Comparative quantification of alcohol exposure as risk factor for global burden of disease

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Abstract

Alcohol has been identified as one of the most important risk factors in the burden experienced as a result of disease. The objective of the present contribution is to establish a framework to comparatively quantify alcohol exposure as it is relevant for burden of disease. Different key indicators are combined to derive this quantification. First, adult per capita consumption, composed of recorded and unrecorded consumption, yields the best overall estimate of alcohol exposure for a country or region. Second, survey information is used to allocate the per capita consumption into sex and age groups. Third, an index for detrimental patterns of drinking is used to determine the additional impact on injury and cardiovascular burden. The methodology is applied to estimate global alcohol exposure for the year 2002. Finally, assumptions and potential problems of the approach are discussed. Copyright © 2007 John Wiley & Sons, Ltd.

Key words: alcohol, burden of disease, adult per capita consumption, patterns of drinking, average volume of consumption

Introduction

In the World Health Organization Comparative Risk Assessment (CRA) Study (Ezzati et al., 2002, 2004; WHO, 2002; World Advertising Research Center Ltd, 2005) alcohol proved to be one of the most important risk factors for global burden of disease, ranking fifth just behind tobacco. This alcohol-attributable global burden of disease in 2000 amounted to 4.0% of the overall burden of disease as measured in disability-adjusted life years compared to 4.1% for tobacco (for details on alcohol exposure as risk factor see Rehm et al., 2003a, c, 2004). Only underweight (resulting mainly from malnutrition and underfeeding), unsafe sex and high blood pressure had more impact on global burden of disease than these two substances (WHO, 2002).

The CRA and its underlying umbrella study, the Global Burden of Disease Study (Murray and Lopez,

1996; Lopez et al., 2006), have introduced or refined many methodological advances in comparative epidemiology, such as the concept of disability-adjusted life years as a gap measure (comparing to an ideal standard, in this case living without disability with the highest life expectancy possible), methods to consistently estimate key epidemiological indicators for a country (for example, incidence, prevalence, case fatality, relative risk for mortality, duration) and the reallocation of 'not otherwise specified' mortality into specific death categories. All of these methodological changes help in the comparison of mortality and burden of disease between different countries and regions. This article aims to add knowledge in this field by describing a method to compare the impact of risk factors on mortality and morbidity in different countries (for general discussion on comparability of risk factors see Murray and Lopez,

1999; Murray et al., 2003; for details on alcohol as a risk factor see Rehm et al., 2001b, 2003b, 2004). The present contribution will not give details on the overall framework of comparison, but will restrict itself to describing how alcohol could be measured in a comparative fashion. In addition, it specifies how exactly alcohol exposure was estimated in the ongoing analyses of alcohol-attributable burden of disease for 2002.

Indicators of alcohol exposure on a country level

The following key indicators of exposure are involved in estimating alcohol-related burden of disease (Rehm et al., 2004):

- adult per capita consumption of recorded alcohol;
- adult per capita consumption of unrecorded alcohol;
- prevalence of abstention by age and sex;
- prevalence of different categories of average volume of alcohol consumption by age and sex;
- score for patterns of drinking.

We will first discuss each of the indicators separately and then summarize the overall procedure to estimate exposure for alcohol-attributable burden of disease.

Adult per capita consumption of recorded alcohol

Per capita alcohol consumption is the sum total consumption of pure alcohol per inhabitant in litres in a given year. These data are available for the majority of countries, often in time series, and avoid the underestimation of total volume of consumption commonly seen in survey data because they are based on sales and production records and thus avoid the subjectivity of self-reports as well as inadequate sampling frames of modern household surveys (see below for further reasoning; for further discussions of the underestimation of alcohol consumption by survey methodology as well as other problems of measuring consumption by surveys see for example, Midanik, 1982; Rehm, 1998; Gmel and Rehm, 2004). Adult per capita consumption – consumption by everyone aged 15 and above – is regarded as preferable to total per capita consumption because alcohol is overwhelmingly consumed most by those 15 years and older. As the population age distribution varies in different countries (United Nations, 2005), so per capita consumption figures based on the total population tend to relatively underestimate consumption in countries where a higher proportion of the population is below age 15, as is the case in many developing

countries. For more information and guidance on estimating per capita consumption see the *International Guide for Monitoring Alcohol Consumption and Related Harm* (WHO, 2000).

How is per capita alcohol consumption measured? There are three principal sources of data for per capita estimates: national government data, data from the Food and Agriculture Organization of the United Nations (FAO), and data from the alcohol industry (Rehm et al., 2003b). National government data, where available, are the best and most reliable data. They are usually based on sales figures, tax revenue and/or production data. Their accuracy does depend on correct data on sales of alcoholic beverages and sales data are beverage specific. However, one of the drawbacks of production data is that they are always dependent on accurate export and import data, otherwise the production figures will yield an underestimation or an overestimation of the current situation.

The most complete and comprehensive international dataset on per capita consumption is published by the FAO. FAOSTAT, the database of the FAO, publishes production and trade data for almost 200 countries for different types of alcoholic beverages. The estimates are based on official reports of production by national governments, mainly as replies by individual country Ministries of Agriculture to an annual FAO questionnaire. Consequently, the accuracy of data in FAOSTAT relies on member nations reporting the data. The statistics on import and export derive mainly from customs departments and if these sources are not available, other government data such as statistical yearbooks are consulted.

The third main source of data comes from the alcohol industry. In this category the most widely used source is *World Drink Trends* (WDT), first published by the Commission for Distilled Spirits (World Advertising Research Center Ltd, 2005). The WDT estimates are based on total sales in litres divided by the total mid-year population and use conversion rates, which are not published. The WDT also tries to calculate the consumption of both incoming and outgoing tourists. Currently, at least partial data are available for 58 countries. There are other alcohol industry sources, as well as market research companies, which are less systematic, contain fewer countries, and are more limited in time scope.

The WHO Global Alcohol Database (GAD) (www3.who.int/whosis) systematically collects and compares

per capita data from different sources on a regular basis (for procedures and further information see WHO, 1999, 2004 and Rehm et al., 2003a) using UN data for population estimates. Since more than one potentially adequate data source for per capita data is available, the following four rules have been used to select the best data for each country:

- for all countries that are 'high income' in the World Bank classification,¹ and where there were WDT estimates, these estimates should be taken, as they are based on country-specific sales data;
- for all other countries where the WDT has used national government statistics, domestic alcohol industry statistics, or supplemented FAO information with additional local sources, WDT estimates should be used;
- for other countries, FAO estimates should be used;
- both FAO and WDT should be replaced if there are government estimates based on written documentation and including sales data for several years.

The use of government statistics as per capita estimates in the GAD has to be approved by the steering committee of GAD. Currently, there are government statistics only for a very small minority of countries. The decision tree specified above assumes the following hierarchy of validity and reliability of data (from most valid/reliable to least valid/reliable):

- government statistics based on sales and taxation data;
- alcohol industry statistics with country specific information on sales (WDT);
- FAO;
- alcohol industry statistics from global sources (this option only to be used when no FAO data exist for the country).

¹Countries classified as 'high income' according to the World Bank are: Andorra, Aruba, Australia, Austria, Bahamas, Bahrain, Belgium, Bermuda, Brunei Darussalam, Canada, Cayman Islands, Channel Islands, Cyprus, Denmark, Faeroe Islands, Finland, France, French Polynesia, Germany, Greece, Greenland, Guam, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Liechtenstein, Luxembourg, Monaco, Netherlands, Netherlands Antilles, New Caledonia, New Zealand, Northern Mariana Islands, Norway, Portugal, Qatar, Republic of Korea, San Marino, Singapore, Slovenia, Spain, Sweden, Switzerland, United Arab Emirates, United Kingdom, United States of America and United States Virgin Islands.

In practice, the algorithm means that many of the developed country estimates are based on either WDT or direct government data, while most estimates for the developing countries are based on FAO data. Sources correlate to a considerable degree (Pearson correlation = 0.74) (Rehm et al., 2003a), but it does not seem possible to find an overall explanation for the systematic differences in the data for all countries. Obviously one explanation is that the FAO estimates are based on production data whereas WDT is primarily based on sales data. This may lead to FAO estimates being higher, as FAO partly reflects production of beverages that do not show up in sales data either because it is so-called home production, for example the production of palm wine or sorghum beer in some African countries, or because WDT does not account for the whole range of beverage categories.

The main limitations of adult per capita estimates are twofold:

- They do not incorporate most of unrecorded consumption (see below).
- They are only aggregate statistics that cannot easily be disaggregated into sex and age groups. Thus, surveys have to play a crucial role in any analysis of risk of alcohol for burden of disease (see below).

For the ongoing efforts of the most recent CRA-type estimate of alcohol-attributable burden of disease for the year 2002, the year with the latest available data on burden of disease in different parts of the world (Mathers et al. 2003), we used an average of the adult per capita information for recorded consumption of three years 2001, 2002 and 2003 to get a more stable country estimate.

Adult per capita consumption of unrecorded alcohol

Unrecorded consumption stems from a variety of sources (Giesbrecht et al., 2000):

- home production of alcoholic beverages;
- illegal production and sale of alcoholic beverages;
- illegal and legal import of alcoholic beverages;
- other production and use of alcoholic beverages, not taxed and/or part of the official production and sales statistics.

Most of these categories are self-explanatory. However, the relation between legal import of alcoholic

beverages and unrecorded consumption needs further exploration. Consider Sweden as an example. Alcohol has been traditionally sold in monopoly stores. After joining the European Union (EU), the very generous travel allowances of the EU became law, which allowed anybody to import several hundred beer or wine bottles if these imports were claimed exclusively for personal use. As a result, recorded sales went down in parts of the country with borders near to countries with cheaper alcohol and this kind of unrecorded consumption went up. For the year 2002, it was estimated that about 30% of the total overall per capita consumption was unrecorded (see Leifman and Gustafsson, 2003, and the GAD database).

How is unrecorded consumption estimated? The Swedish data presented above were obtained from survey information, which are probably the most widely used source for estimating unrecorded consumption (Leifman, 2001). There are other methods, such as indirect calculations based on use of raw materials for alcohol production (for example, sugar or fruits), or based on certain indicators strongly related to overall alcohol consumption (for example, alcohol poisoning – Nemtsov, 1998, 2000).

For the estimated alcohol-attributable burden of disease for 2002, we took the country data on unrecorded consumption from the GAD. For countries where no estimate of unrecorded consumption existed and where there was World Health Survey (WHS) or other large representative survey indicating more consumption than the recorded consumption, we estimated unrecorded consumption from these surveys.

An example of the procedure is given in the following three-point profile. For Congo, the recorded consumption for 2002 amounted to 2.4 l per capita for adults. The abstention rates from the WHS were 48.3% for men and 60.9% for women. The average consumption based on a usual quantity-frequency measure (Gmel and Rehm, 2004) was 20.2 g pure alcohol per day for male and 14.2 g for female drinkers. This results in an estimated total adult per capita of 3.7 l pure alcohol. Applying a correction of under coverage due to bias in recalling usual drinking behaviour of 0.8 (assuming usual quantity and frequency cover 80% of overall consumption), the resulting adult per capita consumption would be 4.6 l pure alcohol. As a result, a value of 2.2 (4.6–2.4) was entered for unrecorded consumption for the Congo. This procedure was applied to six countries.

On the other hand, if the survey data were much lower than the recorded data only, for countries that had previous high estimates of unrecorded consumption (WHO, 2004), unrecorded consumption estimates were set to 0. This procedure of setting unrecorded consumption to zero was applied only to African countries, where the recorded per capita consumption was based on FAO estimates of production only and where it is likely that these estimates already incorporate some unrecorded consumption.

Prevalence of abstention by age and sex

Prevalence of abstention (usually past year) was assessed by surveys. Past-year abstention may introduce some error, however, if the risk relations are based on lifetime abstainers, because former drinkers who stopped drinking for health reasons have a higher risk of mortality and morbidity compared to lifetime abstainers (Shaper, 1990) and moderate drinkers (Rehm et al., 2001a). However, most studies in medical epidemiology are using current abstention. However, using lifetime abstention as a reference group will not result in an overestimation of burden since the proportion of current abstainers is far greater than lifetime abstainers.

For the current estimate of alcohol-attributable burden for the year 2002, large representative surveys completed as close to the year 2002 will be used. Data on abstention from these surveys is available from 118 out of 184 countries (64.1% of the countries), representing 92.8% of the adult population in all the countries. For countries without surveys, missing values were not imputed, and regional estimates were based on population-weighted averages of available countries only.

Prevalence of different categories of average volume of alcohol consumption by age and sex

Prevalence of different categories of average volume of alcohol consumption by age and sex was also assessed by survey. The same criteria for survey selection as above applied. The categories of drinking shown in Table 1 were used, constructed in a way that the risk of many chronic diseases such as alcohol-related cancers were about the same for both men and women in the same drinking category, i.e. drinking categories I, II and III. As women often experience higher risks of disease for less volume of consumption, the respective drinking categories for women consequently had lower means, e.g. 10 g/day in drinking category 1 for women, and 20 g/day in drinking category 1 for men (see Rehm

Table 1. Drinking categories

Drinking categories	Men	Women
Abstainer or very light drinker	0 – <0.25 g/day	0 – <0.25 g/day
Drinking category I	0.25 – <40 g/day	0.25 – <20 g/day
Drinking category II	40 – <60 g/day	20 – <40 g/day
Drinking category <III>	60+ g/day	40+ g/day

Note: the limits of these categories are stated in grams of pure alcohol per day. For reference, a bottle of table wine contains about 70 g of ethanol; 0.25 g/day corresponds to somewhat less than one glass of wine per month.

et al., 2004). These categories were first used as the basis to derive attributable fractions in the first Australian study on the costs of substance abuse (National Health and Medical Research Council, 1992; English et al., 1995) and have since been used in many epidemiological and cost studies:

Please note that the results of the surveys constitute only the raw input into the exposure calculations. They have to be made comparable in order to be used in a CRA-like exercise (see next point).

Score for patterns of drinking

Patterns of drinking impact certain disease categories such as ischaemic heart disease or injuries independently of volume consumed (Rehm et al., 2003b, 2004; in press). To quantify the impact of patterns of drinking, a score has been constructed and validated for the CRA for the year 2000 (Rehm et al., 2001a, b, 2004). The score and its underlying algorithms have been described in detail elsewhere (Rehm et al., 2003a). It comprises four different aspects of heavy drinking (high usual quantity of alcohol per occasion; frequency of festive drinking at fiestas or community celebrations; proportion of drinking occasions when drinkers get drunk; distribution of the same amount of drinking over several occasions), and two other questions, namely about whether drinking co-occurred with meals (yes/no), and drinking in public places. Those aspects were found to be loading on one underlying dimension in an optimal scaling analysis (Bijleveld and Van der Kamp, 1998). In several analyses with different methodology, they have been found to be related to ischaemic heart disease (Gmel et al., 2003; Rehm et al., 2004) and to different forms of injury (Rehm et al., 2004; Cherpitel et al., 2005).

Patterns scores have been assessed by a mixed methodology of key expert interviews and surveys. They are

part of the GAD, and currently only one score per country has been calculated. There are efforts to apply this methodology sex-specifically although these results are not yet available.

Comparatively quantifying exposure

In alcohol epidemiology there is a myth that all that is necessary to construct comparable surveys is to use the same questionnaire and instructions. This is not the case. Using the same questionnaire and instructions is neither a necessary nor a sufficient condition for comparability. For example, if the questionnaire is heavily constructed around the notion of standard drinks and this concept does not exist in a given culture, it will just lead to misunderstandings and incomparable results. As social psychology has pointed out for many years, in operationalizing constructs the key is to achieve the same understanding in the respondents, whereas the wording of the questions are of secondary importance (Aronson et al., 1990).

Most important for comparative risk analyses of alcohol is a valid measurement of the amount of drinking. Obviously this will not be the case if the same survey questionnaire leads to coverage of 30% of the alcohol consumed in one country and 70% in another country. Using these two surveys without further process in a CRA-type study would dramatically overestimate the alcohol-attributable burden in the latter country relatively to the former country. And the example is by no way exaggerated; indeed, more extreme examples can be found. It should also be added that the same reasoning is valid for other comparisons, such as comparing rates of heavy drinking occasions between countries or between different time points in one country. Also, if the underlying surveys of these comparisons have different rates of coverage, the results are likely to be biased.

Thus, consumption has to be adjusted by an external valid yardstick. In general, the most valid measurement of consumption in a country is the adult per capita consumption, as constituted by recorded and unrecorded consumption (Gmel and Rehm, 2004). Obviously, this measure is most valid in countries with a high percentage of recorded consumption and/or with a good indication of unrecorded consumption.

If we accept the reasoning that adult per capita consumption is the best indicator for overall consumption in a given country, the question remains of how to allocate the overall consumption into different sex-age groups. Survey information constitutes the only information available to conduct this task. In order to adjust prevalence of consumption to the adult per capita consumption figure one must assume that prevalence of abstainers was correctly estimated by the surveys. It implies that reported drinking status (abstention or not abstention) is the most valid information from the survey and the least influenced by non-responders.

Table 2 gives a typical picture of survey information for Sweden as an example (data provided by Robin

Room based on Leifman and Gustafsson, 2003). The calculated coverage rate based on GAD data (recorded adult per capita consumption 5.98 litre pure alcohol per year; unrecorded consumption 3 l/year) amounted to 70.2% if one assumed the midpoint of each category as the mean, and 90 g/day as the midpoint of the last drinking category (60+ g/day), which had no upper limit.

The drinking categories in Table 2 are more differentiated and not sex-specific compared to the drinking categories described above. These more differentiated drinking categories have the advantage that the statistical operations to achieve comparability are easier to carry out and illustrate. In collapsing two categories for each sex (for men: 0.25 – <20 g/day and 20 g/day – <40 g/day; for women: 40 – <60 g/day and 60+ g/day), the above categories can easily be obtained.

The next assumption to be made is that the survey accurately reflects the proportions consumed between sex and age groups. Using the same assumptions about midpoints within categories, 61.7% of alcohol is consumed by men, and 38.3% by women. The last row in Table 2, gives the respective proportions by age groups within men and women.

Table 2. Estimated prevalence for Sweden (percentages) for different drinking categories for the year 2002 based on survey

Age in years	Men					Women				
	15–19	20–44	45–64	65+	All	15–19	20–44	45–64	65+	All
Percentage of age group among all adult population	7.5	42.0	32.3	18.2	100.0	6.8	39.0	30.6	23.6	100.0
Drinking levels										
0 ≤ 0.25 g/day	11.9	6.4	8.7	20.0	10.0	20.0	9.0	11.7	31.9	16.0
0.25 ≤ 20 g/day	63.5	65.1	69.6	66.1	66.6	70.0	82.2	81.2	66.0	77.2
20 ≤ 40 g/day	15.1	18.1	15.4	10.8	15.7	8.1	6.8	5.4	1.6	5.2
40 ≤ 60 g/day	3.6	5.3	3.4	1.5	3.9	1.0	1.1	1.0	0.3	0.9
60+ g/day	5.9	5.1	2.9	1.6	3.8	1.0	1.0	0.7	0.3	0.7
Derived indicators										
Average g/day	18.03	19.15	15.91	12.08	16.73	10.80	11.68	10.89	7.47	10.38
Contribution to total	1.35	8.04	5.14	2.20	16.73	0.73	4.55	3.33	1.76	10.38
Proportional contribution	8.1	48.1	30.7	13.1	100.0	7.1	43.9	32.1	17.0	100.0

Note: To derive indicators, on a sex-specific basis, the following steps were undertaken: (1) the average g/day for each age group was estimated by summing the midpoints of each consumption categories times the proportion of the age group in that category; (2) the contribution to the total for each age group was derived by multiplying the midpoint/mean g/day for that group times the proportion of all males or females in that age group (from the top line); (3) the proportional contribution was derived by dividing its contribution to the total by the contribution to total for all males or females.

Because of rounding, percentages may add up to 99.9% or 100.1%.

Up to this point all potential results have been descriptive, albeit based on assumptions. The next step will introduce an iterative procedure to adjust for adult per capita consumption. First, we estimate the expected values for average consumption in g/days based on the overall adult per capita consumption. Consumption in Sweden is estimated to be 19.3 g/day pure alcohol (converted from 8.98 l/year), which translated into 23.8 g/day for men and 14.8 g/day for women, based on proportion of alcohol consumed from the survey. The expected indicators by sex and age can be seen in the first rows of Table 3.

Table 3 also shows the results of the first iteration by drinking category, sex, and age groups. In this iteration, assuming a distribution where the median is close to the mean, and using the mean value from the survey distribution, the median of the distribution among drinkers was roughly estimated: for men 50% of the distribution was assumed to be in the lowest drinking

category, for women 66.6%. Note that this estimation has only to be rough; the initial estimates will be changed by the following iterations. In other words, while the assumption that the midpoint of each category is the mean of the distribution is crucial, first estimate on the overall median of the distribution is not crucial, as any problematic assumption will be corrected in further iterations. The rest of the drinking categories (20 g/day $\leq$ 40 g/day; 40 g/day $\leq$ 60 g/day; >60 g/day) were allocated proportionally to the survey results. The resulting prevalence proportions were relatively close to the expected distributions, fitting better for men than for women (see last row). However, even for men, one age group had a deviation of more than 10 compared to the expected value (see shaded cell for the oldest age group).

In the second iteration, for all drinking categories above 20 g/day, the prevalence rates were adjusted by the factor of expected volume divided by the derived

Table 3. Estimated prevalence for Sweden (percentages) for different drinking categories for the year 2002 based on survey adjusted for per capita consumption (iteration 1)

Age in years	Men					Women				
	15–19	20–44	45–64	65+	All	15–19	20–44	45–64	65+	All
Expected indicators										
Average g/day	25.69	27.28	22.66	17.21	23.84	15.38	16.64	15.51	10.64	14.79
Contribution to total	1.93	11.46	7.32	3.13	23.84	1.05	6.49	4.75	2.51	14.79
Proportional contribution	8.1	48.1	30.7	13.1	100.0	7.1	43.9	32.1	17.0	100.0
Drinking levels (First iteration)										
0 $\leq$ 0.25 g/day*	11.9	6.4	8.7	20.0	10.0	20.0	9.0	11.7	31.9	16.0
0.25 $\leq$ 20 g/day	44.1	46.8	45.7	40.0	45.0	52.8	60.1	58.3	44.9	55.5
20 $\leq$ 40 g/day	27.0	29.8	32.3	31.0	30.6	22.0	23.7	22.6	17.4	21.8
40 $\leq$ 60 g/day	6.4	8.7	7.2	4.3	7.2	2.6	3.8	4.4	2.9	3.7
60+ g/day	10.6	8.3	6.1	4.7	7.1	2.6	3.4	3.0	2.9	3.1
Derived indicators after first iteration										
Average g/day	25.28	25.45	23.38	19.69	23.72	15.56	18.09	17.50	13.79	16.72
Difference from expected in %	1.6	7.2	–3.1	–12.6	0.5	–1.1	–8.1	–11.4	–22.8	–11.5

Note: The average g/day shown in the top line was estimated by taking the survey estimate for the respective sex-age group and adjusting it by per capita estimate for consumption divided by survey estimate of consumption; e.g., 17.21 g/day for men 65+ = 12.08 (See Table 2 derived indicators, average in g/day of this age group.) * 23.84 (overall consumption from per capita) / 16.73 (overall consumption as estimated from survey, see Table 2).

*The abstainer category was estimated directly from the survey and did not change in the iterations (see also explanations of drinking categories in text).

Because of rounding, percentages may add up to 99.9% or 100.1%.

Table 4. Estimated prevalence for Sweden in % for different drinking categories for the year 2002 based on survey adjusted for per capita consumption (final iteration)

Age in years	Men					Women				
	15–19	20–44	45–64	65+	All	15–19	20–44	45–64	65+	All
Expected indicators										
Average g/day	25.69	27.28	22.66	17.21	23.84	15.38	16.64	15.51	10.64	14.79
Drinking levels (Final iteration)										
0 ≤ 0.25 g/day*	11.9	6.4	8.7	20.0	10.0	20.0	9.0	11.7	31.9	16.0
0.25 ≤ 20 g/day	43.3	43.4	47.0	45.0	45.0	53.3	63.8	63.3	52.5	60.3
20 ≤ 40 g/day	27.4	32.0	31.3	27.1	30.6	21.6	20.9	18.8	11.7	18.1
40 ≤ 60 g/day	6.5	9.3	7.0	3.8	7.2	2.6	3.4	3.7	1.9	3.1
60+ g/day	10.8	8.9	5.9	4.1	7.1	2.6	3.0	2.5	1.9	2.6
Derived indicators after last iteration										
Average g/day	25.55	26.61	22.94	18.22	23.72	15.43	17.02	16.05	11.52	15.32
Difference from expected	0.6	2.5	–1.2	–5.5	0.5	–0.3	–2.3	–3.4	–7.6	–3.4

*The abstainer category was estimated directly from the survey and did not change in the iterations (see also explanations of drinking categories in text).

Because of rounding, percentages may add up to 99.9% or 100.1%.

Table 5. Key indicators of alcohol consumption in the world in 2002 (own calculations based on GAD)

WHO Regions	Percent. of abstainers		% M 40+ g/day	% W 20+ g/day	Alcohol consumption†	Unrecorded consumption	Pattern value	Recorded beverage most consumed
	M	W*						
Africa	57.2	71.5	28.9	19.1	7.0	2.5	3.0	Other fermented beverages and beer
America	25.0	45.4	26.7	17.0	8.7	2.1	2.6	Beer, spirits
Eastern Mediterranean	89.6	97.7	1.3	0.2	0.7	0.5	2.6	Beer, spirits
Europe	17.8	32.2	47.2	28.1	11.9	3.0	2.5	Beer, spirits, wine
South-east Asia	78.8	97.8	9.1	0.5	2.0	1.5	3.0	Spirits
Western Pacific	25.0	58.9	21.4	3.9	6.3	1.2	2.2	Spirits
World	44.8	65.6	22.2	10.1	6.2	1.7	2.6	Spirits (~55%)

volume of the first iteration. To give an example: for the youngest age group in men (15–19 years of age; see column 1 in Table 4), the three prevalence proportions were adjusted by a factor of 25.69 (expected) and divided by 25.28 (derived volume from first iteration, see second to last row in Table 3). Then, the differences between expected and derived indicators after the iteration were checked again and the iterations were repeated until no proportional difference of more than 10% could be observed. The final result can be seen in Table 4 (in

the example reached after the second iteration for men, and the third iteration for women).

Results: alcohol exposure around the world

Table 5 gives an overview of results for the year 2002. The following characteristics emerge:

- worldwide, there are more abstainers than drinkers;
- in most regions of the world alcohol is consumed in a way that is detrimental to health;

- spirits are the most prevalent type of beverage around the world;
- unrecorded consumption is still relatively high on a global level, making up about 28% of the total consumption.

Discussion on underlying assumptions

The described procedure can be used to produce comparable estimates for alcohol exposure in different countries. However, it is based on a number of assumptions that should be discussed here. First, it assumes that adult per capita consumption (recorded and unrecorded) is the best estimate for overall consumption level in a country (Gmel and Rehm, 2004). There seems to be a consensus that this measure is superior to survey estimates at least for developed countries, but there may be problems in regions where estimates of the unrecorded consumption are not available or only estimated with large error. On a global scale, this is the case in some developing countries and in the Eastern European region.

The next assumption concerns the valid estimation of abstainer rates by surveys. Alcohol is consumed in such a way that a relatively large proportion of the alcohol is consumed by a relatively small proportion of the population, both in the developed and the developing world (Rehm, 1998; Gmel and Rehm, 2004; Rehm et al., 2004). It may be reasonable to suspect that much of the difference between survey and adult per capita consumption is due to alcohol consumed by relatively small groups of high consumers not covered by the usual representative surveys, such as homeless or institutionalized people (Gmel and Rehm, 2004). If this reasoning is correct then relatively little error is introduced by assuming that surveys can validly estimate abstainer rates. On the other hand, surveys probably introduce high errors in the prevalence estimates of high consumption categories, which are being corrected by the procedure introduced.

In estimating comparable prevalence proportions of alcohol consumption in different drinking categories, we rely on calculations that are based on distributional assumptions within drinking categories. For example, we assume a symmetric distribution with the midpoint as the mean for the consumption within a category, however the estimated prevalence is sensitive towards this assumption. Although this procedure is used almost universally in the field, it is problematic since alcohol distributions are often skewed. As a consequence, in

further research, procedures based on lognormal or other skewed distributions should be developed. This will take some time, as the properties of alcohol distributions in developing countries are currently poorly understood and some of the key assumptions in modelling developed countries may not apply.

Finally, there is the argument that the current procedure, although yielding estimates of alcohol consumption which are comparable between countries, may lead to overestimation of alcohol-attributable burden. As most surveys in developed countries underestimate consumption, the procedure in these countries leads to higher estimates than in surveys. However, the underlying risk-relations are based on similarly flawed measures from epidemiology and, consequently, the attributable burden will be overestimated. Of course, given the beneficial effects of moderate consumption and the non-linear risk relations with other diseases (Gutjahr et al., 2001), the overestimate would by no means be linear. Rehm and colleagues (2006) gave an estimate of the potential error introduced in this procedure for Canada, and showed that, although the alcohol exposure estimates varied widely (i.e. by the factor 3), the mortality burden was much less influenced by the proposed method (i.e. less than 25% difference; (Rehm et al., 2006). In addition, it is easily possible to do sensitivity analyses where only a proportion of total volume is covered, for example 75%. In fact, we recommend undertaking sensitivity analyses for different values from 75% to 100%.

Independent of this recommendation, the underlying assumptions should be better researched: currently we face a situation where surveys are one of the most used tools in alcohol research, even though we know little about the validity of survey results with respect to overall level of consumption and have only limited knowledge about reasons for the different and often small coverage rates in different countries. (See the example of Canada above, where the last national addiction survey covered about one-third of the per capita consumption. For a general discussion see Gmel and Rehm, 2004).

The above argument also fails to take into account the systematic differences in assessment between alcohol and medical epidemiological studies. Medical epidemiological studies usually only have very few questions on alcohol, embedded in other nutrition or lifestyle assessments, which have been shown to yield higher estimates on alcohol exposure compared to

settings where alcohol is the main, or one of the main, topics of enquiry (e.g. King, 1994).

Overall, even though the proposed procedure may constitute a considerable change to current practice in the alcohol field, it should be adopted for future studies as it achieves comparability between countries and future regions. Of course, further refinements are necessary but for monitoring and surveillance of risk factors, comparability over time and regions is key, and, without achieving comparability, interventions may be based on biased data.

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