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Alcohol-attributable mortality in Switzerland in 2011 – age-specific causes of death and impact of heavy versus non-heavy drinking

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Summary

BACKGROUND: Alcohol use causes high burden of disease and injury globally. Switzerland has a high consumption of alcohol, almost twice the global average. Alcohol-attributable deaths and years of life lost in Switzerland were estimated by age and sex for the year 2011. Additionally, the impact of heavy drinking (40+grams/day for women and 60+g/day for men) was estimated.

METHODS: Alcohol consumption estimates were based on the Addiction Monitoring in Switzerland study and were adjusted to *per capita consumption* based on sales data. Mortality data were taken from the Swiss mortality register. Methodology of the Comparative Risk Assessment for alcohol was used to estimate alcohol-attributable fractions.

RESULTS: Alcohol use caused 1,600 (95% CI: 1,472 – 1,728) net deaths (1,768 deaths caused, 168 deaths prevented) among 15 to 74 year olds, corresponding to 8.7% of all deaths (men: 1,181 deaths; women: 419 deaths). Overall, 42,627 years of life (9.7%, 95% CI: 40,245 – 45,008)

were lost due to alcohol. Main causes of alcohol-attributable mortality were injuries at younger ages (15–34 years), with increasing age digestive diseases (mainly liver cirrhosis) and cancers (particularly breast cancers among women). The majority (62%) of all alcohol-attributable deaths was caused by chronic heavy drinking (men: 67%; women: 48 %).

CONCLUSION: Alcohol is a major cause of premature mortality in Switzerland. Its impact, among young people mainly via injuries, among men mainly through heavy drinking, calls for a mix of preventive actions targeting chronic heavy drinking, binge drinking and mean consumption.

Key words: *alcohol; attributable fractions; heavy drinking; mortality; life years lost; injuries; chronic disease; Switzerland*

Introduction

Alcohol consumption is a major risk factor of avoidable burden of disease and injury. The Comparative Risk Assessment (CRA) within the Global Burden of Disease (GBD) Study 2010 [1] estimated it to be the fifth largest cause of burden of disease worldwide and the sixth largest cause in Western Europe [2]. Compared with earlier CRA estimates, methods for estimating alcohol-attributable mortality have been largely refined [2, 3]. The present study estimates alcohol-attributable mortality in Switzerland in detail with the newest available data in Switzerland for 2011, using the CRA methodology.

List of abbreviations:

AAF	Alcohol-attributable fraction
AMIS	Addiction Monitoring in Switzerland
CRA	Comparative Risk Assessment
GBD	Global Burden of Disease
HIV	Human Immunodeficiency Virus
ICD	International Classification of Diseases
IHD	Ischaemic Heart Disease
RR	Relative Risk
RSOD	Risky single occasion drinking
YLL	Years of life lost

Alcohol consumption has a long tradition in Switzerland and is common in many parts of life, resulting in a substantial alcohol consumption of 10.5 litres (recorded [4] and unrecorded [5, 6] of pure alcohol per adult (15+ years), almost twice of that worldwide (6.1 litres [7]), causing marked premature mortality each year. While there are about 30 ICD-10 [8] codes which are 100% alcohol-attributable (e.g. alcoholic liver disease or alcohol dependence syndrome), there are additionally about 200 causes that are partially attributable to alcohol use and for which alcohol-attributable fractions (AAF) can be estimated [9, 10] to quantify the proportion of disease and mortality caused by alcohol. The fraction attributable to alcohol does not only depend on the specific cause of death, but also on the alcohol consumption patterns (average volume and risky single occasion drinking (RSOD), defined as occasions with five or more standard drinks for men, respectively four or more for women) which vary across age and sex groups. Accordingly, alcohol-attributable mortality as well as the composition of different causes to the overall mortality vary between regions, e.g. one would expect a greater share of overall mortality due to acute causes such as injuries in regions with predominantly RSOD on weekends compared with countries where regular alcohol use is more integrated into everyday life, resulting in a higher share of chronic diseases.

For the average drinking amount per day, the risk curves for most chronic causes of death are exponential, so heavy drinking should cause a disproportionately high fraction of alcohol-attributable disease. One of the aims of this publication is to quantify the proportion of mortality caused by heavy drinking in Switzerland. This is important for theoretical reasons, as it will inform the discussion on the so-called Preventive Paradox [11, 12], which states that most of the harm due to alcohol is in drinkers who drink on average light to moderately. It is also important with respect to prevention, as it is relevant for choosing the most effective prevention strategy.

The World Health Organization stresses the importance of monitoring alcohol consumption and resulting harms and benefits at the country level in order to inform alcohol policies that serve individual country needs [13]. In Switzerland, there is a good availability of data to estimate alcohol consumption, and the corresponding causes contributing to the overall mortality, and can thus serve as an example for established market economies in Europe.

There are earlier estimates of alcohol-attributable mortality for Switzerland [5, 14, 15] but those estimates have become outdated, the last one using data from the year 2004. As noted above, the methods have received considerable updates; newer relative risk estimates from meta-analyses have been integrated [9], and mortality caused by some diseases, for example tuberculosis, have been shown to be causally attributable to alcohol and are now included in estimates of alcohol-attributable harm [16]. The Relative Risk (RR) functions are now handled continuously and the inclusion of binge drinking has been refined. Additionally, it is today also possible to integrate RR for former drinkers, as more data have become available. This is important because former drinkers are known to have risks that differ from those of drinkers and lifetime abstainers [e.g. 17].

Method

Definition of alcohol-attributable diseases and determination of alcohol-attributable fractions

The list of alcohol-attributable diseases and injuries (see supplementary Web-Appendix table A1) was adapted [9] from the Comparative Risk Assessment (CRA) for alcohol which is part of the Global Burden of Disease and Injury (GBD) 2010 study [1]. However, as Switzerland has a detailed death registry, some of the smaller causes of death categories 100% attributable to alcohol (e.g. alcoholic cardiomyopathy or alcoholic liver disease) could be used. While the results were calculated for all categories presented in Web Appendix table A1, for the sake of presentation some more refined causes were subsumed under broad categories of injuries, cancers, cardiovascular diseases, digestive diseases, mental disorders, and others (for category assignment see also supplementary Web-Appendix table A1). Although there are some causes which are 100% alcohol-attributable, and for which number of deaths and years of life lost (YLL) can be directly estimated from the mortality registry, most of the diseases and injuries are partially alcohol-attributable. For these diseases the Alcohol-Attributable-Fraction (AAF) methodology [18–20] was used.

The AAF represents the proportion of deaths that would not have occurred if a counterfactual scenario was true. The counterfactual scenario used in the present study and GBD was lifetime abstinence from alcohol. AAFs were calculated for every condition partially attributable to alcohol use, separately for both sexes and seven age categories.

$$AAF = \frac{P_{abs} + P_{former}RR_{former} + \int_{0+}^{150} P_{current}(x)RR_{current}(x)dx - 1}{P_{abs} + P_{former}RR_{former} + \int_{0+}^{150} P_{current}(x)RR_{current}(x)dx}$$

Formula 1: Alcohol-attributable fraction

As can be seen in formula 1, the AAF methodology needs four determinants: the prevalence of abstainers (P_{abs}), former (P_{former}) and current ($P_{current}$) (past 12 months) drinkers, and the relative risk functions at different levels of alcohol consumption volume ($RR_{current}(x)$). Basically, the formula weights the prevalence of drinking at different levels with the relative risk at the corresponding drinking level, compared with the counterfactual scenario. Negative AAF (e.g. for ischaemic heart disease (IHD)) can be interpreted as avoided deaths due to alcohol use. Uncertainty of the AAF was calculated using a method described by Gmel and colleagues [21], based on a Monte-Carlo simulation (see [22] for an introduction).

For three disease/injuries categories the AAF methodology had to be adapted. Firstly, for IHD, RSOD frequency was additionally considered, because the protective effect for IHD disappears for individuals with RSOD at least monthly [23, 24]. Therefore, RR for IHD were set to 1 for individuals with at least monthly RSOD (defined in the present study as 5+ and 4+ standard drinks on one occasion). Secondly, AAFs for mortality from human immun-

odeficiency virus (HIV) attributable to non-adherence to highly active anti-retroviral treatment were calculated using the method outlined by Gmel and colleagues [25]. This calculation does not use formula 1, but it is based on the proportion of HIV-patients in treatment and estimates the number of non-adherence to highly active anti-retroviral treatment and consequences due to alcohol consumption. Thirdly, the AAFs for injuries (separately for motor vehicle accidents and non-motor vehicle accidents) were calculated using the method outlined by Shield and colleagues [26], which takes different drinking patterns into account (average consumption and RSOD) that have also been shown to differentially impact injury risk in Switzerland [27].

Although we mostly followed the methodology of the comparative risk assessment in the GBD 2010 study, there were three significant differences. Firstly, the aim of GBD is to compare results across countries and different risk factors. Therefore, the GBD uses the same standard life expectancy table [1] for every country and for both sexes. While this may be a preferred approach for comparative studies, country-specific life tables offer a more direct approach for estimating YLL due to alcohol in a specific country and were used here. Secondly, the GBD method for liver disease used the total number of liver disease cases (alcoholic and non-alcoholic) and applied an AAF, because globally no data are available for small categories such as alcoholic liver cirrhosis [28, 29]. In the present study this approach would have underestimated alcohol-attributable liver disease compared with the use of 100% alcohol-attributable diagnostic codes of alcoholic liver diseases. Finally, we were able to include deaths from other 100% alcohol-attributable causes such as alcoholic cardiomyopathy, for which no data exist on the global level.

Data sources for alcohol use and relative risk functions

Alcohol consumption data, i.e. abstinence, former drinker and drinking prevalence rates as well as mean amount of alcohol consumed and estimates for binge drinking were taken from the Addiction Monitoring in Switzerland (AMIS [30]), based on 11,000 participants in the year 2011. To account for the underestimation of alcohol consumed as estimated by surveys [31, 32], the volume (in g /day) derived from AMIS was upshifted to 80% of the adult total per capita alcohol consumption, as estimated by the addition of recorded [4] and unrecorded alcohol consumption [5, 6]. Unrecorded alcohol consumption is defined as alcohol that was not taxed in the country where it was consumed [33]. This could be homebrew, illegally produced spirits, non-declared wine, or even non-beverage alcohol such as medicinal alcohol or cosmetics such as mouthwash or after-shaves. An estimate for Switzerland is 0.5 litres of unrecorded consumption per capita [6, 34]. The upshifting to 80% was based on the recommendations of the World Health Organization (WHO) Technical Advisory Group on Alcohol Epidemiology (see discussion on this value below).

AMIS estimates covered about a third (33.7%) of the overall adult per capita consumption including unrecorded consumption in 2011, which is at the lower end of coverage rates reported in the literature [35, 36]. Eighty percent of total per capita consumption was used because some of the

alcohol sold may be lost through spilled-over, left-over in glasses, debauched during stocking, or used with cooking [37]. A lower than 100% value also takes into account that the observational epidemiological studies that provide the risk relation data may themselves underestimate alcohol consumption [31]. Basically, the method of up-estimation uses the sex-by-age proportions of total consumption from surveys and applies these proportions to the per capita consumption. The alcohol-consumption distribution was modelled as a continuous Gamma function [31, 32].

The continuous relative risk functions for diseases in part attributable to alcohol were also taken from the CRA [2, 9]. Table 1 gives an evaluation of these functions for men and women at different consumption levels.

Data sources for mortality estimates

The latest available death statistics for the year 2010 (as an estimate for 2011) with detailed ICD-10 Codes of the primary death cause and age at death from the Swiss Federal Statistical Office were used as outcome data. These data can be obtained upon request as anonymized microdata from the Swiss Federal Statistical Office [38]. Aggregated data can be found in the Statistical Yearbook [39]. Age-specific life expectancy tables to calculate YLL were extracted from the Swiss Federal Statistical Office database [40, 41]. Age-specific means that the life-expectancy varies with age. For example, at the age of 20 a women in Switzerland has a life-expectancy of 85 years (65 remaining years on average), whereas the life expectancy at 60 years is 87 (27 remaining years on average).

Statistical analysis

Number of deaths and YLL were calculated for the age range of 15–74 years. This was done because alcohol-attributable deaths for older people are subject to increased methodological problems, i.e. inaccuracy of death certificates [42]. Particularly, deaths certificates for cardiovascular deaths have a limited reliability in this age group [e.g. 43]. For example, possible false-attribution of deaths to “beneficial” diagnoses such as IHD compared with detrimental diagnoses such as hypertension would grossly influence the overall estimate of alcohol-attributable mortality, as most deaths in this age group are attributable to cardiovascular disease. Additionally, relative risks commonly decrease with age and move towards 1 [17, 44]. Therefore, using RRs for alcohol-attributable-mortality mainly stemming from estimates among younger populations would exaggerate alcohol-attributable deaths caused and avoided in older age groups.

Calculations for number of deaths and YLLs were done for the total population and separately for heavy drinkers, where heavy drinking was defined as 60 g or more of pure alcohol for men and 40 g or more for women. Outcomes were separated into beneficial effects (e.g. due to IHD), detrimental effects and net effects (detrimental-beneficial). The R system for statistical computing version 2.11.1 [45] was used for calculating the AAF, SPSS version 20 was used for calculating deaths and YLL.

Results

Overall in 2011, 1,600 individuals (95% confidence intervals -CI: 1,472 – 1,728) died due to alcohol between 15 and 74 years, almost three times more men than women (419 women and 1,181 men). This corresponds to a rate of 13.8 women and 38.8 men per 100,000. The uncertainty introduced by the AAF results in a confidence range of 374 to 465 for women and 1,061 to 1,301 for men (for AAF estimates see supplementary Web-Appendix tables A2 and A3). These are net deaths, as shown in table 2; net deaths resulted from subtracting deaths avoided (168) from deaths caused by alcohol (1,768). Totally, 42,627 years of life (95% CI: 40,245 – 45,008) were lost due to alcohol. Overall, based on net estimates, 8.7% of all deaths and 9.7% of all YLL in the age group of 15 to 74 years were due to alcohol consumption.

The single most important cause of death due to alcohol among men was alcoholic liver disease, followed by self-inflicted injuries (table 3). For women, alcoholic liver disease was the single most important cause, followed by breast cancers. Overall, in broader categories, most alcohol-attributable deaths were due to injuries (522 deaths), cancers (473 deaths) and digestive diseases (440 deaths).

In younger ages alcohol-attributable deaths mainly stem from injuries, whereas with increasing age, digestive diseases (predominantly liver disease) and cancers gain increasing importance (fig. 1). Among women, breast cancer alone accounts for about one quarter of all alcohol-attributable deaths.

Overall, the share of alcohol-attributable YLL (9.7%, table 4) is higher than the share of alcohol-attributable deaths (8.7%), indicating that alcoholic deaths occur earlier than deaths from other causes in the age group 15–74. Although,

Table 1: Values of the continuous relative risk functions at 20/40/60/80 g/day.

	Women				Men			
	20g/day	40g/day	60g/day	80g/day	20g/day	40g/day	60g/day	80g/day
Oral cavity and pharynx cancer	1.66	2.56	3.71	5.04	1.66	2.56	3.71	5.04
Oesophagus cancer	1.30	1.69	2.19	2.82	1.30	1.69	2.19	2.82
Colon cancer	1.04	1.08	1.12	1.16	1.04	1.08	1.12	1.16
Rectal cancer	1.07	1.15	1.23	1.32	1.07	1.15	1.23	1.32
Liver cancer	1.15	1.31	1.48	1.65	1.15	1.31	1.48	1.65
Larynx cancer	1.33	1.76	2.31	3.00	1.33	1.76	2.31	3.00
Breast cancer	1.19	1.42	1.69	2.02	1.00	1.00	1.00	1.00
Epilepsy	1.29	1.64	2.10	2.69	1.29	1.64	2.10	2.69
Lower respiratory infections	1.10	1.21	1.33	1.46	1.10	1.21	1.33	1.46
Haemorrhagic stroke	1.34	1.80	2.41	3.23	1.15	1.32	1.51	1.74
Tuberculosis	1.00	2.96	2.96	2.96	1.00	2.96	2.96	2.96
Diabetes mellitus	0.60	0.74	1.18	1.18	0.87	0.91	1.00	1.16
Hypertension	1.20	2.12	3.59	5.85	1.20	1.44	1.72	2.07
Liver disease	4.31	7.85	12.46	18.39	1.76	3.07	5.37	9.39
Conduction disorders and other dysrhythmias	1.12	1.26	1.41	1.58	1.12	1.26	1.41	1.58
Pancreatitis	1.06	1.27	1.72	2.62	1.06	1.27	1.72	2.62
Ischaemic stroke 15–34	0.66	0.90	1.39	2.28	0.90	1.03	1.19	1.37
Ischaemic stroke 35–64	0.68	0.91	1.36	2.16	0.90	1.03	1.18	1.34
Ischaemic stroke 65+	0.76	0.93	1.25	1.75	0.93	1.02	1.13	1.24
Ischaemic heart disease 15–34	0.87	1.00	1.00	1.00	0.80	0.79	1.00 ²⁾	1.00
Ischaemic heart disease 35–64	0.88	1.00	1.00	1.00	0.81	0.81	1.00 ²⁾	1.00
Ischaemic heart disease 65+	0.91	1.00	1.00	1.00	0.86	0.85	1.00 ²⁾	1.00

Remarks: 1) Ischaemic heart disease and stroke RR's were calculated for 3 different age groups. 2) For ischaemic heart disease, RR is set to 1 for chronic heavy drinkers and risky single occasion drinkers (at least once monthly). For evidence on the effects of chronic heavy drinking see [23], for risky single occasion drinking see [24]. 3) RR for injuries are not shown because AAF's for Mortality are derived from the Morbidity AAF and because the calculation also accounts for binge drinking. 4) RR for HIV are not shown because the calculation does not use a dose dependent relative risk function. 5) For the source of the original RR, see [9].

Table 2: Alcohol-attributable mortality in Switzerland for 2011 by sex, for age 15–74.

	Women	Men	Total
Alcohol-attributable beneficial effect	–42	–126	–168
Alcohol-attributable detrimental effect (deaths)	461	1,307	1,768
Alcohol-attributable net effect (net deaths)	419	1,181	1,600
Total deaths in alcohol-attributable categories	2,853	5,251	8,104
Average AAF for these categories	14.7%	22.5%	19.7%
Total deaths	6,936	11,550	18,486
Proportion of deaths attributable to alcohol	6.0%	10.2%	8.7%
Alcohol-attributable death rate per 100,000 population	13.79	38.79	26.3
Years of life lost due to alcohol	11,747	30,880	42,627
Proportion of years of life lost attributable to alcohol	6.6%	11.8%	9.7%
Years of life lost per 100,000	386	1,015	701

there are relatively few alcohol-attributable deaths at younger ages, the proportion of alcohol-attributable deaths on all deaths is especially high in young men. More than 20% of all deaths of men aged 15–34 are due to alcohol. Among women in this age group more than 8% are due to alcohol. Most of the alcohol-attributable deaths in younger age groups were injuries, while chronic diseases prevail in higher age groups (table 4). Overall, there were about six-fold more injury deaths attributable to alcohol among men (446 deaths) compared with women (75 deaths), whereas the difference in deaths from chronic diseases was slightly higher than two-fold between men (734 deaths) and women (344 deaths).

Figure 2 shows that a substantial part of alcohol-attributable deaths is due to heavy drinking, defined as 60+ g/day for men and 40+ g/day for women. In total, 62% of all alcohol-attributable deaths (56% of all alcohol-attributable YLL, not tabulated) are due to heavy drinking. The share of heavy drinking increases with age. However, the share

of heavy drinking stems mainly from men 45 years and older. In women except for the oldest age group, deaths from non-heavy drinking outnumber those of heavy drinking. Most of the caused deaths from non-heavy drinking in women (total net deaths = 216) stem from breast cancer (69 deaths) and injuries (47 deaths). Overall, the share of heavy drinking is 67% for men and 48% of women. Beneficial effects of non-heavy drinking only occur in older age groups. There are no beneficial effects of heavy drinking and the beneficial effects of non-heavy drinking do not outnumber (neither in number of deaths nor in terms of YLL (results not shown)) detrimental effects of non-heavy alcohol use in any age group.

Discussion

Overall, with 8.7% of all deaths caused and 9.7% of all YLL among 15–74 year old people, alcohol is a major risk factor for avoidable mortality in Switzerland. The most

Table 3: Deaths, death rates and years of life lost per disease, by sex for age 15–74.

Condition	Deaths		Rate per 100,000		YLL	
	Women	Men	Women	Men	Women	Men
Cancers	169	304	6.00	10.00	4,179	6,286
Oral Cavity and Pharynx Cancer	21	117	0.70	3.84	525	2,578
Oesophagus Cancer	10	77	0.31	2.55	221	1,551
Colon Cancer	12	21	0.38	0.69	260	406
Rectum Cancer	7	19	0.22	0.64	155	379
Liver Cancer	10	52	0.32	1.71	231	1,032
Larynx Cancer	3	17	0.09	0.55	57	340
Breast Cancer	107	0	3.52	0.00	2,729	0
Cardiovascular diseases	27	–38	1.00	–1.00	613	–889
Hypertension	11	19	0.37	0.62	200	334
Haemorrhagic Stroke	29	29	0.96	0.96	705	602
Ischaemic Stroke	–14	5	–0.45	0.15	–313	66
Ischaemic heart disease	–7	–120	–0.22	–3.94	–180	–2,541
Conduction disorders and other dysrhythmias	4	15	0.14	0.50	99	326
Alcoholic cardiomyopathy	3	14	0.10	0.46	102	323
Digestive diseases	116	324	4.00	11.00	3,285	7,646
Pancreatitis	1	9	0.03	0.28	17	190
Liver Disease	115	315	3.78	10.35	3,268	7,456
Injuries	75	446	2.00	15.00	2,734	14,351
Motor Vehicle Accidents	6	49	0.21	1.61	231	1,926
Falls	9	72	0.31	2.36	264	1,656
Other unintentional injuries	23	127	0.75	4.18	864	4,410
Self inflicted injuries	35	193	1.14	6.35	1,276	6,171
Assault	2	5	0.08	0.17	98	189
Mental disorder due to use of alcohol	42	117	1.38	3.84	1,106	2,797
Mental disorder due to use of alcohol	42	117	1.38	3.84	1,106	2,797
Other	–10	28	0.00	1.00	–170	689
Epilepsy	4	9	0.13	0.30	114	260
Lower respiratory infections	5	15	0.16	0.48	109	284
Tuberculosis	1	1	0.02	0.05	15	42
HIV	1	2	0.02	0.06	22	57
Diabetes Mellitus	–22	–6	–0.71	–0.20	–464	–127
Other 100% alcohol-attributable ¹	2	7	0.07	0.23	34	173
Total beneficial	–42	–126	–1.38	–4.15	–957	–2,678
Total adverse	461	1,307	15.17	42.94	12,704	33,558
Total net	419	1,181	13.79	38.79	11,747	30,880

Remark: ¹ Degeneration of nervous system due to alcohol, Alcoholic polyneuropathy.

important alcohol-attributable death causes were injuries (including self-inflicted injuries), followed by cancers and digestive diseases (mostly liver disease). About three quarters of all alcohol-attributable deaths occur in men, and the difference between men and women is larger for injuries than for chronic diseases. Injuries accounted for over a third of alcohol-attributable mortality in men, but only about a sixth in women. In younger ages (15–34) injuries are by far the most important cause of alcohol-attributable deaths causing more than 20% of all deaths in men (more

than 8% among women) at ages between 15 and 34 years old. This corresponds well to the literature that alcohol use is the leading cause of mortality (and also morbidity) in adolescence and early adulthood [46, 47]. A major factor for alcohol related injuries has been found to be RSOD [48], which is the predominant drinking style among young people in Switzerland, particularly among men [30, 49, 50].

Later in life (35–54 years) digestive diseases, mainly alcoholic liver disease, and cancers become the most relevant factors, with cancer being the dominant cause in the oldest age group (65–74 years). About a quarter (107 deaths) of

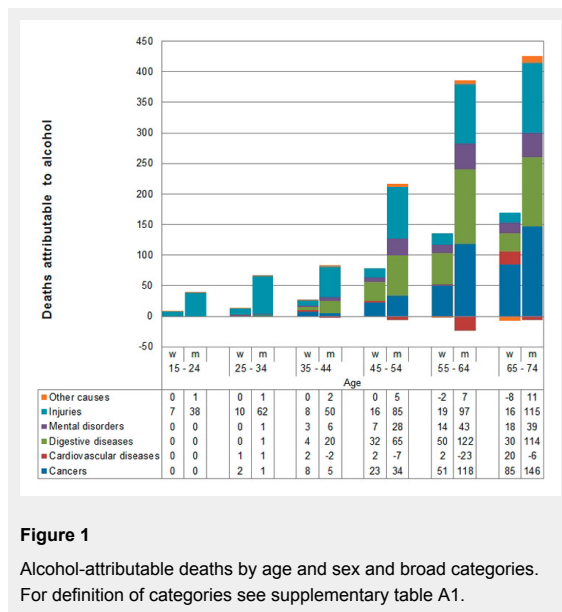


Figure 1
Alcohol-attributable deaths by age and sex and broad categories. For definition of categories see supplementary table A1.

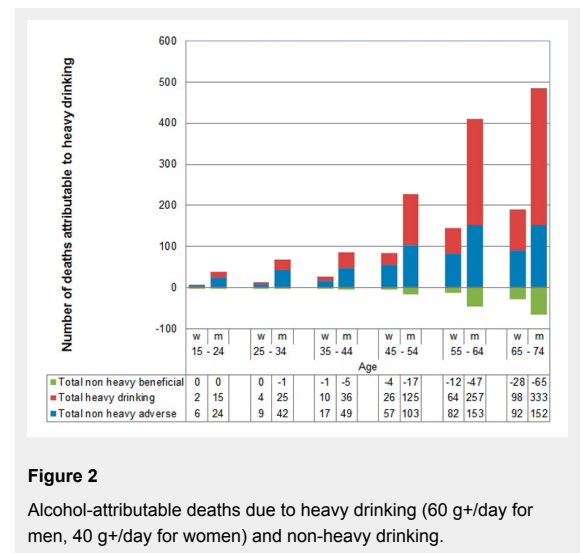


Figure 2
Alcohol-attributable deaths due to heavy drinking (60 g+/day for men, 40 g+/day for women) and non-heavy drinking.

Table 4: Alcohol-attributable deaths and years of life lost (YLL) by age and injuries versus diseases.							
	Women						
	15 – 24	25 – 34	35 – 44	45 – 54	55 – 64	65 – 74	Total
Injury deaths	7	10	8	16	19	16	75
Disease deaths	0	3	18	63	115	145	344
Total deaths	7	13	26	79	133	162	419
% of total deaths	8.7%	9.0%	7.1%	8.2%	6.8%	4.7%	6.0%
Injury YLL	446	551	380	558	512	288	2,734
Disease YLL	10	161	771	2,267	3,112	2,692	9,013
Total YLL	456	712	1151	2,825	3,623	2,980	11,747
% of total YLL	8.6%	9.0%	7.0%	8.2%	7.0%	4.8%	6.6%
	Men						
	15 – 24	25 – 34	35 – 44	45 – 54	55 – 64	65 – 74	Total
Injury deaths	38	62	50	85	97	115	446
Disease deaths	1	5	31	126	267	305	734
Total deaths	39	67	81	211	363	420	1,181
% of total deaths	20.9%	24.3%	12.7%	13.4%	11.0%	7.5%	10.2%
Injury YLL	2,299	3,215	2,044	2,733	2,251	1,809	14,351
Disease YLL	71	244	1,245	3,969	6,168	4,833	16,528
Total YLL	2,370	3,459	3,289	6,702	8,418	6,642	30,880
% of total YLL	20.9%	24.4%	12.7%	13.4%	11.1%	7.8%	11.8%
	Total						
	15 – 24	25 – 34	35 – 44	45 – 54	55 – 64	65 – 74	Total
Injury deaths	45	72	58	100	115	131	522
Disease deaths	1	8	48	189	381	450	1,078
Total deaths	46	80	106	289	497	581	1,600
% of total deaths	17.2%	19.0%	10.6%	11.4%	9.5%	6.4%	8.7%
Injury YLL	2,745	3,766	2,424	3,291	2,762	2,097	17,085
Disease YLL	82	405	2,016	6,235	9,279	7,525	25,541
Total YLL	2,826	4,171	4,440	9,526	12,042	9,622	42,627
% of total YLL	17.0%	18.9%	10.5%	11.3%	9.5%	6.5%	9.7%

alcohol-attributable deaths in women is caused by breast cancer alone. The greater part of those breast cancer deaths (69 deaths, 65% of all alcohol-attributable breast cancers) are caused by non-heavy drinking, i.e. relative low amounts of alcohol consumption. This indicates that, especially for women, even low levels of alcohol may not be advisable, which is corroborated by the fact that the number of deaths by breast cancer due to non-heavy drinking alone exceeded the total beneficial effects of alcohol in women between 15 and 74 years old. This finding is also consistent with earlier reviews [14] and was confirmed by a recent meta-analysis on light drinking (one drink or less), showing that a relevant share of breast cancer mortality is caused by light to moderate drinking [51]. Thus, particularly for women, preventive actions that target alcohol use at all levels and not only heavy drinking are important.

Overall, 62% of all alcohol-attributable deaths and 56% of all alcohol-attributable YLL are caused by heavy drinking defined as 60+ grams per day for men, and 40+ grams per day for women. However, this effect is mainly due to heavy drinking among men (67% of all alcohol-attributable deaths), especially among those aged 45 years and older, and its impact on chronic diseases. Nevertheless, these findings show that targeted preventive approaches for heavy drinking and alcohol dependence are needed.

The present study also showed some protective effects, which stem mainly from ischaemic heart disease and were more prominent in men. The reason for the gender difference in protective effects is that the protective effect for ischaemic heart disease is lower for women and that women die less often from IHD before the age of 74. Protective effects only occurred in non-heavy drinkers and never outnumbered deaths or YLL in any age group. Protective effects of alcohol consumption have received significant attention in the past and were estimated to be high in earlier studies in Switzerland [14, 46]. In the estimate for the year 1998 [14], prevented deaths even outweighed caused deaths over all age groups. This conflicting findings [14] were mainly due to the oldest age group of 75+ years, i.e. the total number of alcohol caused deaths was about equal to the number of prevented death among people aged 75 years and older. In the present study with a restricted age range of 15–74 years, prevented deaths (168 deaths) were less than 10% of the deaths caused (1,768 deaths) by alcohol. Besides the age effect, the low proportion of prevented deaths is also due to the fact that in earlier estimates the lack of protective effects in people with RSOD has not been incorporated, as was done in the present study. A further reason is that, compared to the present study, former drinkers could not be excluded from the reference group, which resulted in an overestimate of the protective effect compared to using lifetime abstainers as reference. The present findings indicate that prevented deaths should not be used as an argument to promote moderate drinking as a general population goal [52].

The present study has certain limitations: The uncertainty estimates around alcohol-attributable deaths and YLLs account for neither the uncertainty introduced by the upshifting to per capita consumption, nor for the uncertainty of the death statistics. Studies show that the uncertainty introduced by the latter might be considerable [42, 53]. Such un-

certainty may affect total mortality statistics less if causes of death are misclassified between categories with similar AFFs (e.g. different alcohol-attributable cancers), however it may strongly affect overall estimates if, for example, there is uncertainty [e.g. 43, 54] between diagnosing IHD (mainly beneficial) and detrimental causes (hypertension, cancers) as a cause of death. The method for estimating alcohol consumption volume by upshifting to 80% of the per capita consumption is another possible source of bias in the mortality estimates. Upshifting relies on the difficult to prove assumptions that surveys underestimate alcohol consumption more than the clinical studies from which the relative risk data were taken, that surveys do not reach a relevant part of the heavy drinking population (such as homeless or institutionalized people) and that per capita consumption is the better indicator for overall alcohol consumption volume. A sensitivity analysis using data from the United States (US) with and without up-estimation of alcohol consumption from survey data to per capita consumption showed that alcohol-related death would be 11% and YLL around 9% lower without up-estimation (for alcohol related mortality in the US see [7], for further sensitivity analyses on this assumption see [55]).

While the present methods accounts for many causes of death for which a causal alcohol link is established, there are still some causes for which a causal relation to alcohol is likely, for example infection with sexually transmitted diseases [56] or depression [57], but evidence is not yet strong enough or quantification is not possible. For example, because the role of depression induced by alcohol cannot be separated from the role of alcohol as self medication in depression.

Despite some limitations, the relevance of heavy drinking, non-heavy drinking and RSOD for alcohol-attributable mortality points to the importance of multiple preventive approaches as different drinking styles are relevant for alcohol-attributable mortality. Heavy drinking is overall responsible for the majority of alcohol-attributable deaths. RSOD is relevant for injuries and especially relevant for deaths among young people [58]. Although the individual risk of non-heavy drinking is smaller compared to heavy drinking, it still causes a relevant share of alcohol-attributable deaths through the large number of people in the non-heavy drinking group. Thus, a mixture of approaches such as treatment for heavy and dependent drinking [59], preventive measures to reduce RSOD but also harm from RSOD, as well as measures to reduce overall exposure to alcohol, e.g. by taxation [60], are needed to reduce alcohol-attributable mortality. The first two approaches are already core parts of the national alcohol program in Switzerland [61], while the reduction of drinking through universal preventive approaches currently receives relatively little attention in Switzerland.

A much discussed concept in alcohol research is the preventive paradox [11, 12], stating that the majority of health risks stem not from the heaviest drinking group, but from the moderate drinkers because of their relatively higher numbers compared to heavy drinkers. The present studies results indicate that a relevant share of alcohol-attributable mortality is indeed due to non-heavy drinking, especially in women. The overall larger part of alcohol-attributable mor-

tality, however, is due to heavy drinking, showing clearly the relevance of approaches targeting heavy drinkers [62]. One promising and effective approach is the use of screening and brief intervention through general practitioners [63]. Much of the alcohol-attributable burden stems from an age onwards where visits to health professionals become more and more likely. Health professionals should systematically screen their patients for alcohol use and provide adequate interventions when necessary. Brief interventions or advice to reduce drinking are already indicated in people that drink relatively little alcohol and the effectiveness of such brief Interventions has also been shown in Switzerland among young people [e.g. 64, 65]. Some promising approaches to promote delivering of brief interventions by general practitioners exist in Switzerland [66] and should be implemented on a large scale.

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Supplementary Web-Appendix

Table A1: Disease and injury categories causally impacted by alcohol.	
Category	ICD-10 code
Cancers	
Mouth, nasopharynx, other pharynx and oropharynx cancer	C00–C14
Oesophagus cancer	C15
Colon and rectal cancer	C18–C21
Liver cancer	C22
Larynx cancer	C32
Breast cancer (female)	C50
Cardiovascular diseases	
Hypertensive heart disease	I11–I13
Ischaemic heart disease	I20–I25
Cardiomyopathy	
Alcoholic cardiomyopathy	I42.6
Conduction disorders and other dysrhythmias	I47–I49
Cerebrovascular disease	
Haemorrhagic and other non-ischaemic stroke	I60–I62, I69.0, I69.1, I69.2
Ischaemic stroke	I63–I67, I69.3
Digestive diseases	
Alcoholic gastritis	K29.2
Alcoholic liver disease	K70
Alcoholic fatty liver	K70.0
Alcoholic hepatitis	K70.1
Alcoholic fibrosis and sclerosis of liver	K70.2
Alcoholic cirrhosis of liver	K70.3
Alcoholic hepatic failure	K70.4
Alcoholic liver disease, unspecified	K70.9
Pancreatitis (we used AAF for the larger category based on RR)	K85, K86.0, 86.1
Alcohol-induced acute pancreatitis	K85.2
Alcohol-induced chronic pancreatitis	K86.0
Injuries	
Toxic effect of alcohol	T51
Ethanol	T51.0
Methanol	T51.1
Other alcohols	T51.8
Alcohol unspecified	T51.9
Unintentional injuries	
Motor-vehicle accidents	§
Poisoning	X40–X49
Accidental poisoning by and exposure to alcohol	X45
Falling	W00–W19
Fires	X00–X09
Drowning	W65–W74
Other unintentional injury	†Rest of V-series and W20–W64, W 75–W99, X10–X39, X50–X59, Y40–Y86, Y88, and Y89.1–89.9, Y15
Intentional injuries	
Self-inflicted injuries	X60–X84, Y87.0
Intentional self-poisoning by and exposure to alcohol	X65
Violence	X85–Y09, Y87.1
Other intentional injury	Y35, Y89.0
Mental and behavioural disorders due to use of alcohol	
Acute intoxication	F10.0
Harmful use	F10.1
Dependence syndrome	F10.2
Withdrawal state	F10.3
Withdrawal state with delirium	F10.4
Psychotic disorder	F10.5
Amnesic syndrome	F10.6
Residual and late-onset psychotic disorder	F10.7
Other mental and behavioural disorders	F10.8
Unspecified mental and behavioural disorder	F10.9

Other diseases	
Tuberculosis	A15–A19, B90
HIV/AIDS	B20–B24
Diabetes mellitus	E11–E14
Degeneration of nervous system due to alcohol	G31.2
Alcohol-induced pseudo-Cushing's syndrome	E24.4
Epilepsy	G40, G41
Alcoholic polyneuropathy	G62.1
Alcoholic myopathy	G72.1
Lower respiratory infections: pneumonia	J09–J22, J85
Finding of alcohol in blood	R78.0

§ 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.

Remark: shaded causes are 100% alcohol-attributable. Adapted from Rehm et al. [9]

Table A2: Alcohol-attributable fractions, women 2011.

Disease	Age											
	15 – 24		25 – 34		35 – 44		45 – 54		55 – 64		65 – 74	
	AAF	SD	AAF	SD	AAF	SD	AAF	SD	AAF	SD	AAF	SD
Oral cavity and pharynx cancer	23.57%	0.0248	30.11%	0.0281	26.01%	0.0264	27.85%	0.0278	33.78%	0.0311	36.40%	0.0312
Oesophagus cancer	13.20%	0.0140	18.10%	0.0175	14.84%	0.0153	15.97%	0.0165	19.85%	0.0201	22.10%	0.0210
Colon cancer	3.51%	0.0075	6.18%	0.0112	4.14%	0.0085	4.33%	0.0090	4.97%	0.0107	6.32%	0.0122
Rectal cancer	4.83%	0.0065	7.78%	0.0100	5.59%	0.0074	5.91%	0.0078	6.97%	0.0091	8.42%	0.0105
Liver cancer	7.78%	0.0129	11.28%	0.0163	8.81%	0.0142	9.38%	0.0152	11.22%	0.0183	12.83%	0.0194
Larynx cancer	14.08%	0.0157	19.17%	0.0196	15.80%	0.0173	17.01%	0.0187	21.14%	0.0227	23.45%	0.0236
Breast cancer	9.32%	0.0115	13.31%	0.0150	10.55%	0.0128	11.31%	0.0137	13.89%	0.0169	15.76%	0.0181
Epilepsy	12.88%	0.0183	17.60%	0.0230	14.44%	0.0201	15.51%	0.0219	19.18%	0.0274	21.37%	0.0290
Lower respiratory infections	5.89%	0.0173	9.08%	0.0221	6.77%	0.0193	7.19%	0.0208	8.60%	0.0261	10.14%	0.0281
Haemorrhagic stroke	13.62%	0.0387	17.97%	0.0523	15.24%	0.0432	16.54%	0.0469	21.08%	0.0594	23.12%	0.0654
Tuberculosis	7.38%	0.0195	13.38%	0.0261	9.28%	0.0226	10.57%	0.0248	15.31%	0.0319	18.20%	0.0340
Diabetes mellitus	-23.13%	0.0382	-22.09%	0.0455	-23.54%	0.0413	-24.22%	0.0445	-23.27%	0.0528	-21.08%	0.0551
Hypertension	1.11%	0.0876	10.58%	0.1011	4.44%	0.0942	7.15%	0.0999	18.65%	0.1108	23.64%	0.1118
Liver cirrhosis	64.38%	0.0413	71.74%	0.0427	67.09%	0.0412	68.72%	0.0404	73.29%	0.0380	75.70%	0.0377
Ischaemic stroke	-25.71%	0.0677	-20.94%	0.0755	-23.28%	0.0655	-23.06%	0.0670	-17.35%	0.0649	-10.42%	0.0526
Pancreatitis	5.69%	0.0123	10.63%	0.0217	7.08%	0.0154	8.00%	0.0183	12.51%	0.0314	15.86%	0.0370
Ischaemic heart diseases	-4.04%	0.0628	-1.46%	0.0738	-4.26%	0.0594	-4.46%	0.0630	-4.12%	0.0683	-0.49%	0.0692
Conduction disorders and other dysrhythmias	6.73%	0.0110	10.11%	0.0146	7.69%	0.0122	8.19%	0.0131	9.88%	0.0162	11.49%	0.0175
Motor vehicle accidents	13.91%	0.0184	14.72%	0.0181	8.83%	0.0106	10.64%	0.0097	12.22%	0.0107	14.53%	0.0187
Non-motor vehicle accidents	16.13%	0.0311	16.14%	0.0326	11.69%	0.0219	12.24%	0.0219	15.76%	0.0296	14.49%	0.0382
HIV treatment non-adherence	5.67%	0.0139	5.65%	0.0139	5.73%	0.0141	5.82%	0.0143	5.75%	0.0141	5.59%	0.0138

Table A3: Alcohol-attributable fractions, men 2011.

Disease	Age											
	15 – 24		25 – 34		35 – 44		45 – 54		55 – 64		65 – 74	
	AAF	SD	AAF	SD	AAF	SD	AAF	SD	AAF	SD	AAF	SD
Oral cavity and pharynx cancer	48.23%	0.0304	50.50%	0.0296	44.25%	0.0320	48.41%	0.0307	54.39%	0.0279	59.97%	0.0233
Oesophagus cancer	30.30%	0.0246	32.36%	0.0247	26.88%	0.0242	30.46%	0.0248	35.98%	0.0246	41.76%	0.0220
Colon cancer	4.82%	0.0161	5.33%	0.0172	4.33%	0.0144	4.99%	0.0162	5.96%	0.0195	7.10%	0.0229
Rectal cancer	8.37%	0.0121	9.13%	0.0127	7.47%	0.0109	8.56%	0.0121	10.28%	0.0141	12.23%	0.0159
Liver cancer	15.22%	0.0274	16.34%	0.0286	13.75%	0.0252	15.44%	0.0275	18.20%	0.0312	21.14%	0.0346
Larynx cancer	32.20%	0.0283	34.32%	0.0283	28.65%	0.0276	32.37%	0.0283	38.05%	0.0285	43.91%	0.0265
Breast cancer	0.00%	0.0000	0.00%	0.0000	0.00%	0.0000	0.00%	0.0000	0.00%	0.0000	0.00%	0.0000
Epilepsy	29.15%	0.0401	31.18%	0.0416	25.84%	0.0367	29.32%	0.0400	34.74%	0.0440	40.48%	0.0464
Lower respiratory infections	11.23%	0.0445	12.19%	0.0474	10.00%	0.0396	11.42%	0.0446	13.73%	0.0531	16.32%	0.0620
Haemorrhagic stroke	16.37%	0.0297	17.72%	0.0315	14.55%	0.0269	16.62%	0.0300	19.89%	0.0345	23.52%	0.0388
Tuberculosis	27.15%	0.0460	29.26%	0.0469	23.10%	0.0440	27.26%	0.0461	32.89%	0.0487	38.27%	0.0495
Diabetes mellitus	-5.35%	0.0670	-4.95%	0.0716	-6.42%	0.0614	-5.44%	0.0680	-4.62%	0.0810	-2.98%	0.0929
Hypertension	20.75%	0.0286	22.23%	0.0299	18.31%	0.0262	20.84%	0.0284	25.04%	0.0320	29.59%	0.0348
Liver cirrhosis	65.24%	0.0537	68.13%	0.0514	58.73%	0.0566	65.15%	0.0537	72.74%	0.0469	79.26%	0.0381
Ischaemic stroke	-2.07%	0.0327	-0.74%	0.0335	-4.75%	0.0325	-2.04%	0.0317	0.94%	0.0324	3.77%	0.0248
Pancreatitis	28.21%	0.0627	31.69%	0.0661	21.12%	0.0529	28.00%	0.0626	37.79%	0.0711	48.73%	0.0737
Ischaemic heart diseases	-6.90%	0.0482	-7.68%	0.0555	-9.78%	0.0408	-9.34%	0.0402	-9.73%	0.0426	-7.57%	0.0696
Conduction disorders and other dysrhythmias	13.49%	0.0255	14.59%	0.0269	11.99%	0.0228	13.68%	0.0255	16.43%	0.0299	19.50%	0.0339
Motor vehicle accidents	34.13%	0.0624	36.11%	0.0612	21.65%	0.0359	26.10%	0.0327	29.97%	0.0364	35.64%	0.0634
Non-motor vehicle accidents	28.50%	0.0331	36.50%	0.0749	20.09%	0.0408	25.49%	0.0505	34.53%	0.0685	51.01%	0.1038
HIV treatment non-adherence	5.90%	0.0145	5.96%	0.0146	6.16%	0.0150	6.01%	0.0147	6.11%	0.0149	6.00%	0.0147

Figures (large format)

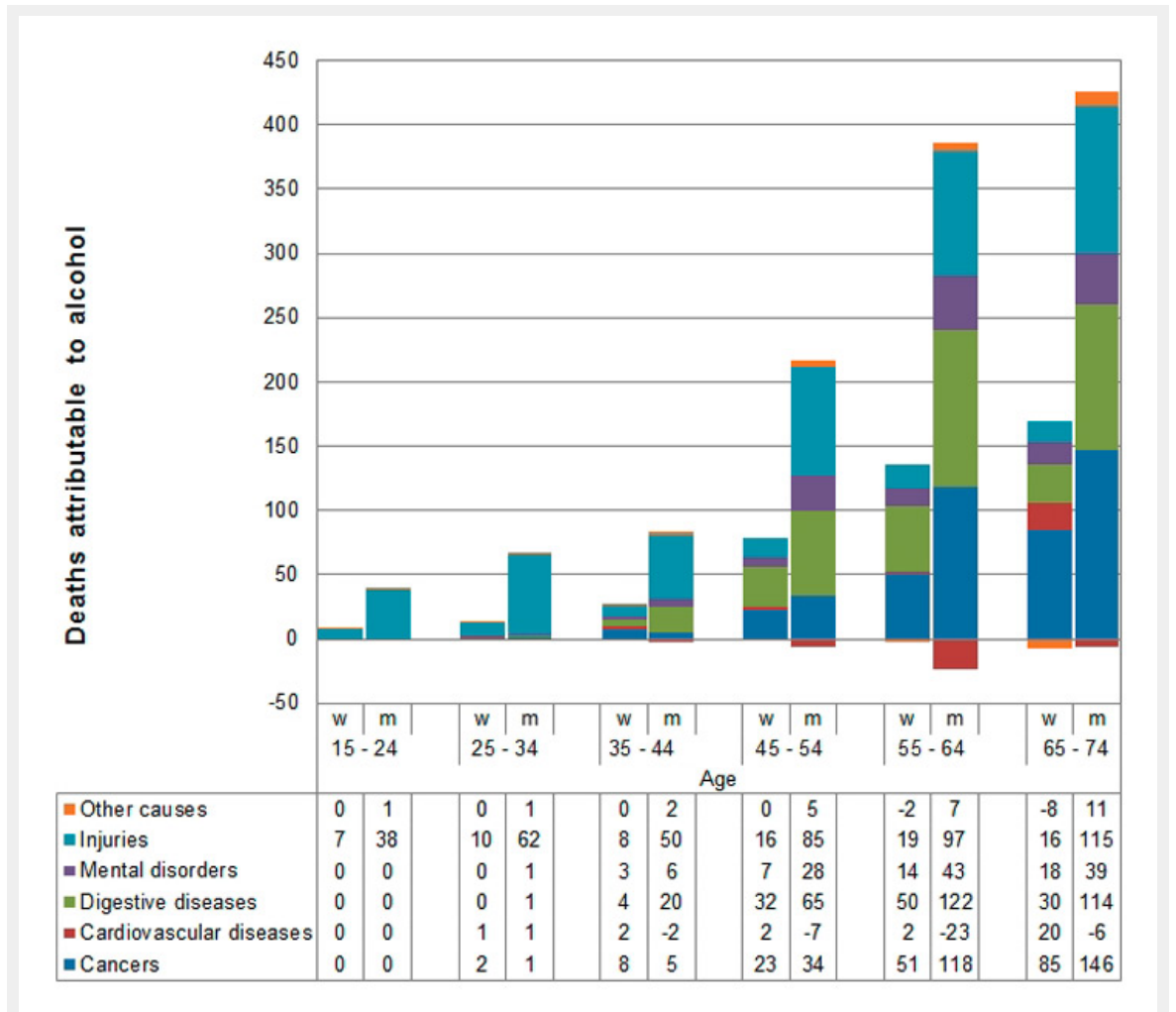


Figure 1

Alcohol-attributable deaths by age and sex and broad categories. For definition of categories see supplementary table A1.

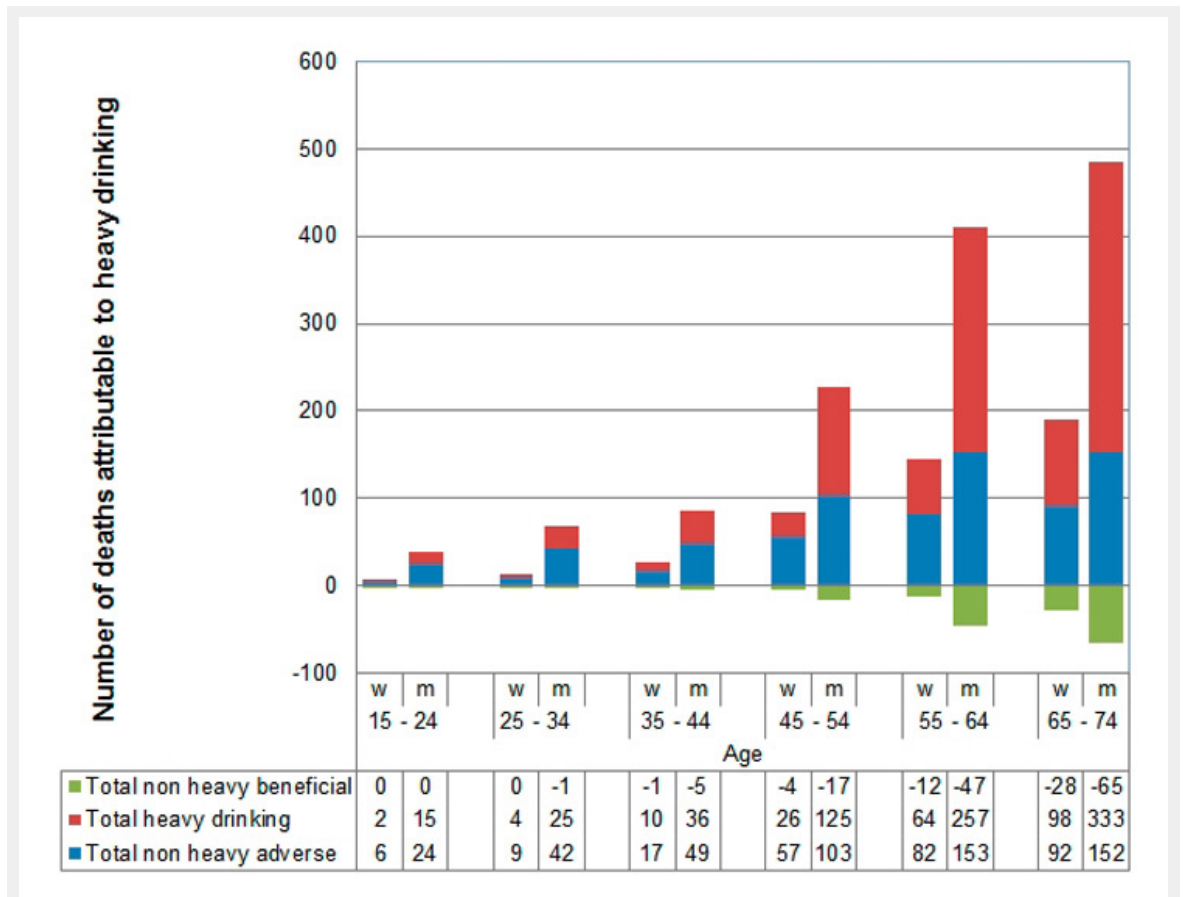


Figure 2

Alcohol-attributable deaths due to heavy drinking (60 g+/day for men, 40 g+/day for women) and non-heavy drinking.