Published in final edited form as:

Subst Use Misuse. 2020 ; 55(5): 772–786. doi:10.1080/10826084.2019.1702700.

A Multilevel Analysis of Regional and Gender Differences in the Drinking Behavior of 23 Countries

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Abstract

Introduction.—Drinking behavior differs not only among countries, but also among regions within a country. However, the extent of such variation and the interplay between gender and regional differences in drinking have not been explored and are addressed in this study.

Methods.—Data stem from 105,061 individuals from 23 countries of the GENACIS dataset. The outcomes were heavy drinking (10 /20 grams or more of pure ethanol per day for women / men), and risky single occasion drinking [RSOD] (5+ drinks per occasion) at least monthly. Analyses used binary logistic mixed models. Variance at specific levels was measured by the intra-class correlation coefficient (ICC). Gender differences in outcomes were measured using gender ratios.

Results.—Country-level ICC was 0.13 (95% CI: 0.09–0.18) for heavy drinking and 0.16 (95% CI: 0.10–0.26) for RSOD. Within-country regional-level ICC for heavy drinking and RSOD was 0.02 (95% CI: 0.009–0.05; 0.01–0.04, resp.), implying that 2% of variation in heavy drinking and RSOD was explained by regional variation. Variance in drinking indicators was larger for women compared to men across countries. Gender ratios were higher in low- and middle-income countries.

Conclusions.—Regional variations in risky drinking were more often present in low- to middle-income countries as well in a few higher income countries, and could be due to cultural and demographic differences. Variations in gender differences were larger on the country level than on the regional level, with lower income countries showing larger differences. These results can help to better identify specific high-risk groups for prevention strategies.

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Declaration of interest statement: None.

Declaration of interest: The authors report no conflicts of interest.

Keywords

alcohol consumption; gender; region; international

INTRODUCTION

Multinational comparative research on population alcohol use and risks often treats consumption patterns as if they were homogeneous within each of the countries in a study (Shield et al., 2013; Taylor et al., 2007). However, drinking behavior differs not only between countries, but also between regions within countries (e.g., Kerr, 2010). The inaccuracy of summarizing drinking patterns for entire countries is evident from the results of the few studies on within-country regional differences in alcohol consumption (e.g., Bloomfield, Grittner, Kraus, & Piontek, 2017; Foster, Held, Gmel, & Mohler-Kuo, 2016; Greenfield, 2017; Li, Wang, Chen, Chai, & Tang, 2015). The assumed national homogeneity oversimplifies drinking patterns and problems at the national level, and can lead to the development of alcohol policies which overlook potentially important regional differences in the effects of those policies (R. W. Wilsnack, Wilsnack, Kristjanson, Vogeltanz-Holm, & Gmel, 2009). Thus, studying alcohol use and alcohol-related problems with respect to within-country regional differences is a major step forward for international alcohol research and policy development.

Currently, regional variability in alcohol consumption has been approached on two different levels: (1) it has been considered at the “supra-national” level; that is, groups of countries, which form regions, such as Europe, Asia, North America, and so on, or (2) regional variations have been identified at the “sub-national” (or “within-country”) level, such as regional groupings of the US federal states or the Swiss cantons (e.g., Foster, et al., 2016; Kerr, 2010; Li, et al., 2015).

Research on alcohol use at the “supra”-national level (i.e., regions consisting of grouped countries) has a long tradition and has been recognized by international agencies and consortia of international researchers. For example, studies conducted under the auspices of the World Health Organization have grouped countries according to global regions. As is traditional in all WHO global publications, the latest *Global Status Report on Alcohol and Health* (World Health Organisation, 2018) divides the world’s nations into six global regions: Africa, the Americas, Eastern Mediterranean, Europe, Southeast Asia and Western Pacific. The World Bank employs a similar organizing strategy with countries grouped also into six regions: Europe and Central Asia; East Asia and Pacific; South Asia; North America; Latin America and the Caribbean; Middle East and North Africa, Sub-Saharan Africa (The World Bank, 2018). Such categorizations help to describe the basic traits, which countries within the group share. For example, Europe has old and established drinking styles where most of its national populations are consumers. In contrast, alcohol use across Asian countries is heterogeneous with respect to regular consumption. This is seen as due to background characteristics such as religious or other cultural attitudes towards drinking, or having had a history of European colonization (Waleewong, Laslett, Chenhall, & Room, 2018a, 2018b).

Regional groupings have been useful not only for monitoring and reporting purposes, but also for research on variations in drinking patterns. For example, in order to compare alcohol consumption in countries of Central and Eastern Europe to other European countries, Popova et al. (Popova, Rehm, Patra, & Zatonski, 2007) developed a scheme based on average per capita alcohol consumption in 2002 to organize the 31 study countries into six categories.

The second approach to examining regional drinking considers geographical differences within countries. There has been a tradition in the United States of examining drinking patterns in various parts of the country (Hilton, 1988). A more current example of this approach is given by Kerr's study (Kerr, 2010) of differing drinking patterns in six regions of the U.S. The North Central and New England regions had the highest consumption and heavy drinking levels; the Middle Atlantic, Pacific and South Coast regions had moderate drinking levels; and the Dry South had the lowest drinking level. Another study used the designations of Northeast, Midwest, West, and South, as well as degree of urbanization, to examine US military veterans' current alcohol consumption by place of residence (Vander Weg & Cai, 2012).

Research on regional variation in drinking has also taken place in European countries. Using 12 areas distinguished by degrees of global latitude, a Swedish study of the general population found that areas closer to the European continent were marked by higher consumption and a higher prevalence of risky heavy drinking (Branstrom & Andreasson, 2008). A Swiss cohort study of young men which used four different definitions of regional areas also found regional variation for three different indicators of heavy alcohol use (Foster, et al., 2016). The studies of Meyer et al. (Meyer, Rumpf, Hapke, & John, 1998) and Kraus et al. (Kraus, Augustin, Bloomfield, & Reese, 2001) examined Germany's 16 federal states, and demonstrated the existence of a north-south gradient in various drinking indicators. Finnish researchers have identified regional variation in drinking attributed to differences in religiosity (Winter, Karvonen, & Rose, 2002). Additionally, British researchers investigated variations in the cross-sectional relationship between indicators of alcohol consumption and alcohol-related mortality in ten regions of Great Britain (Robinson, Shipton, Walsh, Whyte, & McCartney, 2015).

Most studies on regional variation in drinking have examined the prevalence of drinking indicators. A modest number of studies explored additional demographic variations, such as gender differences, individual economic status or national economic development. Since drinking behavior of men and women is often distinct within a society, gender plays a major role when investigating within-country regional variation in drinking behavior. But relatively few studies have explored the role of gender in within-country studies of regional variations in drinking. Of those few studies Caetano et al. (Caetano, Mills, & Vaeth, 2012) investigated alcohol consumption among Mexican Americans living near the Mexican border compared to Mexican Americans living in more distant cities. They found a "border" effect for younger women, meaning that younger women living closer to the border were more often heavy drinkers than those in more distant regions. More recently, in comparing the alcohol dependence risks of Mexican-origin drinkers in the US and Mexico, both on and off the border, Greenfield et al. (2017) found border effects in both countries but for men only. In

examining rates of harmful use of alcohol and drugs in regions of Australia, Roxburgh et al. (Roxburgh, Miller, & Dunn, 2013) found that men living in remote areas were more likely to engage in risky drinking and daily drinking than men in urban areas. Another study that examined regional variation in alcohol consumption and cardiovascular mortality in Kazakhstan also analyzed gender differences. The authors found that both genders consumed more in the north-eastern regions, but results varied by ethnicity (Davletov et al., 2015) whereby ethnic Kazakhs reported heavy drinking less often than ethnic Russians and this difference was more pronounced in women compared to men.

In addition to research on gender differences at the regional level, there has also been a number of international comparative studies that have examined national economic development and alcohol use (e.g., Grittner et al, 2012; Grittner et al, 2013; Chaiyasong et al, 2018). In general, these studies have shown that there is less variation in the prevalence of drinking as well as in regular drinking among higher income countries as compared to lower income countries. Moreover, international studies of drinking have shown that higher income countries not only demonstrate a consistently higher prevalence of regular drinking and high-frequency drinking, but there are also smaller differences between the genders (higher degree of similarity) in the prevalence of such drinking indicators in high income countries (e.g., Wilsnack et al, 2009; Astudillo et al, 2010; Chaiyasong et al, 2018).

Given these findings, it is worth exploring whether variations in drinking behavior, as well as gender variations in drinking behavior, at the regional level exist. Thus, the aim of the present study was to investigate regional variations in drinking behavior within the 23 countries of the multinational GENACIS project (e.g., Taylor, Wilsnack, & Rehm, 2008; S. C. Wilsnack, 2012) for which information on regions was available (S. C. Wilsnack, Greenfield, & Bloomfield, 2018).

More precisely, the study seeks to answer the following questions:

1. Do regional variations in drinking behavior exist within the 23 study countries? (How do they compare to country differences of drinking? Are regional variations more pronounced than differences between countries?)
2. Are there gender differences in drinking behavior across countries and across regions within countries?
3. Moreover, is drinking behavior between within-country regions more homogenous in high income countries compared to lower income countries? Are gender differences smaller in higher income countries compared to lower income countries?

Through this process, we aim to identify the presence and extent of both cross-country as well as within-country regional variation in risky drinking. Simultaneously we seek to identify variations in gender differences in risky drinking across and within countries, and to determine whether our findings might be related to the economic development of the countries. Such new information will help to better locate where more precise alcohol policies may be needed in the prevention of risky drinking.

METHODS

Data

The data used for the present analysis come from the GENACIS project (R. W. Wilsnack, et al., 2009) as included in GENAHTO (S. C. Wilsnack, et al., 2018) and represent cross-sectional data from 23 countries: Australia, Austria, Belize, Canada, Costa Rica, Czech Republic, Denmark, Finland, France, Germany, Hungary, India, Ireland, Mexico, New Zealand, Nicaragua, Nigeria, Spain, Sri Lanka, Sweden, Switzerland, Uganda, and USA. Data came from interviews (computer assisted telephone interviews or face-to-face). Only in Germany and New Zealand were data procured through postal surveys. The period of data collection spanned from 1993 (Austria) to 2007 (Australia and New Zealand) (Table 1). More detailed information on survey data collection has been published elsewhere (R. W. Wilsnack et al., 2018; R. W. Wilsnack, et al., 2009). Three hundred and sixty-nine cases were excluded due to missing information on the drinking variables (range: three cases in Finland to 127 in the USA). The resulting dataset consisted of 105,061 participants. Information on urban/rural residence was not available in surveys of Germany, Canada, USA, Mexico, Nicaragua, Belize, and Australia.

Measures

Drinking indicators: We used heavy drinking and risky single occasion drinking (RSOD) as two separate indicators of harmful drinking. Respondents who drank on average 10 grams (for women) / 20 grams (for men) or more of ethanol per day were categorized as heavy drinkers. Respondents who engaged in risky single occasion drinking (RSOD) at least monthly were categorized as RSO drinkers. The threshold used for heavy drinking of 10 / 20 grams of ethanol for women / men is based on the lower values found in national drinking guidelines in many countries (International Alliance For Responsible Drinking (IARD), 2018). A higher volume of drinking has been shown to be associated with higher risks of dependency (Dawson, Grant, & Li, 2005). A higher cut-off is used for men because of the known biological differences between men and women with regard to alcohol metabolism (Thomasson, 1995). We chose a cut-off frequency for RSOD of at least once a month as this is commonly used in general population studies (Bloomfield, Hope, & Kraus, 2013; Kuntsche, Rehm, & Gmel, 2004). To analyze gender differences on the country- and regional level, we used a simple gender ratio by dividing prevalence of men's risky drinking by prevalence of women's risky drinking for each country and for each region similar to Wilsnack et al. 2009 (R. W. Wilsnack, et al., 2009).

Gross domestic product (GDP) based on purchasing power parity per capita from 2004 was employed as a simple measure of economic strength and development. We used this to explore associations between regional variation or gender differences in risky drinking and country characteristics. The World Bank groups countries according to their level of economic development (The World Bank, 2018). Following this grouping, Uganda is a low income country; India, Sri Lanka, Nicaragua, and Nigeria are lower-middle income countries; Mexico, Belize, and Costa Rica are upper-middle income countries; and all other study countries are high income countries.

Regions

Regions in the present study are geographic areas within a country or a federal state of a country. All of them are based on administrative jurisdictions (e.g., federal states, provinces, local districts or counties). For some countries, smaller adjacent regions (states or provinces) were combined (e.g., Mexico, Czech Republic) so that the sample size of each region was at least 60 and thus adequately stable for analytic purposes (see Table 1 for the actual number of regions used for each country).

Generally, alcohol policy is set at the national level for most countries. Exceptions to this are the United States and Canada (Brand et al, 2007; Giesbrecht et al, 2016). Apart from the national legal alcohol purchasing age of 21 years in the US, alcohol taxation and availability policies are set at the state or provincial levels in the US and Canada. In order to be able to estimate stable statistical models, states and provinces in both countries were grouped into larger regions which often contained states or provinces with differing alcohol policies. Thus, for the US and Canada a one-to-one correspondence between existing alcohol policies and specifically affected states/provinces was not possible in the present study.

From Table 1 it can be seen that the majority of countries had nationally representative samples. However, for five countries only a sample of regions within each country was included (i.e., Australia, Nicaragua, Nigeria, Spain and Uganda, Table 1). India was represented by only one of its member states, Karnataka, which similarly to the countries just mentioned, was represented by a selected number of districts within that state.

Statistical analyses

To analyse within country regional variation in drinking we calculated intra-class correlation coefficients (ICC) and 95% confidence intervals (CI) to give a first impression of regional variation in the drinking indicators within each country. The ICC estimates are based on two-level binary logistic mixed models (random intercept models) in each study country for heavy drinking and RSOD, adjusted for age, sex and additionally urban/rural residence (if this information was available).

For estimation of gender differences in drinking we calculated gender ratios at the country and regional level. To test whether gender differences in drinking varied between regions within a country we used country-specific two-level mixed binary logistic models with age, urbanity (if information was available) and gender as fixed effects with random intercepts and an additional random slope for gender. The model with the additional random slope for gender was compared to the simpler model (with only fixed effects for gender, age, urbanity and random intercept for regions) using a likelihood ratio-test, in order to test whether the additional random slope significantly improved the model. The p-value is derived from this model comparison.

In order to estimate regional variation in heavy drinking and RSOD across countries, we used three-level binary logistic mixed models (Model M1, random intercept models) including a level for countries, a level for regions within countries, and a level for individuals (Models M1, Table 3). We calculated models for the total sample and for men and women separately to explore regional and country level variation in risky drinking in

men and women separately. All models were adjusted for age and country level variation. Models for the total sample were additionally adjusted for sex. We compared these three-level binary logistic mixed models with two level models that adjusted for country-level variation, without estimates of regional-level variation in harmful drinking (Models M0 and M1, Table 3) (random intercept models). To analyze the variance explained across countries as well as across regions within countries, intra-class correlation coefficients (ICC) were calculated along with their 95% CI.

To evaluate whether gender differences varied significantly between countries as well as between regions, we used likelihood-ratio tests and tested the following models against each other (with unweighted data) (Table 4): (a) Three-level model with country and regional levels adjusted for age and sex (fixed effects) (random intercept model, same as Model M1 in Table 2), (b) Model (a) with additional random slope for gender on country level (testing variation in gender differences between countries), (c) Model (a) with an additional random slope for gender on regional level (testing variation on gender differences among regions), (d) Model (a) with an additional random slope for gender on country level as well as on regional level (testing both parallel country and regional variation in gender differences).

To assess how gender differences might be associated with GDP on the country level we first used scatter plots for GDP and gender ratios and calculated Spearman's correlation coefficient (ρ). In order to answer our question regarding whether there exists less variance in higher income countries, we examined the relationship between countries' ICC for the two drinking variables and country-level economic development (GDP).

All likelihood ratio tests of model fit comparisons were conducted with unweighted data. All other analyses in which we report and interpret regression coefficients involved weighted data. Weights were provided from the individual survey leaders and account for non-response with regard to sociodemographic characteristics of age, sex, and region.

RESULTS

Almost 70% of the respondents in the entire study sample were current drinkers, nearly 18% were heavy drinkers (on average 10/20 grams or more of ethanol on average per day (women/men) and over 11% had engaged in RSOD at least once a month (Table 1). With regard to differences between countries, the proportion of current drinkers ranged from 20% in India to 95% in Germany. The range for heavy drinking spanned from less than five percent in Nicaragua to 36% in Ireland. At least monthly RSOD ranged from roughly three percent in Switzerland to over 39% in Ireland.

Within-country regional variation in drinking

In regard to within-country regional variation the lowest proportion of heavy drinkers was found in Dakshina Kannada in India with 1.1%, whereas in Dublin (Ireland) the highest rate was observed, with more than 40% of the respondents being heavy drinkers (median across all regions: 15.6%, IQR: 7.8%–23.8%, Tables 2a–2d). With regard to RSOD no RSO drinkers were found in the North Western Province of Sri Lanka. In contrast the prevalence

of RSOD was more than 50% in Dublin (median across all regions: 12.7%, IQR: 7.9% –21.7%).

When analyzing the study countries separately for within-country regional variation in heavy drinking, the variance explained due to differences across the within-country regions was small for most countries, meaning that drinking behavior across the regions was similar (i.e., less than one per cent in Australia, Austria, Canada, Czech Republic, Denmark, Germany, India, New Zealand and Sri Lanka, as indicated by the ICC for heavy drinking; Table 1). However, in France, Hungary, Ireland and the USA the variance explained due to regional differences was one per cent. All countries with an ICC of one percent or less were higher income countries (The World Bank, 2019).

More variation was found regarding RSOD, where most countries had an ICC over one percent. Ireland had the highest ICC at 14%. In Spain, Sweden, Mexico, Belize, Nicaragua, Costa Rica, Nigeria and Uganda regional differences explained between 2 and 7% of drinking variation. At the other end of the spectrum Denmark and Finland, along with India and Sri Lanka, all who had negligible ICC values, indicating very little variation across within-country regions for RSOD in these countries.

Regional variation in drinking and gender differences were diverse between countries (Tables 2a to 2d). For instance, some countries had relatively high levels of heavy drinking and RSOD, small regional variation and small variation in gender differences. These included France, Czech Republic, Denmark, USA, Australia and New Zealand. In other countries specific regions could be identified with divergent drinking levels, such as Conn/Ulster in Ireland with 23% heavy drinking compared to other Irish regions having 34% or more. Another example is Spain with around 20% of heavy drinking prevalence in Cantabria, Castellon Valencia and La Coruna, while the prevalence in other regions was around 10%.

Country-level variation compared to regional variation in drinking

Across the complete sample, the variance explained in heavy drinking due to country differences was 13% (95% CI: 9 – 18%) as indicated by the ICC values in the left-hand columns of Table 3. After adjustment for country-level variation, 2% (95% CI: 0.09 – 5%) of total variance was due to regional differences in risky drinking indicating that within-country regional variation in heavy drinking was smaller than the variation across countries (i.e., 2% vs. 13%).

The amount of variance explained by differing rates of heavy drinking across countries was considerably greater for women than for men (ICC: 32% vs. 10%, Table 3). Additionally, the variance explained in monthly RSOD due to country differences was 16% (95% CI: 10 – 26%) (Table 3). After adjustment for country-level variation, again, only 2% (95% CI: 1 – 4%) of total variance was due to regional differences in RSOD indicating that within-country regional variation in RSOD was smaller than the variation across countries (i.e., 2% vs. 16%). The amount of variance explained by differing rates of RSOD between countries again was considerably greater for women than for men (ICC: 32% vs. 14%).

Variation in gender differences in drinking across countries and regions

As with regional variations in risky drinking, we also tested whether gender differences varied across countries and across regions within countries (i.e., random slope for gender). Table 4 reports the results from model comparisons testing for variations in gender differences in heavy drinking and monthly RSOD between countries and regions. A regression model that included an additional random slope for gender on both the country level as well as on the regional level (after including fixed effects for gender and age) proved to be better than the preceding models (Model d, Table 4). This means, that variation in gender differences for both heavy drinking and RSOD was present both, across countries and across regions within countries. Variation of gender differences in drinking on the country level was mainly driven by larger variation of women's drinking across countries compared to men's drinking. This is obvious when comparing country level ICCs for separate models by gender in M0 models in Table 3 (ICC for men /women: 10%/32% for heavy drinking, 14% / 32% for RSOD). However, when looking at the individual countries, in only a few of them did we find substantial variation in gender differences in drinking between regions within the countries (see p-values in Tables 2a to 2d). Those countries with substantial regionally-specific variations in gender differences were Hungary (RSOD), Ireland (RSOD), Canada (heavy drinking), Belize (heavy drinking and RSOD), and Nigeria (heavy drinking and RSOD) (Tables 2a – 2d).

Country income levels and regional variation

We found the association between countries' ICC and GDP to be weak for heavy drinking (Spearman's $\rho = -0.23$). The ICCs in some high income countries, such as Spain, Finland and Sweden, indicated that regional variation in heavy drinking was substantial. However, in India and Sri Lanka (lower-middle income countries) regional variation in heavy drinking was not present at all (supplementary figure 1a). For RSOD, the association of regional variation (ICC) and GDP was even weaker (Spearman's $\rho = -0.17$). However, Ireland was an outlier in this analysis with an ICC of 14%. A sensitivity analysis without Ireland produced a new Spearman's correlation coefficient of -0.34 (supplementary figure 1b).

As mentioned in the introduction, previous research has found smaller gender differences in drinking variables in high income countries. Thus, to further examine the variation in gender differences across our study countries, we also investigated whether any present gender variation may be smaller in higher income countries than in lower income countries. Figure 1 shows by visual inspection that gender ratios at the country level were larger in middle and lower income countries as compared to high-income countries. This association was stronger for heavy drinking than for RSOD (the correlation between country-gender-ratio and GDP for heavy drinking Spearman's $\rho = -0.65$, for RSOD: $\rho = -0.38$, Supplementary figure 2a/b).

DISCUSSION

The current study has examined both within-country regional-level and across-country variation in drinking behavior in 23 countries. It also has evaluated gender differences in risky drinking at the regional and country levels. We observed larger variation in heavy drinking and risky single occasion drinking (RSOD) across countries than across regions

within countries. Most countries had ICC values larger than one percent to describe their within-country regional variation. Interestingly, we found that those few countries with very small ICC values were countries with either a relatively low prevalence of heavy drinking or RSOD, or a rather high prevalence of these drinking variables. Thus, uniformity of drinking within a country could be found at either end of the consumption spectrum. In addition we found that *gender ratios* for risky drinking (either heavy drinking or RSOD) were higher (meaning, e.g., higher prevalence in men compared to lower prevalence in women) in low to middle income countries as compared to higher income countries.

Reasons for regional differences in drinking behavior are diverse and could be related to population composition with regard to socioeconomic status, ethnicity, religious preferences, and urban vs. rural differences. In some instances they might be due to an area being a border region, and sharing a differing drinking culture with the neighboring country (e.g., Bloomfield et al, 2017) or it could be a region near the border of a country with cheaper alcohol (e.g., Caetano et al, 2012). For example, the regional differences that we identified include the geographic variations found in Sweden which can be related to the proximity to the southern border (i.e., either to Denmark or more importantly, Germany) where alcohol prices are considerably lower (Gustafsson, 2010). Furthermore, it appears that gender differences in the prevalence of heavy drinking are also related to this geographical gradient, showing a lower gender ratio in the south and around Stockholm and a larger ratio in the north (i.e., Table 2b).

Another example of causes for regional differences is found in Uganda where the prevalence of risky drinking varies considerably across its four major regions. Reasons for this could be due to the civil war which occurred before the survey period, and which displaced many residents of the northern region, leading to higher consumption not only there but in adjacent areas (N. Tumwesigye, personal communication, 8.12.18). In Ireland the prevalence of RSOD among the four provinces varies generally by population density of the provinces, with the rural areas of Conn/Ulster in particular having lower rates (A. Hope, personal communication, 3.01.2019).

Additionally, we found that the extent of gender differences in heavy drinking varied across the study countries, such that those with lower or middle incomes were more likely to have larger differences between men and women. Moreover, we found within-country regional variation in gender differences in some countries. Reasons for this within-country regional variation in gender differences could be related to cultural traditions and ethnic compositions of the population, differing regional rates of higher educational achievement of women, urban vs. rural differences, and other factors. In Hungary the lowest difference in risky drinking between men and women was found in the capital Budapest, a large city with a high rate of women with higher educational achievement (Z. Elekes, personal communication, [Dec 2018]). The positive association of educational achievement and heavier drinking among women has been demonstrated already for several countries (Grittner, Kuntsche, Gmel, & Bloomfield, 2013).

Limitations

One limitation of this study is its exploratory character. In particular, since regions were based simply on administrative needs (e.g., counties, districts), and not based on local (drinking) cultures, differing socio-demographic composition of the local populations, or socioeconomic differences, the interpretation of any regional differences in drinking was thus difficult.

Some methodological issues exist with the type of analysis employed in the present study. These include the fact that with the given sample sizes, there was the need to collapse certain areas together in order to acquire sufficient power for each region (as we did for Germany and Mexico). However, too much merging could lead to a masking of actual regional differences in drinking. On the other hand, we cannot be entirely certain that the regional variations that we did find were not due to methodological artefacts for some countries. For example, quota sampling (in Ireland) may have produced statistically significant variations, and such estimates may not be truly representative of the population's drinking practices. In the case of Nigeria or Spain, there may be significant results because only previously-defined areas (i.e., not randomly selected) were chosen and surveyed. Another limitation is that we used GDP data from 2004, but 21 of the 23 study surveys were conducted within 2000 and 2008. Finally, our results have shown only rather small variations on the regional level, as indicated by the low ICC values. One might ask if this is due to measurement issues, e.g. of setting the threshold for heavy drinking too low (10/20 grams of ethanol per day). However, due to the large variety of countries in the present study, a low heavy drinking threshold was necessary in order to be able to include those countries with low per capita consumption.

Despite these possible drawbacks, this study has revealed that: (1) country-level variation in heavy drinking and RSOD is larger than within-country regional variation, (2) low to middle income countries show somewhat more within-country regional variation in drinking than do high income countries, and (3) gender differences at both the country and within-country levels are higher in low to middle income countries. We also have demonstrated that variation of gender differences in drinking behavior across countries is mainly due to the large variation in the prevalence of women's drinking.

These new findings can inform both future research and the development of more specific and targeted alcohol policies. For example, future research should examine in more detail the drinking patterns of men and women in low income countries and identify under what circumstances their drinking practices diverge from one another and from those in higher income countries. Also, alcohol policies should mainly be targeted at men in certain regions or certain countries, such as the Americas, where it is clear that they engage in more risk drinking. A recent news release of the WHO actually has used such messaging (World Health Organization, 2018). Moreover, such targeting may be especially helpful in low- and middle-income countries, where resources are often stretched. Thus, being able to pinpoint the use of scarce policy funding to where it may do the most good would be advantageous.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

The data used in this paper are from the GENAHTO Project (Gender and Alcohol's Harm to Others), supported by NIAAA Grant No. R01 AA023870 (Alcohol's Harm to Others: Multinational Cultural Contexts and Policy Implications). GENAHTO is a collaborative international project affiliated with the Kettil Bruun Society for Social and Epidemiological Research on Alcohol and coordinated by research partners from the Alcohol Research Group/ Public Health Institute (USA), University of North Dakota (USA), Aarhus University (Denmark), the Centre for Addiction and Mental Health (Canada), the Centre for Alcohol Policy Research at La Trobe University (Australia), and the Addiction Switzerland Research Institute (Switzerland). Support for aspects of the project has come from the World Health Organization (WHO), the European Commission (Concerted Action QLG4-CT-2001-0196), the Pan American Health Organization, the Thai Health Promotion Foundation (THPF), the Australian National Health and Medical Research Council (NHMRC Grant No. 1065610), and the U.S. National Institute on Alcohol Abuse and Alcoholism/National Institutes of Health (Grants R21 AA012941, R01 AA015775, R01 AA022791, R01 AA023870, and P50 AA005595). Support for individual country surveys was provided by government agencies and other national sources. National funds also contributed to collection of all of the data sets included in WHO projects. Study directors for the survey data sets used in this paper have reviewed the paper in terms of the project's objective and the accuracy and representation of their contributed data. The study directors and funding sources for data sets used in this report are: Switzerland (Gerhard Gmel, Swiss Federal Office for Education and Science Contract 01.0366, Swiss Federal Statistical Office), Austria (Irmgard Eisenbach-Stangl, Boltzmann Institute), Germany (Ludwig Kraus (Germany Federal Ministry of Health and Institute for Therapy Research Munich), France (Francois Beck, National Institute of Prevention and Health Education), Spain (Antonio Vidal, Dirección General de Atención a la Dependencia, Conselleria de Sanidad, Generalitat Valenciana, Comisionado do Plan de Galicia sobre Drogas, Conselleria de Sanidade, Xunta de Galicia, Dirección General de Drogodependencias y Servicios Sociales, Gobierno de Cantabria), Sweden (Karin Bergmark (Ministry of Social Affairs and Health Sweden), Finland (Pia Mäkelä, National Research and Development Centre for Welfare and Health Finland), Denmark (Kim Bloomfield, Sygekassernes Helsefond, Danish Medical Research Council), Czech Republic (Ladislav Csemy, Ministry of Health of Czech Republic, Grant Number: MZ 23752), Hungary (Zsuzsanna Elekes, Ministry of Youth and Sport Hungary), Ireland (Ann Hope, Department of Health and Children Ireland), USA (Thomas Greenfield, National Institute on Alcohol Abuse and Alcoholism / National Institute of Health, Grant AA05595), Canada (Kathryn Graham, Canadian Institute of Health Research), Mexico (Martha Romero, Ministry of Health, Mexico, Office of Antinarcotics Issues; U. S. Embassy in Mexico, National Institute of Psychiatry, National Council Against Addictions, General Directorate of Epidemiology and Subsecretary of Prevention and Control of Diseases, Ministry of Health, Mexico), Costa Rica (Julio Bejarano, WHO), Belize (Claudina Cayetano, Pan American Health Organization), Nicaragua (Jose Trinidad Caldera, Pan American Health Organization), Uganda (Nazarius, Mbona Tumwesigye, WHO), Nigeria (Akanidomo Ibanga, WHO), India (Vivek Benegal, WHO), Sri Lanka (Siri Hettige, WHO), Australia (Paul Dietze, Robin Room, National Health and Medical Council, Grant 398500), New Zealand (Jennie Connor, Otago University Research Grant). Opinions are those of the authors and do not necessarily reflect those of the National Institute on Alcohol Abuse and Alcoholism, the National Institutes of Health, the WHO, and other sponsoring institutions. (GENAHTO survey information at <https://genahto.org/abouttheproject/>).

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Figure 1a/b.

Prevalence of heavy drinking (average volume of 10 grams (for women) /20 grams (for men)) or more ethanol per day (a), and risky single occasion drinking (RSOD, 5+drinks per occasion) at least monthly (b) by country and sex (ordered by size of gender ratio)

Overview of study countries: sample size and prevalence of current drinking, heavy drinking (HD), and monthly RSO drinking: results of multi-level regressions (ICC for regional variation, 95%CI) (adjusted for age, sex and urbanity)

Table 1.

Continent	Country	Survey year	N individuals	N regions	Sampling frame/survey mode	Percent drinkers	Percent HD	ICC for regional variation in HD	95%CI for ICC	Percent monthly RSOD	ICC for regional variation in RSOD	95%CI for ICC
Central Europe												
	Spain	2002	1,850	8 ^a	Regional / Face-to-face	55.0	14.9	0.05^b	0.03–0.07	7.5	0.03^b	0.01–0.12
	France	2000	13,664	8	National / CATI	64.6	23.1	0.01^b	0.002–0.02	n.a.	--	
	Germany	2000	8,052	8	National / Postal	94.6	28.4	0.002^c	0.00–0.01	26.8	0.02	0.01–0.06
	Switzerland	2002	12,994	7	National / CATI	80.7	20.7	0.02^b	0.01–0.04	3.4	0.005^b	0.00–0.04
	Austria	1993	7,389	9	National / Face-to-face	62.4	24.1	0.004^b	0.00–0.17	n.a.	--	
	Czech Republic	2002	2,526	2	National / Face-to-face	84.9	30.9	0.002^b	0.00–0.02	16.9	0.001^b	0.00–0.32
	Hungary	2001	2,243	6	National / Face-to-face	82.7	6.7	0.01^b	0.00–0.17	21.0	0.004^b	0.001–0.01
Nordica + Ireland												
	Ireland	2002	1,042	4	National / Face-to-face	72.9	36.2	0.01^b	0.004–0.05	39.1	0.14^b	0.06–0.31
	Denmark	2003	2,030	5	National / CATI	94.3	27.4	0.003^b	0.00–0.03	27.8	<0.001^b	--
	Sweden	2002	5,468	7	National / CATI	83.7	5.3	0.04^b	0.01–0.12	9.5	0.02^b	0.004–0.06
	Finland	2000	1,929	5	National / Face-to-face	90.5	13.5	0.03^b	0.02–0.06	26.4	<0.001^b	--
North America												
	Canada	2004	13,806	5	National / CATI	77.6	18.1	0.006^c	0.003–0.01	17.3	0.008^c	0.002–0.03
	USA	2000	7,485	9	National / CATI	61.3	9.9	0.01^c	0.00–0.10	10.0	0.005^c	0.00–0.02
	Mexico	1998	5,711	6	National / Face-to-face	58.2	7.4	0.02^c	0.01–0.04	16.3	0.02^c	0.01–0.04

Continent	Country	Survey year	N individuals	N regions	Sampling frame/survey mode	Percent drinkers	Percent HD	ICC for regional variation in HD	95%CI for ICC	Percent monthly RSOD	ICC for regional variation in RSOD	95%CI for ICC
Middle America												
	Belize	2005	3,969	6	National / Face-to-face	34.4	9.2	0.11 ^c	0.04–0.27	13.7	0.07 ^c	0.03–0.16
	Nicaragua	2005	2,030	5 ^a	Regional / Face-to-face	20.2	4.4	0.04 ^c	0.01–0.13	9.6	0.03 ^c	0.02–0.06
	Costa Rica	2003	1,273	4	National / Face-to-face	54.8	8.7	0.02 ^b	0.001–0.49	9.0	0.03 ^b	0.004–0.22
Africa												
	Nigeria	2003	2,059	6 ^a	Regional / Face-to-face	31.0	15.2	0.07 ^b	0.03–0.14	16.0	0.06 ^b	0.02–0.17
	Uganda	2003	1,478	4 ^a	Regional / Face-to-face	43.4	19.2	0.03 ^b	0.01–0.11	13.7	0.04 ^b	0.02–0.07
Asia												
	India	2003	2,584	4 ^a	Regional / Face-to-face	19.9	7.9	<0.001 ^b	---	10.8	<0.001 ^b	---
	Sri Lanka	2002	1,193	7	Regional / Face-to-face	30.3	7.0	<0.001 ^b	---	3.5	<0.001 ^b	---
Australasia												
	Australia	2007	2,434	2 ^a	Regional / CATI	83.4	14.2	<0.001 ^c	---	10.9	0.02 ^c	0.17–0.03
	New Zealand	2007	1,852	5	National / Postal	88.5	24.4	<0.001 ^b	---	25.6	0.002 ^b	0.00–0.10
Total			105,061	132		69.0	17.6			11.6		

CATI: Computer Assisted Telephone Interview, Heavy drinking: 10/20 grams or more of ethanol per day on average for women / men

^a regions do not represent all regions from the country, but only some of the regions

^b additionally adjusted for urban/rural

^c no urban/rural information available

^d values almost 0, or very large confidence intervals

Table 2a.

Results of descriptive analysis for % risky drinkers, gender ratio by country and region, p-value for regional differences in gender ratios; **Central Europe**

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (p for regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
SPAIN	1850	894	956	14.9	20.7	9.5	2.2 (p=1.000)	7.5	12.1	3.3	3.7 (p=1.000)
Cantabria	350	168	182	19.5	27.2	12.2	2.2	11.8	17.3	6.6	2.6
Alicante	345	170	175	8.7	10.0	7.5	1.3	4.6	5.3	4.0	1.3
Castellon	117	58	59	21.2	32.8	10.0	3.3	6.8	13.8	0.0	--
Valencia	538	260	278	18.3	23.8	13.3	1.8	9.4	15.3	4.0	3.8
La Coruna	202	97	105	19.4	31.1	8.6	3.6	8.9	14.4	3.8	3.8
Lugo	70	33	37	7.3	15.4	0.0	--	4.3	9.1	0.0	--
Orense	64	30	34	9.4	13.5	5.9	2.3	1.6	3.5	0.0	--
Pontevedra	164	78	86	9.8	11.4	8.2	1.4	7.4	12.8	2.4	5.4
FRANCE	13664	6019	7645	23.1	30.8	15.6	2.0 (p=0.289)	--			
Paris area	2087	879	1208	21.6	25.8	17.8	1.5				
Paris basin	2430	1079	1351	20.3	27.8	13.0	2.1				
North	928	405	523	22.6	30.6	15.3	2.0				
West	2062	910	1152	24.5	33.4	15.9	2.1				
East	1376	621	755	21.4	29.8	13.3	2.2				
South East	1548	690	858	30.9	40.7	20.7	2.0				
Centre East	1690	751	939	22.4	29.3	15.5	1.9				
Mediterranean area	1543	684	859	24.5	34.4	14.2	2.4				
GERMANY	8052	3635	4417	28.4	31.4	25.2	1.2 (p=1.000)	26.8	40.4	12.7	3.2 (p=1.000)
Schleswig-Holstein, Hamburg	396	162	234	29.6	26.7	32.0	1.2	23.6	39.4	10.0	4.0
Lower Saxony, Bremen	916	415	501	26.6	27.6	25.6	1.1	29.9	44.8	14.8	3.0
North Rhine-Westphalia	1662	778	884	28.9	32.2	25.4	1.3	35.3	51.2	18.4	2.8
Hesse, Rhineland-Palatinate, Saarland	1161	549	612	30.7	33.9	27.2	1.2	29.1	43.2	13.5	3.2
Baden-Wuerttemberg	1249	586	663	24.0	26.4	21.5	1.2	18.8	29.1	7.4	3.9
Bavaria	1049	457	592	28.2	33.4	23.3	1.4	20.8	34.3	8.0	4.3
Berlin, Brandenburg, Mecklenburg-Western Pomerania	583	258	325	29.0	31.6	26.2	1.2	26.6	38.2	14.2	2.7
Saxony, Saxony-Anhalt, Thuringia	1036	430	606	30.8	36.1	25.5	1.4	25.2	38.1	12.1	3.2
SWITZERLAND	12994	5755	7239	20.7	24.0	17.6	1.4 (p=1.000)	3.4	6.0	0.9	6.7 (p=1.000)
Area around Lake Geneva	3109	1360	1749	26.6	30.2	23.2	1.3	4.4	8.3	0.8	10.3

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (p for regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
Swiss Plateau	2742	1201	1541	19.8	23.2	16.8	1.4	3.2	5.6	0.9	5.9
Northwestern Switzerland	1592	756	836	20.1	22.0	18.1	1.2	2.5	4.0	1.0	4.2
Zurich	1578	703	875	20.7	24.3	17.2	1.4	3.8	7.0	0.7	9.8
Eastern Switzerland	1475	646	829	16.4	19.6	13.5	1.5	3.2	5.5	1.2	4.6
Central Switzerland	1393	633	760	15.8	18.4	13.2	1.4	3.0	5.1	0.9	5.5
Tessin	1105	456	649	26.4	34.7	19.8	1.8	2.7	4.8	1.0	4.9
AUSTRIA	7389	3493	3896	24.1	33.0	16.2	2.0 (p=0.951)	--			
Upper Austria	1168	552	616	26.4	37.3	16.6	2.3				
Salzburg	398	174	224	18.8	26.4	12.9	2.0				
Lower Austria	1571	752	819	24.7	34.6	15.6	2.2				
Vienna	1623	757	866	23.0	28.1	18.6	1.5				
Burgenland	233	117	116	30.0	41.9	18.1	2.3				
Styria	1137	546	591	25.1	35.5	15.4	2.3				
Carinthia	587	282	305	25.0	33.7	17.0	2.0				
Tyrol	439	201	238	17.8	22.4	13.9	1.6				
Vorarlberg	233	112	121	24.9	40.2	10.7	3.7				
CZECH REPUBLIC	2526	1244	1282	30.9	41.2	20.8	2.0 (p=0.490)	16.9	26.1	8.0	3.3 (p=0.882)
Bohemia	1515	741	774	33.1	43.5	23.3	1.9	17.7	27.1	8.7	3.1
Moravia	1011	503	508	27.5	38.0	17.1	2.2	15.7	24.7	6.9	3.6
HUNGARY	2243	1086	1157	6.7	11.6	1.9	6.1 (p=0.297)	21.0	34.8	7.4	4.7 (p=0.020)
Budapest	842	382	460	7.6	11.3	4.5	2.5	23.0	35.9	11.7	3.1
North West	306	162	144	4.2	7.4	0.7	10.7	19.0	30.2	6.3	4.8
South West	207	102	105	9.7	16.7	2.9	5.8	21.7	38.2	5.7	6.7
Middle East	330	160	170	6.1	11.3	1.2	9.6	18.5	32.5	5.3	6.1
North East	330	173	157	7.3	13.3	0.6	20.9	24.8	40.5	7.6	5.3
South East	228	107	121	6.1	11.2	1.7	6.8	18.0	30.8	6.6	4.7

Table 2b.

Results of descriptive analysis for % risky drinkers, gender ratio by country and region, p-value for regional differences in gender ratios; **Nordica + Ireland**

Country/ region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (p for regional differences in gender ratio)	total	men	women	Male/female ratio (p for regional differences in gender ratio)
IRELAND	1042	503	539	36.2	43.1	29.7	1.5 (p=0.529)	39.1	52.9	26.2	2.0 (p=0.003)
Dublin	324	157	167	43.6	47.2	40.2	1.2	53.5	66.7	40.9	1.6
Rest of Leinster	269	130	139	34.0	44.9	23.8	1.9	44.0	57.3	31.6	1.8
Munster	257	124	133	38.6	46.8	30.9	1.5	33.7	47.7	20.5	2.3
Conn/Ulster	192	92	100	22.9	28.0	18.3	1.5	15.5	30.2	2.0	15.3
DENMARK	2030	897	1133	27.4	28.2	26.7	1.1 (p=1.000)	27.8	38.3	17.7	2.2 (p=1.000)
Hovedstaden	893	401	492	31.2	34.5	27.9	1.2	30.4	40.1	20.8	1.9
Sjaelland	155	56	99	27.8	33.9	23.6	1.4	22.6	36.1	13.2	2.7
Syddanmark	300	127	173	21.9	19.2	24.3	0.8	28.7	41.8	17.6	2.4
Midtjylland	510	225	285	25.1	23.8	26.4	0.9	25.0	35.3	14.9	2.4
Nordjylland	172	88	84	28.6	27.0	30.4	0.9	28.2	36.1	18.4	2.0
SWEDEN	5468	2654	2814	5.3	4.6	6.0	0.8 (p=0.629)	9.5	15.9	3.3	4.8 (p=0.329)
Kronoberg, Blekinge, Halland	418	203	215	5.2	3.7	6.7	0.6	9.3	15.8	2.6	6.0
Norrland	770	354	416	2.9	2.6	3.2	0.8	7.4	13.1	1.6	8.3
other Gotland	633	324	309	3.2	3.9	2.5	1.5	9.5	15.1	3.9	3.9
other Svealand	1019	507	512	3.8	3.0	4.6	0.7	8.6	14.5	2.9	5.0
Skanen	679	327	352	5.9	4.6	7.2	0.6	7.3	12.9	1.6	7.9
greater Stockholm	1008	489	519	8.6	7.2	9.9	0.7	13.3	21.8	5.0	4.3
Western Gotland	941	450	491	5.8	5.3	6.2	0.9	9.4	15.1	3.9	3.9
FINLAND	1929	943	986	13.5	18.5	8.8	2.1 (p=0.972)	26.4	40.9	12.5	3.3 (p=1.000)
Uusimaa	488	223	265	17.0	21.5	13.2	1.6	26.4	42.2	13.2	3.2
Southern Finland	666	331	335	16.2	23.3	9.3	2.5	26.3	40.5	12.2	3.3
Eastern Finland	283	148	135	10.2	13.5	6.7	2.0	31.1	43.9	17.0	2.6
Western Finland	269	135	134	7.4	8.9	6.0	1.5	23.0	35.6	10.4	3.4
Northern Finland	223	106	117	9.4	16.0	3.4	4.7	24.7	42.5	8.5	5.0

Table 2c.

Results of descriptive analysis for % risky drinkers, gender ratio by country and region, p-value for regional differences in gender ratios; **North America / Central America**

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (p for regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
CANADA	13806	5938	7868	18.1	20.3	16.5	1.2 (p=0.002)	17.3	27.9	9.3	3.0 (p=0.429)
Atlantic provinces (Nfld, PEI, NS, NB)	1763	757	1006	15.4	21.1	11.1	1.9	21.5	34.3	12.2	2.8
Quebec	3134	1275	1859	20.0	23.8	17.4	1.4	14.9	26.0	7.2	3.6
Ontario	4237	1826	2411	18.3	20.1	16.9	1.2	16.9	26.8	9.4	2.8
Prairie prov. (MB, SK, AB)	2872	1314	1558	15.1	15.9	14.4	1.1	18.4	29.3	9.2	3.2
British Columbia	1800	766	1034	19.8	20.4	19.4	1.1	18.9	29.1	11.5	2.5
USA	7485	3437	4048	9.9	12.5	7.5	1.7 (p=0.249)	10.0	16.1	4.5	3.6 (p=0.778)
New England	443	194	249	13.1	13.7	12.7	1.1	10.9	16.4	5.9	2.8
Mid Atlantic	923	390	533	8.8	11.1	6.9	1.6	10.0	16.4	4.7	3.5
NE Central	986	483	503	10.8	13.9	7.9	1.8	12.3	18.4	6.3	2.9
NW Central	572	278	294	9.3	15.8	3.1	5.1	12.0	20.7	3.9	5.4
S Atlantic	1496	650	846	9.5	12.5	6.9	1.8	8.2	13.5	3.4	4.0
SE Central	479	215	264	5.6	6.8	4.5	1.5	7.5	10.0	5.2	1.9
SW Central	824	383	441	9.9	13.7	6.2	2.2	10.6	18.6	2.9	6.4
Mountain	572	275	297	9.7	11.5	8.1	1.4	10.6	14.2	7.3	1.9
Pacific	1190	569	621	11.6	12.6	10.6	1.2	9.3	16.1	3.0	5.5
MEXICO	5711	2382	3329	7.4	15.7	1.5	10.5 (p=1.000)	16.3	35.7	2.5	14.3 (p=1.000)
Baja California, Baja California Sur	469	196	273	8.1	18.4	0.8	22.9	15.4	33.3	2.8	11.9
Chihuahua, Durango, Sonora, Sinaloa	844	350	494	10.4	22.3	2.3	9.9	21.2	47.0	3.6	13.0
Coahuila, Nuevo Leon, Tamaulipas	1115	485	630	11.8	24.5	2.1	11.7	22.1	47.8	2.3	21.0
Jalisco, Michoacan, Guanajuato, San Luis Potosí	962	390	572	7.8	17.6	1.1	15.5	15.6	35.8	1.9	19.3
Distr. Federal, Est. de Mexico, Morelos, Puebla, Hidalgo	1560	647	913	5.9	12.0	1.5	7.8	15.2	32.8	2.5	13.0
Veracruz, Chiapas, Tabasco, Yucatan	761	314	447	6.0	13.1	1.1	11.7	13.0	28.0	2.5	11.4
BELIZE	3969	1899	2070	9.2	16.1	3.0	5.4 (p=0.005)	13.7	23.7	4.6	5.2 (p<0.001)
Corozal	557	280	277	5.2	9.5	0.8	12.5	8.0	15.2	0.8	20.0
Orange Walk	637	325	312	8.3	14.8	1.6	9.6	14.3	26.6	1.6	17.1
Belize	1208	553	655	11.0	18.8	4.3	4.3	16.2	26.8	7.2	3.7

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (pfor regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
Cayo	752	347	405	6.4	12.7	1.1	11.0	10.5	19.8	2.5	7.9
Stann Creek	432	218	214	19.7	31.2	8.1	3.8	23.5	35.9	11.0	3.3
Toledo	383	176	207	2.7	4.7	1.0	4.5	5.9	11.7	1.1	10.5
COSTA RICA	1273	416	857	8.7	13.7	3.8	3.6 (p=1.000)	9.0	14.6	3.5	4.2 (p=0.984)
San Jose	897	298	599	10.0	15.7	4.2	3.7	10.2	17.3	3.0	5.7
Alajuela	120	46	74	3.5	5.4	1.1	4.8	4.3	5.4	3.0	1.8
Cartago	115	46	69	9.4	11.5	6.8	1.7	4.3	6.9	1.1	6.2
Heredia	141	26	115	3.9	9.1	1.2	7.3	8.9	11.5	7.7	1.5
NICARAGUA	2030	614	1416	4.4	10.6	1.7	6.2 (p=0.074)	9.6	25.1	2.8	9.0 (p=0.056)
Bluefields	410	121	289	7.8	15.7	4.5	3.5	13.2	28.9	6.6	4.4
Esteli	400	122	278	5.3	13.1	1.8	7.3	7.0	18.9	1.8	10.5
Juigaiapa	411	133	278	3.4	9.8	0.4	27.2	8.5	23.3	1.4	16.2
Leon	400	129	271	2.8	7.0	0.7	9.5	12.5	31.8	3.3	9.6
Rivas	409	109	300	2.7	7.3	1.0	7.3	6.6	22.0	1.0	22.0

Table 2d.

Results of descriptive analysis for % risky drinkers, gender ratio by country and region, p-value for regional differences in gender ratios; **Africa/ Asia /Australasia**

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (p for regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
NIGERIA	2059	1106	953	15.2	18.6	11.1	1.7 (p<0.001)	16.0	22.0	9.0	2.4 (p=0.001)
Akwa Ibom State	369	194	175	20.3	25.8	14.3	1.8	12.7	16.5	8.6	1.9
Benue State	379	205	174	7.7	12.7	1.7	7.4	11.1	19.5	1.1	17.0
Federal Capital Territory	187	97	90	19.3	18.6	20.0	1.1	28.3	34.0	22.2	1.5
Nasarawa State	398	210	188	7.8	12.4	2.7	4.7	10.3	17.1	2.7	6.4
Plateau State	365	211	154	20.8	23.2	17.5	1.3	20.5	24.6	14.9	1.7
River State	361	189	172	18.0	19.6	16.3	1.2	19.7	26.5	12.2	2.2
UGANDA	1478	720	758	19.2	27.0	11.4	2.4 (p=0.304)	13.7	21.5	5.9	3.6 (p=1.000)
Central	392	165	227	11.3	15.4	8.3	1.8	8.7	13.9	4.9	2.8
Western	443	194	249	19.9	35.4	7.7	4.6	18.8	31.4	8.9	3.5
Eastern	338	159	179	18.3	23.9	13.3	1.8	9.7	15.1	5.0	3.0
Northern	305	202	103	30.6	35.4	21.4	1.7	19.9	27.1	5.8	4.7
INDIA	2584	1341	1243	7.9	14.5	0.7	20.7 (p=1.000)	10.8	20.3	0.6	33.8 (p=1.000)
Bangalore, Bangalore rural, Bangalore urban	1705	885	820	8.9	16.3	1.0	16.7	12.3	22.8	0.9	26.7
Bidar	397	206	191	6.5	12.6	0.0	--	8.8	17.0	0.0	--
Dakshina Kannada	89	46	43	1.1	2.2	0.0	--	5.6	10.9	0.0	--
Davanagere, Davanagere urban	393	204	189	6.4	11.8	0.5	22.2	7.9	14.7	0.5	27.8
SRI LANKA	1193	603	590	7.0	13.4	0.3	44.7 (p=1.000)	3.5	7.0	0.0	--
North Western Province	118	61	57	2.5	4.9	0.0	--	0.0	0.0	0.0	--
North Central Province	120	62	58	9.2	16.1	1.7	9.4	5.0	9.7	0.0	--
Central Province	154	82	72	8.4	15.9	0.0	--	6.5	12.2	0.0	--
Uva	274	137	137	8.4	16.8	0.0	--	1.8	3.6	0.0	--
Southern Province	120	60	60	6.7	13.3	0.0	--	3.3	6.7	0.0	--
Sabaragamuwa	120	61	59	8.3	16.4	0.0	--	6.7	13.1	0.0	--
Western Province	287	140	147	5.2	10.0	0.7	14.3	3.1	6.4	0.0	--
AUSTRALIA	2434	1000	1434	14.2	15.9	12.5	1.3 (p=1.000)	10.9	16.9	5.2	3.3 (p=1.000)
Melbourne + suburbs	1190	493	697	13.5	15.4	11.6	1.3	9.5	14.2	4.9	2.9
else	1244	507	737	15.8	17.2	14.5	1.2	13.7	22.6	5.8	3.9

Country / region	N			% heavy drinker				% at least monthly RSOD			
	total	men	women	total	men	women	Male/female ratio (GR) (p for regional differences in GR)	total	men	women	Male/female ratio (GR) (p for regional differences in GR)
NEW ZEALAND	1852	814	1038	24.4	23.3	25.6	0.9 (p=1.000)	25.6	33.1	18.2	1.8 (p=1.000)
Upper North Island	514	215	299	25.3	24.4	26.1	0.9	21.7	28.0	16.5	1.7
Mid North Island	490	205	285	24.8	23.1	26.6	0.9	26.6	32.2	20.9	1.5
Lower North Island	317	148	169	20.9	15.3	27.8	0.6	29.7	39.7	17.2	2.3
Upper South Island	318	144	174	24.3	24.7	24.0	1.0	23.2	28.8	17.9	1.6
Lower South Island	213	102	111	26.8	32.6	20.9	0.6	29.6	41.5	17.7	2.3

Table 3.

Binary logistic mixed models estimating variance in heavy drinking and at least monthly RSOD at country and regional levels (OR, 95%CI). M0: two-level models estimating variance explained by country differences, M1: three-level models estimating variance explained at the country and the regional level, ICC (95%CI), separate models for men and women

	Heavy drinking			At least monthly RSOD		
	total	men	women	total	men	women
N individuals	105,061	47,393	57,668	84,008	37,881	46,127
N countries	23	23	23	21	21	21
N regions	132	132	132	115	115	115
M0 (2-level model; country level variation)						
Age (in decades), OR (95%CI)	1.09 (0.93–1.27)	1.10 (0.94–1.30)	1.06 (0.92–1.23)	0.72 (0.66–0.79)	0.75 (0.69–0.82)	0.64 (0.59–0.70)
Gender (males), OR (95%CI)	1.92 (1.53–2.41)	--	--	5.03 (3.93–6.43)	--	--
ICC (country) 95% CI	0.13 (0.09–0.18)	0.10 (0.05–0.18)	0.32 (0.21–0.45)	0.16 (0.10–0.26)	0.14 (0.08–0.22)	0.32 (0.17–0.52)
M1 (3-level model; country and regional variation measured by ICC)						
Age (in decades), OR (95%CI)	1.09 (0.93–1.27)	1.11 (0.94–1.30)	1.06 (0.91–1.24)	0.72 (0.66–0.78)	0.75 (0.68–0.82)	0.64 (0.58–0.69)
Gender (males), OR (95%CI)	1.93 (1.54–2.42)	--	--	5.09 (3.97–6.53)	--	--
ICC (country) 95%CI	0.13 (0.09–0.17)	0.10 (0.05–0.19)	0.31 (0.21–0.44)	0.16 (0.10–0.24)	0.14 (0.08–0.22)	0.30 (0.16–0.51)
ICC (region) 95%CI	0.02 (0.009–0.05)	0.02 (0.016–0.04)	0.02 (0.01–0.05)	0.02 (0.01–0.04)	0.02 (0.01–0.03)	0.04 (0.02–0.07)

model comparison to test variation in gender differences in heavy drinking (10/20g or more of pure ethanol on average per day for women/men) and RSOD (5 or more drinks per occasion at least monthly) between countries and between regions (three-level logistic mixed models for risky drinking adjusted for age and gender.)

Table 4:

Model	Description of model	Heavy drinking 105,061 individuals, 132 regions, 23 countries			At least monthly RSOD 84,008 individuals, 115 regions, 21 countries		
		Log-Likelihood (higher is better)	df (degrees of freedom) for random effects	p for Likelihood-Ratio- Test	Log-Likelihood (higher is better)	df (degrees of freedom) for random effects	p for Likelihood-Ratio- Test
Model a	Random intercept for country Random intercept for region, fixed gender slope, adjusted for age	-45683.07	2	--	-28446.72	2	--
Model b	Model a + random slope for gender on country level (testing variation in gender differences between countries)	-45278.59	3	Model a vs. b p<0.001	-28240.60	3	Model a vs. b p<0.001
Model c	Model a + random slope for gender on regional level (testing variation in gender differences between regions)	-45380.75	3	Model a vs. c p<0.001	-28293.55	3	Model a vs. c p<0.001
Model d	Model a + random slope for gender on country level (testing variation in gender differences between countries) + random slope for gender on regional level (testing variation in gender differences between regions)	-45270.87	4	Model a vs. d p<0.001 Model b vs. d p<0.001 Model c vs. d p<0.001	-28234.74	4	Model a vs. d p<0.001 Model b vs. d p<0.001 vs. d p<0.001