Lifetime risk of mortality due to different levels of alcohol consumption in seven European countries: implications for low-risk drinking guidelines

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Summary

Background and aims: Low-risk alcohol drinking guidelines require a scientific basis that extends beyond individual or group judgements of risk. Lifetime mortality risks, judged against established thresholds for acceptable risk, may provide such a basis for guidelines. Therefore, the aim of this study was to estimate alcohol mortality risks for seven European countries based on different average daily alcohol consumption amounts.

Methods: The maximum acceptable voluntary premature mortality risk was determined to be 1 in 1,000, with sensitivity analyses of 1 in 100. Lifetime mortality risks for different alcohol consumption levels were estimated by combining disease-specific relative risk and mortality data for seven European countries with different drinking patterns (Estonia, Finland, Germany, Hungary, Ireland, Italy, and Poland). Alcohol consumption data were obtained from the Global Information System on Alcohol and Health, relative risk data from meta-analyses, and mortality information from the World Health Organization.

Results: The variation in the lifetime mortality risk at drinking levels relevant for setting guidelines was less than that observed at high drinking levels. In Europe, the percentage of adults consuming above a risk threshold of 1 in 1,000 ranged from 20.6% to 32.9% for women and from 35.4% to 54.0% for men. Lifetime risk of premature mortality under current guideline maximums ranged from 2.5 to 44.8 deaths per 1,000 women in Finland and Estonia respectively, and from 2.9 to 35.8 deaths per 1,000 men in Finland and Estonia respectively. If based upon an acceptable risk of 1 in 1,000, guideline maximums for Europe should be 8-10 g/day for women and 15-20 g/day for men.

Conclusions: If low-risk alcohol guidelines were based on an acceptable risk of 1 in 1,000 premature deaths, then maximums for Europe should be 8-10 g/day for women and 15-20 g/day for men, and some of the current European guidelines would require downward revision.

Keywords: Guideline; Alcohol; Mortality; Chronic Disease; Infection; Wounds; Injuries

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Introduction

The consumption of alcohol causes a substantial burden of communicable and non-communicable diseases, as well as injuries [1-4]. In hopes of reducing this burden, many countries have implemented drinking guidelines [5, 6]. The implementation of such guidelines fits well with the modern ideal of a consumer society, with well-informed consumers putatively conforming their behaviour based on advice from governmental, research, and professional sources [5]. Over time, the aim of drinking guidelines has changed from the designations of “safe” or “sensible” guidelines to the designation of “low-risk” guidelines, as research has indicated for a number of health outcomes, such as gastrointestinal diseases, cancer and injuries, that there is no safe level of alcohol consumption [1, 7-9].

There has been a lack of consistency on how drinking guidelines are formulated [10]. Differences in the methodologies used to formulate guidelines contribute to variations in guidelines between countries and to inconsistent information being disseminated about what constitutes low-risk drinking, creating confusion for consumers and health care professionals. While there have been thorough efforts trying to summarize the available empirical evidence (e.g., [11, 12]), guideline thresholds of low-risk alcohol consumption are often set by a group of independent experts, and in some cases community stakeholders (i.e. blue ribbon committees), based on average alcohol consumption relative risk (RR) curves for all-cause or selected disease mortality.

The RR curves used to estimate the threshold for low-risk drinking are problematic due to two factors. Firstly, the all-cause mortality RRs are estimated based on large, non-representative cohort studies; these studies are constructed for ease of follow-up, and their findings may be biased when applied to the general population by the over-representation of deaths that occur in the middle class population compared to other segments of the general population, such as deaths caused by cardiovascular diseases [13, 14]. Secondly, these RR estimates are usually derived from large cohort studies which took place in one country; however, many country-specific factors determine the impact on health of the average volume of alcohol consumed, contributing to country variations in cause-of-death structures. In particular, genetics can modify the impact of alcohol on health. For example, for populations with a high prevalence of the *ALDH2* gene (the “flushing gene”), alcohol can have a much higher impact on the development of cancer [15, 16]. Additionally, alcohol interacts with other risk factors, such as smoking and drug use, and these interactions determine, in part, the impact of alcohol on health [17, 18]. Furthermore, environmental factors modify the impact of alcohol on health (e.g., highway safety modifies the impact of alcohol on traffic injuries) [7]. Lastly, competing risks (i.e., mortality that occurs before an alcohol-attributable death would be observed) modify the impact of alcohol on health. For instance, mortality from cancer generally occurs later in life than does mortality from injuries, and, thus, alcohol’s impact on cancer is more strongly impacted by competing risks when compared to other alcohol-related diseases and injuries. However, the impact of these factors on cause-of-death structures at low levels of alcohol consumption (<20 grams of pure alcohol per day) is unknown.

Due to the limitations in the current guidelines' methodologies, the objectives of this paper are:

1. to present and assess a new methodology for the systematic formulation of low-risk drinking guidelines based on country-level lifetime mortality risks;
2. to assess the need for country-specific guidelines by estimating lifetime risks of an alcohol-attributable death in the European countries of Estonia, Finland, Germany, Hungary, Ireland, Italy and Poland (these countries were chosen to represent maximum heterogeneity with respect to drinking cultures and mortality profiles in Europe) (see the appendix and [8, 19]);
3. to assess the lifetime risk of an alcohol-attributable death for a person drinking the highest average daily alcohol consumption amount allowed by current guidelines; and
4. to assess the proportion of the population in each of the chosen countries that is drinking more alcohol than acceptable risk threshold levels.

Methods

Cause-of-death data were obtained from the World Health Organization [20]. Mortality data were obtained as the sex- and age-specific number of deaths in 2012, by 163 cause-of-death categorizations (see [20] and supplementary material). Population data were obtained from the United Nations [21]; all such data were obtained by sex and age (in 5-year age groups). Information on current low-risk alcohol drinking guidelines for each examined country was

obtained from the Joint Action on Reducing Alcohol Related Harm survey [22] and from Ireland's Department of Health, Health Service Executive [23].

Data on alcohol-attributable deaths for 2012 (deaths that would not have occurred under the counterfactual scenario of everyone being a lifetime abstainer) were based on the 2014 Global Status Report on Alcohol and Health (GSRAH) [1]. The appendix provides an overview of the diseases and injuries causally related to alcohol consumption as determined by the 2014 GSRAH [1] and by the Global Burden of Disease Study 2010 [24], except for HIV/AIDS which was not included due to the small number of alcohol-attributable HIV/AIDS deaths in Europe [25]. Furthermore, RRs for these diseases and injuries were obtained from meta-analyses by sex and level of drinking (see appendix). The data sources for RRs were the same as in recent Comparative Risk Assessments [1, 24], except for ischemic heart disease and ischemic stroke which have since been updated ([26] based on [27]). These are the most up-to-date and robust estimates of RRs [1, 24]. Furthermore, these RR functions are similar to other recent meta-analyses, as the majority of the study estimates contained in these meta-analyses are the same [24].

Lifetime risk calculations

In order to assess the lifetime risk of an alcohol-attributable death under various consumption amounts, the lifetime risk of an alcohol-attributable death was modelled using 1 gram intervals for people who consumed on average 1 to 40 grams (g) of alcohol per day, and using 10 gram

intervals from 40 to 100 g/day (see appendix). Risks were calculated for people aged 15-74 years, as in older ages there is considerable misclassification of the cause of death [28-30], and in younger ages alcohol-attributable deaths are rare [1].

The first step in assessing the lifetime risk of an alcohol-attributable death, for each country, was to estimate the absolute age- and country-specific mortality risk for lifetime abstainers on the basis of non-sex-specific mortality and population data for the year 2012 (results using sex-specific mortality are outlined in the supplemental material). For this, the cause-specific alcohol-attributable deaths, by age, were subtracted from the overall deaths from that cause. The result of this subtraction was divided by the mid-year population to estimate the cause-specific mortality risk per person per year for a lifetime abstainer. Next, for all modelled consumption amounts (see details in [31]), the RRs (adverse or protective as compared to lifetime abstention) were estimated from a continuous RR function, by cause of death. Thereafter, the cause-specific risk for lifetime abstainers was multiplied by the cause-specific excess RR (the RR minus 1) at each alcohol consumption level (see formula in the appendix). These cause-specific risks were combined to estimate sex- and age-specific mortality risks for an alcohol-attributable death. Lastly, sex- and age-specific alcohol-attributable mortality risks and non-alcohol-attributable mortality risks (competing risk of death) were used to estimate the lifetime risk of an alcohol-attributable death. A more detailed description of the methodology is outlined in the appendix.

Data on drinking behaviours and alcohol consumed were obtained from the Global Information System on Alcohol and Health (GISAH) [20]. Specifically, these drinking behaviours include the prevalence of current drinkers (those who have consumed at least one standard drink of alcohol in the past year) and current abstainers (those who have not consumed at least one standard drink of alcohol in the past year), as well as the adult *per capita* consumption of alcohol (PCA) (the amount of alcohol consumed at the population level from recorded, unrecorded and tourist sources (see [20])). The proportion of the population consuming alcohol above various risk thresholds was modelled for the European Union and the 7 individual European countries for 2012 using data from the GISAH according to the methods of Rehm and colleagues using 80% of PCA [32, 33].

Uncertainty estimation

Uncertainty was calculated by means of Monte Carlo methodology with 40,000 simulations of the lowest level parameters [34]. The 2.5 and 97.5 percentiles of each sex-, country- and alcohol consumption-specific lifetime mortality risk simulated distribution were used as approximations for 95% confidence intervals (CI).

Definition of acceptable risk

An acceptable level of risk tends to be defined differently for voluntary behaviours (such as alcohol drinking, smoking, etc. [35]) compared to risks from involuntary exposures (e.g., air pollution [36-38]); (for background of the distinction between voluntary and involuntary risk, see

[35, 39-41]). The conclusion of Starr's analysis (see [35] p. 1237) can be used to estimate acceptable voluntary risk, namely that the public is willing to accept "voluntary" risks roughly 1,000 times greater than "involuntary" risks (see [35] and [8]).

A one in one million lifetime mortality risk has become somewhat of a gold standard of acceptable risk for involuntary exposure, and has been used in different areas such as water safety in Australia and the US [36, 37] and for increases in exposure to carcinogens in air, sediment or soil [38]. Dividing this risk by 1,000 (the ratio from Starr (see [35]) for acceptable levels of involuntary versus voluntary risk) leads to a maximum acceptable voluntary risk of 1 in 1,000 [35]. However, it should be noted that other definitions of acceptable voluntary risk have been used [38]. For the Australian guidelines [11] and the UK guidelines [12], implicitly a standard of 1 in 100 was used, which standard we used for sensitivity analyses.

Results

If in 2012 all people consumed alcohol at current country-specific guideline thresholds, we would have observed for men an estimated range in the alcohol-attributable lifetime premature mortality risk of 2.5 deaths per 1,000 in Finland (maximum of 20 g/day) to 44.8 deaths per 1,000 in Estonia (maximum of 40 g/day) (see Table 1). For women, we would have observed an estimated range in the alcohol-attributable lifetime premature mortality risk of 2.9 deaths per 1,000 in Finland (maximum of 10 g/day) to 35.8 deaths per 1,000 in Estonia (maximum of 20 g/day). The amount of alcohol that leads to the lowest alcohol-attributable premature mortality risk is outlined in the

supplemental material. The alcohol-attributable lifetime premature mortality risks at maximum consumption levels within the current alcohol drinking guidelines are greater than 1 in 1,000 for all countries examined. Furthermore, Poland and Estonia had alcohol-attributable lifetime premature mortality risks above 1 in 100 under current guideline maximums.

< Insert Table 1 about here >

Figure 1 outlines the lifetime risk of an alcohol-attributable death up to 74 years of age for various levels of alcohol consumption. Among men, alcohol consumption of 10g/day over a lifetime was associated with a protective rather than a detrimental effect in most investigated countries (only Estonian men experienced a detrimental effect at 10 g/day). In contrast, among women, consuming 10 g/day was protective in only one country (Poland) and was detrimental in the remaining countries.

< Insert Figure 1 about here >

At lower levels of alcohol consumption, the alcohol-attributable lifetime premature mortality risk did not vary appreciably by country. Women who consumed 10 g/day had a risk higher than the risk threshold of 1 in 1,000 in Estonia, Finland, Italy and Germany, and women who consumed 20 g/day had a risk higher than this threshold in all countries examined. For men, those who consumed 10 g/day in Estonia had a risk higher than this threshold, and those who consumed 20

g/day had a risk higher than this threshold in all other countries, except for Poland, where men who consumed 30 g/day had a risk higher than this threshold.

At higher levels of alcohol consumption, the alcohol-attributable lifetime premature mortality risk varied appreciably by country. Estonia had the highest alcohol-attributable lifetime premature mortality risk at all levels of alcohol consumption for both men and women, while Italy had the lowest alcohol-attributable lifetime premature mortality risk for both men and women at all levels of alcohol consumption. At the highest level of consumption examined (100 g/day), for men, the alcohol-attributable lifetime premature mortality risk ranged from 88.7 per 1,000 (95% CI: 67.6 to 100.7) in Italy to 237.4 per 1,000 (95% CI: 201.8 to 272.0) in Estonia. For a woman who consumed on average 100 g/day, the alcohol-attributable lifetime premature mortality risk ranged from 172.6 per 1,000 (95% CI: 138.8 to 216.5) in Italy to 526.2 per 1,000 (95% CI: 444.7 to 652.0) in Estonia. This can be attributed to the different underlying age-specific risks of death from causes that are causally related to alcohol consumption in these countries [42], such as cardiovascular diseases and cancer which are also impacted by other risk factors such as tobacco and obesity [43], and injuries which are affected by injury prevention efforts [44], and differences in the age-specific risks of competing causes of death.

With the assumption that there is the same level of risk for male and female non-drinkers, the same level of alcohol consumption leads to higher absolute mortality risks for women than for

men in all countries examined. This reflects the higher RRs given the same level of alcohol consumption for women compared to men for almost any alcohol-related disease or injury.

Table 2 outlines the prevalence of people, differentiated by sex, who consumed 10, 20, 30, 60 and 100 g/day, resulting in a lifetime premature mortality risk above 1 in 1,000. A large proportion of the adult population in the examined countries drank amounts of alcohol above the mortality risk limit of 1 in 1,000. For women, this proportion ranged from 20.6% of the population in Poland to 32.9% of the population in Germany, while for men, this proportion ranged from 35.4% of the population in Italy to 54.0% of the population in Estonia. Furthermore, in the European Union, 2.6% of all adult women (3.7% of all adult female drinkers) and 13.7% of all adult men (19.2% of all adult male drinkers) consumed on average more than 60 g/day, and thus were chronic heavy drinkers.

< Insert Table 2 about here >

Discussion

If based on a maximum voluntary lifetime premature mortality risk of 1 in 1,000, guidelines for Europe should indicate that alcohol consumption should not exceed 7 to 13 g/day for women and 7 to 20 g/day for men. Even using a risk of 1 in 100, alcohol consumption should not exceed 11 to 19 g/day for women and 17 to 34 g/day for men. Secondly, coupling alcohol consumption data with lifetime risk estimates indicates that a large proportion of the examined populations drank at

risky levels. Thirdly, although the risks at high levels of consumption differed between countries, there was much less variation in these risks at levels relevant for setting low-risk guidelines.

< Insert Box 1 about here >

This is the first study to systematically determine thresholds for low-risk alcohol consumption by accounting for competing risks and using an acceptable maximum premature mortality risk threshold used for other risks. The lifetime risk method is easier to understand and clearer to communicate [45], uses established thresholds for acceptable lifetime premature mortality risks [8, 46] which can be changed if there is social consensus, and allows for a comparison of lifetime mortality risk from alcohol consumption with other risk factors. As indicated above, there may be other standards used for involuntary risk, both more or less strict (see above and [47]). The chosen threshold of 1 in 1,000 would be in line with recommendations for food with respect to carcinogenicity [48], or with the considerations of the UK Health and Safety Executive ([47], pp. 44ff.). One way to escape the arbitrariness of thresholds would be for international organizations such as the World Health Organization or the United Nations to establish a single standard for all behavioural risk factors [49].

Limitations

Our study is subject to limitations. Firstly, the reported risks are based on average consumption, and not on drinks consumed per drinking occasion. For instance, for persons engaged in heavy

episodic drinking (consuming ≥ 60 g on at least one occasion monthly), there is no protective effect of alcohol consumption on ischemic cardiovascular diseases [50, 51]. Furthermore, drinking patterns affect the risk of injury, whereby the risk of injury is lower for people who consume a consistent amount of alcohol over many days than for people who consume the same amount on fewer occasions (this mortality risk due to drinking patterns may also be different by country due to differences in, for example, road safety [1]). In this sense, the current calculations may be conservative, and taking into account drinking patterns would lead to lower average guidelines, as the alcohol-attributable mortality risk decreases at average moderate drinking levels, the more that the same amount of alcohol consumed is spread out over time, i.e., the lower the variance, and the more similar the drinking patterns are over time [52].

Secondly, statistical models are only as good as their input. The RRs were obtained from meta-analyses, which have been based on studies where participants may have underestimated their drinking, likely leading to higher guidelines. Unfortunately, while there is literature on the average level of underestimation of general population surveys [53, 54], the coverage rate of epidemiological studies is not that clear, as different methods of assessment yield different results [55], and the gold standard is not clear, since sales or other administrative statistics for specific groups of people are not available. The use of food frequency questionnaires in more medical epidemiology settings may yield different results, as those questionnaires have been successfully validated and have yielded higher average consumption levels in experimental research [55-58]. Furthermore, the underlying RRs upon which the meta-analyses are based use lifetime abstainers

as a reference category which leads to various biases [59], including a proportion of former drinkers being misclassified as lifetime abstainers leading to an underestimation of the RRs [60]. Lastly, as previously mentioned, the underlying cohort studies upon which the RRs are in part based typically follow middle-class participants who are middle aged, and, thus, the cause-specific RRs from these studies may not apply to other segments of the general population [13, 14].

Thirdly, as with all other guidelines, alcohol-attributable health harms to others (such as low birth weight [61], traffic injuries [9], and violence [62]) were not accounted for, as guidelines are intended to inform drinkers about risks to themselves. Furthermore, this study was limited to alcohol's impact on mortality, and did not include (i) risk tolerance differences between countries and cultures [63], (ii) alcohol's impact on society, the economy, or morbidity, or (iii) the pleasure that people may obtain from drinking (an internal measure, which has been shown to be hard to quantify [64]), as guidelines for risk factors are currently set based on mortality alone [1].

Lastly, cohort studies have observed that women have a higher risk of death per gram of pure alcohol consumed even at smaller amounts when compared to men [65]. However, men have a higher overall risk of death from all causes when compared to women. Therefore, if the underlying risk of death for men and for women were not combined, we would obtain estimates of the risk of an alcohol-attributable death by sex that are low for women when compared with results observed in cohort studies (although there is a bias in cohort studies towards certain

causes of death when compared to the general population) [66-68]. To lessen the differences between the lifetime risk of an alcohol-attributable death reported in this paper and the sex-specific risks of alcohol-attributable death obtained from observational studies, we performed an analysis combining the age and cause-specific risk of death by sex.

To address these limitations, cause-specific mortality studies are needed which address the effects of patterns as well as levels of drinking. Such studies will allow improved estimation of low-risk thresholds for consumption per drinking occasion.

Research is also needed on the health risks to others than the drinker, as such risks have been observed to be substantial [69]; for instance, in Australia in 2008, 387 deaths and 14,000 hospitalizations occurred due to the drinking of others, representing a mortality risk higher than 1 in 1,000 deaths and a hospitalization risk of 0.5 in 1,000 [69]. In this light, there would be substantial justification on public health grounds for drinking guidelines to be based on an involuntary risk standard (one in one million). Such guidelines would be well below consumption of 10 g/day [8].

Comparison to previous studies

This study's methodology represents an improvement when compared to previous analyses. The majority of guidelines have been based on all-cause alcohol RR curves. The use of these RRs should be avoided, as their generalizability is limited since there are marked differences in cause-

of-death structures across countries and time [49], and because the cohorts are often selected for the ease of follow-up rather than to be representative [70]. The Australian low-risk drinking guidelines (and the UK drinking guidelines which were based on the Australian methodology) used a different approach [11, 71]. The low-risk alcohol consumption threshold of the Australian guidelines was formulated using a lifetime risk approach [11], based on risks disaggregated by sex and cause of death. However, the Australian guidelines have limitations compared to this study. Firstly, the guidelines do not include the protective effects of alcohol, as the existence of these effects was controversial [11] (the UK guidelines added in the protective effects of alcohol [71]). Secondly, the guidelines are based on the now out-of-date 2004 Comparative Risk Assessment study methodology [72]. Thirdly, the lifetime risk was calculated by summing alcohol-attributable mortality risk across age groups, and therefore did not account for the risk of dying from competing causes of death. However, the methodology of the Australian and UK guidelines does produce estimates of low-risk consumption which are in line with our findings [11, 71].

The methodology presented in this manuscript overcomes weaknesses in previous methodologies by using a lifetime risk approach based on acceptable limits used for other behavioural risks, accounting for competing risks, and including the protective effects of alcohol. The findings of this study indicate that current thresholds for low-risk drinking guidelines are higher than what is considered acceptable for other consumptive behaviours, and confirm observations that alcohol is commonly consumed in Europe at risky levels [73].

Clinical and public health applications

The findings of this study have multiple clinical and public health applications. The limited variation in the lifetime risk of an alcohol-attributable death between European countries at levels relevant for setting alcohol drinking guidelines suggests that a common threshold for low-risk drinking in Europe is appropriate – for instance at 7-13 g/day for women and 7-20 g/day for men – which would keep the lifetime risk of an alcohol-related death either below or close to 1 in 1,000. Such agreement would inform policy decisions regarding screening for alcohol abuse and/or dependence and for health information printed on labels of alcoholic beverage containers. However, other avenues used to decrease alcohol's harms, such as taxation increases and availability restrictions, should also be implemented [74]. Low-risk guidelines are a potential educational and persuasive tool, but are only a single element of effective policies to reduce harms from hazardous alcohol consumption [8].

Conclusions

If drinking guidelines are based on a threshold of 1 in 1,000 as an acceptable mortality risk from behavioural risk factors, then most current guidelines in most European countries are in need of downward revision. Taking into consideration the harms to others caused by alcohol, this situation is further exacerbated. Revising the levels defined as low-risk consumption based on scientific evidence and making explicit the considerations underpinning the definition would best fulfill the central objective of drinking guidelines: to offer evidence-based guidance to the

citizenry on risk levels for a voluntary behaviour, which they can then balance against what they find positive about drinking in making decisions about their consumption levels.

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Completing interests

None declared

Ethics approval

Ethics approval was not required, as this study involved secondary data analyses only.

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Figures, tables and boxes

Box 1. Key messages of the study

Figure 1. Lifetime risk (up to 74 years of age) of an alcohol-attributable death for men and women in (A) Estonia, (B) Finland, (C) Germany, (D) Hungary, (E) Ireland, (F) Italy, and (G) Poland for different average daily alcohol consumption volumes

Table 1. Current country guidelines for low-risk average alcohol consumption amounts, risk of death under these guidelines, and average alcohol consumption limits based on an acceptable lifetime risk of 1 in 1,000 people and 1 in 100 people

Table 2. Prevalence of average daily alcohol intake for adult (15 years of age and older) women and men in 2012 in the European Union and in various European countries

Appendices

Supplemental material

Box 1. Key messages of the study

- A lifetime risk approach is presented for estimating alcohol-attributable deaths in seven European countries, taking into consideration competing risks.
- If drinking guidelines are based on the common thresholds for an acceptable lifetime mortality risk for other behavioural risk factors (i.e., 1 in 1,000), then most current European low-risk guideline maximums should be revised downward to 8 to 10 g/day for women and 15 to 20 g/day for men.
- Revising guideline thresholds for low-risk consumption downward based on scientific evidence of lifetime risk, as well as making the underpinning considerations explicit, would bring the manner in which alcohol risks are regarded in line with other behavioural risk factors.

Table 1. Current country guidelines for low-risk average alcohol consumption amounts, risk of death under these guidelines, and average alcohol consumption limits based on an acceptable lifetime risk of 1 in 1,000 people and 1 in 100 people

Sex	Country	Current guidelines on average daily consumption not to exceed (g/day)	Lifetime risk of death at guideline maximum (per 1,000 people)	Alcohol consumption (g/day) where lifetime risk of death equals 1 in 100	Alcohol consumption (g/day) where lifetime risk of death equals 1 in 1,000
Men	Estonia	40	44.8	17	7
	Finland	20	2.5	31	16
	Germany	24	5.7	30	14
	Hungary	Range (24 - 28)	(7.6-12.4)	26	17
	Ireland	24.3*	4.2	34	17
	Italy	24	5.7	31	13
	Poland	40	22.6	30	20
Women	Estonia	20	35.8	11	7
	Finland	10	2.9	15	7
	Germany	12	3.7	17	8
	Hungary	Range (18-21)	(18.9-27.6)	14	10
	Ireland	15.7*	6.0	19	10

Italy	12	3.1	18	9
Poland	20	14.1	18	13

* Up to 11 standard drinks among men and 17 standard drinks among women per week

Table 2. Prevalence of average daily alcohol intake for adult (15 years of age and older) women and men in 2012 in the European Union and in various European countries

Sex	Country	g/day that result in a lifetime risk above 1 in 1,000	> g/day that result in a lifetime risk above 1 in 1,000	≥ 10 g/day	≥ 20 g/day	≥ 30 g/day	≥ 60 g/day	≥ 100 g/day
Women	Estonia	7	31.7%	26.3%	15.1%	9.2%	2.4%	0.5%
	Finland	7	37.6%	32.1%	20.2%	13.2%	4.2%	1.0%
	Germany	8	39.2%	34.7%	19.8%	11.9%	3.0%	0.5%
	Hungary	10	33.1%	33.1%	19.2%	11.7%	3.0%	0.5%
	Ireland	10	32.1%	32.1%	17.5%	10.0%	2.2%	0.3%
	Italy	9	21.0%	19.3%	8.7%	4.2%	0.6%	0.1%
	Poland	13	20.6%	23.5%	15.4%	10.5%	3.6%	1.0%
	European Union	-	-	30.8%	17.4%	10.4%	2.6%	0.5%
Men	Estonia	7	54.0%	49.5%	38.1%	30.0%	15.3%	6.6%
	Finland	16	44.3%	52.1%	40.0%	31.4%	16.0%	6.8%
	Germany	14	49.2%	55.5%	41.5%	31.7%	15.0%	5.8%
	Hungary	17	49.1%	59.3%	45.4%	35.5%	18.0%	7.7%
	Ireland	17	42.7%	54.2%	38.8%	28.4%	11.9%	4.0%
	Italy	13	35.4%	41.6%	24.7%	15.2%	3.9%	0.7%
	Poland	20	37.8%	46.9%	37.8%	31.1%	18.0%	9.1%
	European Union	-	-	53.4%	39.1%	29.5%	13.7%	5.4%

Reference List

1. WORLD HEALTH ORGANIZATION (2014) *Global status report on alcohol and health* (Geneva, Switzerland, World Health Organization).
2. REHM, J., MATHERS, C., POPOVA, S., THAVORNCHAROENSAP, M., TEERAWATTANANON, Y. & PATRA, J. (2009) Global burden of disease and injury and economic cost attributable to alcohol use and alcohol use disorders, *Lancet*, 373, 2223-2233.
3. FOROUZANFAR, M. H.ALEXANDER, L.ANDERSON, H. R.BACHMAN, V. F.BIRYUKOV, S.BRAUER, M. et al. (2015) Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks in 188 countries, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013, *Lancet*, 386, 2287-323.
4. GBD 2015 RISK FACTORS COLLABORATORS (2016) Global, regional, and national comparative risk assessment of 79 behavioral, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015, *Lancet* 388, 1659-1724.
5. ROOM, R. & REHM, J. (2012) Clear criteria based on absolute risk: reforming the basis of guidelines on low-risk drinking, *Drug and Alcohol Review*, 31, 135-140.
6. STOCKLEY, C. S. (2007) Recommendations on alcohol consumption: an international comparison, *Contemporary Drug Problems*, 34, 681-714.
7. REHM, J., BALIUNAS, D., BORGES, G. L., GRAHAM, K., IRVING, H. M., KEHOE, T. et al. (2010) The relation between different dimensions of alcohol consumption and burden of disease - An overview, *Addiction*, 105, 817-843.
8. REHM, J., LACHENMEIER, D. W. & ROOM, R. (2014) Why does society accept a higher risk for alcohol than for other voluntary or involuntary risks?, *BMC Medicine*, 12, 189.
9. HURST, P., HARTE, W. & FIRTH, W. (1994) The Grand Rapids dip revisited, *Accident Analysis and Prevention*, 26, 647-654.

10. REHM, J., ROOM, R. & TAYLOR, B. (2008) Method for moderation: measuring lifetime risk of alcohol-attributable mortality as a basis for drinking guidelines, *International Journal of Methods in Psychiatric Research*, 17, 141-151.
11. NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL (2009) *Australian guidelines to reduce health risks from drinking alcohol* (Canberra, Australia, Commonwealth of Australia).
12. NATIONAL HEALTH AND MEDICAL RESEARCH COUNCIL (2016) *Alcohol Guidelines Review - Report from the Guidelines development group to the UK Chief Medical Officers* (London, United Kingdom: Department of Health).
13. REHM, J. (2000) Alcohol consumption and mortality. What do we know and where should we go?, *Addiction*, 95, 989-995.
14. REHM, J., GMEL, G., SEMPOS, C. & TREVISAN, M. (2003) Alcohol-related mortality and morbidity, *Alcohol Research & Health*, 27, 39-51.
15. ROERECKE, M., SHIELD, K. D., HIGUCHI, S., YOSHIMURA, A., LARSEN, E., REHM, M. X. et al. (2015) Estimates of alcohol-related oesophageal cancer burden in Japan: systematic review and meta-analyses, *Bulletin of the World Health Organization*, 93, 329-338c.
16. BROOKS, P. J., ENOCH, M. A., GOLDMAN, D., LI, T. K. & YOKOYAMA, A. (2009) The alcohol flushing response: an unrecognized risk factor for esophageal cancer from alcohol consumption, *PLoS Medicine*, 6, 258-263.
17. KUPER, H., TZONOU, A., KAKLAMANI, E., HSIEH, C. C., LAGIOU, P., ADAMI, H. O. et al. (2000) Tobacco smoking, alcohol consumption and their interaction in the causation of hepatocellular carcinoma, *International Journal of Cancer*, 85, 498-502.
18. LIEBER, C. S. (1990) Interaction of alcohol with other drugs and nutrients, *Drugs*, 40, 23-44.
19. POPOVA, S., REHM, J., PATRA, J. & ZATONSKI, W. (2007) Comparing alcohol consumption in central and eastern Europe to other European countries, *Alcohol and Alcoholism*, 42, 465-473.
20. WORLD HEALTH ORGANIZATION (2015) *Global Health Observatory: mortality and global health estimates* (Geneva, Switzerland: World health Organization).

21. UNITED NATIONS (2013) *World Population Prospects: The 2012 Revision* (New York, USA, United Nations).
22. SCAFATO, E., GALLUZZO, L., GHIRINI, S. & GANDIN, C. (2014) Where do EU Countries set the limit for low risk drinking. Results from the EU RARHA survey *6th European Alcohol policy conference* (Brussels, Belgium). Archived by WebCite® at <http://www.webcitation.org/6IHTbxoYg> (accessed 15 October 2016)
23. HEALTH SERVICES EXECUTIVE (2017) *Alcohol Programme* (Health Services Executive; Dublin, Ireland).
24. LIM, S. S.VOS, T.FLAXMAN, A. D.DANAEI, G.SHIBUYA, K.ADAIR-ROHANI, H. et al. (2012) A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010 *Lancet* 380, 2224-2260.
25. GMEL, G., SHIELD, K. & REHM, J. (2011) Developing a methodology to derive alcohol-attributable fractions for HIV/AIDS mortality based on alcohol's impact on adherence to antiretroviral medication, *Population Health Metrics*, 9, 5.
26. REHM, J., SHIELD, K. D., ROERECKE, M. & GMEL, G. (2014) *Modelling the impact of alcohol consumption on cardiovascular disease mortality for comparative risk assessments: an overview* (Toronto, Canada, Centre for Addiction and Mental Health).
27. ROERECKE, M. & REHM, J. (2014) Alcohol consumption, drinking patterns, and ischemic heart disease: a narrative review of meta-analyses and a systematic review and meta-analysis of the impact of heavy drinking occasions on risk for moderate drinkers, *BMC Medicine*, 12, 182.
28. COLEMAN, M. P. & AYLIN, P. (2000) *Death certification and mortality statistics: an international perspective (Studies on medical and population subjects # 64)* (London, UK, The Stationary Office).
29. HARTELOH, P., DE BRUIN, K. & KARDAUN, J. (2010) The reliability of cause-of-death coding in the Netherlands, *European Journal of Epidemiology*, 25, 531-538.

30. ALPÉROVITCH, A., BERTRAND, M., JOUGLA, E., VIDAL, J. S., DUCIMETIÈRE, P. & HELMER, C. (2009) Do we really know the cause of death of the very old? Comparison between official mortality statistics and cohort study classification, *European Journal of Epidemiology*, 24, 669-675.
31. REHM, J., GMEL, G., PROBST, C. & SHIELD, K. D. (2015) *Lifetime-risk of alcohol-attributable mortality based on different levels of alcohol consumption in seven European countries. Implications for low-risk drinking guidelines* (Toronto, Canada, Centre for Addiction and Mental Health).
32. REHM, J., KEHOE, T., GMEL, G., STINSON, F., GRANT, B. & GMEL, G. (2010) Statistical modeling of volume of alcohol exposure for epidemiological studies of population health: the example of the US, *Population Health Metrics*, 8, 3.
33. KEHOE, T., GMEL, G., JR., SHIELD, K., GMEL, G., SR. & REHM, J. (2012) Determining the best population-level alcohol consumption model and its impact on estimates of alcohol-attributable harms, *Population Health Metrics* 10, 6.
34. GMEL, G. J., SHIELD, K. D., FRICK, H., KEHOE, T., GMEL, G. & REHM, J. (2011) Estimating uncertainty of alcohol-attributable fractions for infectious and chronic diseases, *BMC Medical Research Methodology*, 11, 48.
35. STARR, C. (1969) Social benefit versus technological risk, *Science*, 165, 1232-1238.
36. NATIONAL HEALTH MEDICAL RESEARCH COUNCIL (2004) *Australian drinking water guidelines, Canberra: National Health and Medical Research Council* (Canberra, Australia, National Health and Medical Research Council).
37. HUNTER, P. R. & FEWTRELL, L. (2001) Acceptable risk, in: Fewtrell, L. & Bartram, J. (Eds.) *Water quality: guidelines, standards and health*, pp. 207-227 (London, UK, IWA Publishing).
38. RIFKIN, E. & BOUWER, E. (2007) *The Illusion of Certainty: Health Benefits and Risks* (New York, USA, Springer).
39. KAHNEMAN, D. (2011) *Thinking Fast and Slow* (New York, Farrar, Straus and Giroux).

40. FISCHHOFF, B., LICHTENSTEIN, S., SLOVIC, P., DERBY, S. L. & KEENEY, R. L. (1981) *Acceptable risk* (Cambridge, UK, Cambridge University Press).
41. SLOVIC, P. (1987) Perception of Risk, *Science*, 236, 280-285.
42. GBD 2015 MORTALITY AND CAUSES OF DEATH COLLABORATORS (2016) Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015, *Lancet*, 388, 1459-1544.
43. MOKDAD, A. H., FOROUZANFAR, M. H., DAOUD, F., MOKDAD, A. A., EL BCHERAOU, C., MORADI-LAKEH, M. et al. (2016) Global burden of diseases, injuries, and risk factors for young people's health during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013, *Lancet*, 387, 2383-2401.
44. HAAGSMA, J. A., GRAETZ, N., BOLLIGER, I., NAGHAVI, M., HIGASHI, H., MULLANY, E. C. et al. (2016) The global burden of injury: incidence, mortality, disability-adjusted life years and time trends from the Global Burden of Disease study 2013, *Injury Prevention*, 22, 3-18.
45. GIGERENZER, G. (2013) *Risk Savvy: How to Make Good Decisions* (New York, USA, Penguin).
46. BLASTLAND, M. & SPIEGELHALTER, D. (2013) *The Norm chronicles. Stories and number about risk* (London, UK, Profile).
47. HEALTH & SAFETY EXECUTIVE (2001) *Reducing risks, protecting people: HSE's decision-making process* (Norwich, UK, Crown).
48. LACHENMEIER, D. W., PRZYBYLSKI, M. C. & REHM, J. (2012) Comparative risk assessment of carcinogens in alcoholic beverages using the margin of exposure approach, *International Journal of Cancer*, 131, E995-E1003.
49. REHM, J. & PATRA, J. (2012) Different guidelines for different countries? On the scientific basis of low-risk drinking guidelines and their implications, *Drug and Alcohol Review*, 31, 156-161.

50. ROERECKE, M. & REHM, J. (2010) Irregular heavy drinking occasions and risk of ischemic heart disease: a systematic review and meta-analysis, *American Journal of Epidemiology*, 171, 633-644.
51. SUNDELL, L., SALOMAA, V., VARTIAINEN, E., POIKOLAINEN, K. & LAATIKAINEN, T. (2008) Increased stroke risk is related to a binge drinking habit, *Stroke*, 39, 3179-3184.
52. WALSH, G. & REHM, J. (1996) Daily drinking and harm, *Contemporary Drug Problems*, 23, 465-478.
53. MIDANIK, L. T. (1982) The validity of self-reported alcohol consumption and alcohol problems: a literature review, *British Journal of Addiction*, 77, 357-382.
54. REHM, J., KLOTSCH, J. & PATRA, J. (2007) Comparative quantification of alcohol exposure as risk factor for global burden of disease, *International Journal of Methods in Psychiatric Research*, 16, 66-76.
55. KING, A. C. (1994) Enhancing the self-report of alcohol consumption in the community: two questionnaire formats, *American Journal of Public Health*, 84, 294-296.
56. WILLETT, W. (2012) *Nutritional epidemiology* (Oxford, UK, Oxford University Press).
57. GIOVANNUCCI, E., COLDITZ, G., STAMPFER, M. J., RIMM, E. B., LITIN, L., SAMPSON, L. et al. (1991) The assessment of alcohol consumption by a simple self-administered questionnaire, *American Journal of Epidemiology*, 133, 810-817.
58. REHM, J. (1998) Measuring quantity, frequency and volume of drinking, *Alcoholism: Clinical & Experimental Research*, 22, 4S-14S.
59. REHM, J., IRVING, H., YE, Y., KERR, W. C., BOND, J. & GREENFIELD, T. K. (2008) Are lifetime abstainers the best control group in alcohol epidemiology? On the stability and validity of reported lifetime abstinence, *American Journal of Epidemiology*, 168, 866-871.
60. ZEISSER, C., STOCKWELL, T. R. & CHIKRITZHS, T. (2014) Methodological biases in estimating the relationship between alcohol consumption and breast cancer: the role of drinker misclassification errors in meta-analytic results, *Alcoholism: Clinical & Experimental Research*, 38, 2297-2306.

61. PATRA, J., BAKKER, R., IRVING, H., JADDOE, V. W. V., MALINI, S. & REHM, J. (2011) Dose-response relationship between alcohol consumption before and during pregnancy and the risks of low birthweight, preterm birth and small for gestational age (SGA)-a systematic review and meta-analyses, *International Journal of Obstetrics and Gynaecology*, 118, 1411-1421.
62. EVANS, C. M. (1980) Alcohol, violence and aggression, *Alcohol and Alcoholism*, 15, 104-117.
63. WEBER, E. U. & HSEE, C. (1998) Cross-cultural differences in risk perception, but cross-cultural similarities in attitudes towards perceived risk, *Management science*, 44, 1205-1217.
64. JOHANSSON, P., JARL, J., ERIKSSON, A., ERIKSSON, M., GERDTHAM, U., HEMSTRÖM, Ö. et al. (2006) The social costs of alcohol in Sweden 2002 (Stockholm, Sweden, SoRADs Stockholm University)
65. SHIELD, K. D., PARRY, C. & REHM, J. (2013) Focus on: Chronic diseases and conditions related to alcohol use, *Alcohol Research* 85, 2.
66. GAZIANO, J. M., GAZIANO, T. A., GLYNN, R. J., SESSO, H. D., AJANI, U. A., STAMPFER, M. J. et al. (2000) Light-to-moderate alcohol consumption and mortality in the Physicians' Health Study enrollment cohort, *Journal of the American College of Cardiology*, 35, 96-105.
67. FUCHS, C. S., STAMPFER, M. J., COLDITZ, G. A., GIOVANNUCCI, E. L., MANSON, J. E., KAWACHI, I. et al. (1995) Alcohol consumption and mortality among women, *The New England Journal of Medicine*, 332, 1245-1250.
68. SHAPER, A. (1990) Alcohol and mortality: a review of prospective studies, *British Journal of Addiction*, 85, 837-847.
69. LASLETT, A. M., CATALANO, P., CHIKRITZHS, T., DALE, C., DORAN, C., FERRIS, J. et al. (2010) *The range and magnitude of alcohol's harm to others* (Fitzroy, Australia, Turning Point Alcohol & Drug Centre).
70. ROTHMAN, K. J., GREENLAND, S. & LASH, T. L. (2008) *Modern Epidemiology*, 3rd ed (Philadelphia, USA, Lippincott Williams & Wilkins).

71. HOLMES, J., ANGUS, C., BUYKX, P., ALLY, A., STONE, T., MEIER, P. et al. (2016) Mortality and morbidity risks from alcohol consumption in the UK: Analyses using the Sheffield Alcohol Policy Model (v.2.7) to inform the UK Chief Medical Officers' review of the UK lower risk drinking guidelines, Sheffield, UK: Sheffield, U. o.
72. REHM, J., ROOM, R., MONTEIRO, M., GMEL, G., GRAHAM, K., REHN, N. et al. (2004) Alcohol Use, in: Ezzati, M., Lopez, A. D., Rodgers, A. & Murray, C. J. L. (Eds.) *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors*, pp. 959-1109 (Geneva, Switzerland, World Health Organization).
73. LACHENMEIER, D. W. & REHM, J. (2015) Comparative risk assessment of alcohol, tobacco, cannabis and other illicit drugs using the margin of exposure approach, *Scientific Reports*, 5, 8126.
74. ANDERSON, P., CHISHOLM, D. & FUHR, D. (2009) Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol, *Lancet*, 373, 2234-2246.

(A) Estonia

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