributable burden of disease and injury in Canada, 2004. *Int J Public Health* **57**:391–401.
Shield KD, Gmel G, Patra J *et al*. (2012c) Global burden of injuries attributable to alcohol consumption in 2004: a novel way of calculating the burden of injuries attributable to alcohol consumption. *Popul Health Metr* **10**:9.
Stahre M, Naimi T, Brewer R *et al*. (2006) Measuring average alcohol consumption: the impact of including binge drinks in quantity-frequency calculations. *Addiction* **101**:1711–8.
StataCorp (2009) *Stata Statistical Software: Release 11*. College Station, TX: StataCorp LP.
Steenland K, Armstrong B. (2006) An overview of methods for calculating the burden of disease due to specific risk factors. *Epidemiology* **17**:512–9.
Sussman S, Ames SL. (2008) *Drug abuse: concepts, prevention, and cessation*. New York: Cambridge University Press.
Taylor B, Rehm J, Room R *et al*. (2008) Determination of lifetime injury mortality risk in Canada in 2002 by drinking amount per occasion and number of occasions. *Am J Epidemiol* **168**:1119–25; discussion 1126–31.
Taylor B, Irving HM, Baliunas D *et al*. (2009) Alcohol and hypertension: gender differences in dose-response relationships determined through systematic review and meta-analysis. *Addiction* **104**:1981–90.
Taylor B, Irving HM, Kanteres F *et al*. (2010) The more you drink, the harder you fall: a systematic review and meta-analysis of how acute alcohol consumption and injury or collision risk increase together. *Drug Alcohol Depend* **110**:108–16.
Watts C, Cairncross S. (2013) Should the GBD risk factor rankings be used to guide policy? *Lancet* **380**:2060–61.
World Health Organization. (2009) *Global Health Risks. Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva, Switzerland: World Health Organization.
World Health Organization. (2011) *Global Status Report on Alcohol and Health*. Geneva: World Health Organization.
World Health Organization. (2013) Global Health Observatory Data Repository [Online]. Geneva. Available: http://apps.who.int/gho/data/node.main.A1035?Lang=en (01 April 2013, date last accessed).