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Why Is Per Capita Consumption Underestimated in Alcohol Surveys? Results from 39 Surveys in 23 European Countries

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Abstract

Aims: The aims of the article are (a) to estimate coverage rates (i.e. the proportion of 'real consumption' accounted for by a survey compared with more reliable aggregate consumption data) of the total, the recorded and the beverage-specific annual per capita consumption in 23 European countries, and (b) to investigate differences between regions, and other factors which might be associated with low coverage (prevalence of heavy episodic drinking [HED], survey methodology).
Methods: Survey data were derived from the Standardised European Alcohol Survey and Harmonising Alcohol-related Measures in European Surveys (number of surveys: 39, years of survey: 2008–2015, adults aged 20–64 years). Coverage rates were calculated at the aggregated level by dividing consumption estimates derived from the surveys by alcohol per capita estimates from a recent global modelling study. Fractional response regression models were used to examine the relative importance of the predictors.
Results: Large variation in coverage across European countries was observed (average total coverage: 36.5, 95% confidence interval [CI] [33.2; 39.8]), with lowest coverage found for spirits consumption (26.3, 95% CI [21.4; 31.3]). Regarding the second aim, the prevalence of HED was

associated with wine- and spirits-specific coverage, explaining 10% in the respective variance. However, neither the consideration of regions nor survey methodology explained much of the variance in coverage estimates, regardless of the scenario.

Conclusion: The results reiterate that alcohol survey data should not be used to compare or estimate aggregate consumption levels, which may be better reflected by statistics on recorded or total per capita consumption.

INTRODUCTION

Epidemiological surveys are one of the backbones of public health surveillance as they provide population-based data on relevant health behaviors such as alcohol consumption at the individual level. Alcohol consumption is of particular political interest in Europe, as it is a leading risk factor for premature mortality, causing 8.3% (95% CI [7.2; 9.3]) of all years of life lost due to premature mortality in 2016 in the European Union plus Switzerland and Norway (Rehm *et al*., 2019; World Health Organization, 2019). However, surveys, which usually assess the typical quantity and frequency of drinking over a specified reference period (Gmel and Rehm, 2004; Nugawela *et al*., 2016), tend to underestimate the 'real consumption' at the aggregate level (Midanik, 1982; Probst *et al*., 2017), where the latter is mainly assessed by routine statistics such as taxation records or production, import and export (see below for exact definition). The proportion of the 'real consumption' that is covered by surveys is known as coverage rate (Midanik, 1982). In the Standardised European Alcohol Survey (SEAS), which resulted from the Joint Action on Reducing Alcohol-Related Harm (RARHA), the coverage rates on total annual consumption in 19 European countries ranged between 32.1% in France and more than 80% in Bulgaria and Norway in 2015 (Sierosławski *et al*., 2016). Comparable variability in coverage rates were observed in the RARHA Harmonising Alcohol-related Measures in European Surveys (HARMES), which harmonized data from 24 surveys conducted in 20 European countries between 2008 and 2013 (range: 20.5% in Croatia 2011 to 77.7% in Hungary 2009; see Piontek *et al*., 2016).

In this paper, we integrated and compared the coverage rates derived from both, the RARHA SEAS and RARHA HARMES surveys, between countries and supranational regions in order to capture a unified and comprehensive picture of alcohol consumption coverage in Europe. Thereby, we compared estimates of total and beverage-specific alcohol consumption derived from the surveys with the respective 'real consumption' estimates (total, recorded and beverage-specific recorded) from a recent global modelling study (Manthey *et al*., 2019). 'Real consumption' is usually defined by the total *per capita* consumption in adults, which includes recorded and unrecorded alcohol while taking tourist consumption into account (Poznyak *et al*., 2013; Griswold *et al*., 2018). However, once gender and age-specific *per capita* consumption estimates are applied, it should be noted that the demographically based projections are in part based on survey data.

While being the gold standard to determine the level of consumption in a country (Gmel and Rehm, 2004), *per capita* consumption cannot replace survey data because, for example, it does not tell us anything about the prevalence of alcohol use, patterns of consumption among drinkers of different demographic groups and variations of consumption levels in the population. This information is necessary for calculating the harm caused by alcohol, including but not limited to the burden of disease and mortality (Rehm *et al*., 2004). Therefore, survey data are a crucial component of alcohol monitoring even if their accuracy as regards consumption levels is limited.

Several potential factors underlying low coverage were discussed in previous studies. First, with decreasing participation in surveys, contemporary surveys may be increasingly affected by non-response bias. A high non-response rate, frequently exceeding 50% in general population surveys, was shown to lead to the underestimation of alcohol use, as late- and non-responders are more likely to report heavier drinking (Zhao *et al*., 2009). Second, the evaluation of one's drinking behaviour can be influenced by survey methodology such as the reference period (Ekholm, 2004; Greenfield and Kerr, 2008; Stockwell *et al*., 2008; Ekholm *et al*., 2011). For example, Stockwell and colleagues obtained the highest coverage using a detailed 'yesterday' approach in contrast to a quantity-frequency and a graduated-frequency method referring to the past 12 months. Moreover, an earlier study examining survey data from 10 European countries found significant differences in the survey methodology between countries, with the authors concluding that a cross-country comparison should therefore be avoided (Knibbe and Bloomfield, 2001). Third, bias due to under-reporting may be related to difficulties to cognitively breakdown variable drinking patterns into the 'usual drinking' in standard surveys (National Institute on Alcohol Abuse and Alcoholism–Task Force on Recommended Alcohol Questions, 2003). Furthermore, the omission of irregular heavy drinking occasions which may constitute a large part of drinking (Dawson, 1998) and the tendency to present oneself in a positive light as a moderate drinker (Davis *et al*., 2010) are potential contributing factors to low coverage at the individual level. Previous studies investigating individual-level differences in under-reporting alcohol consumption identified young men, middle-aged women and low-risk drinkers, i.e. those who report no or infrequent heavy episodic drinking (HED), as more likely to underestimate their drinking (Rogers and Greenfield, 2000; Stockwell *et al*., 2014; Livingston and Callinan, 2015).

In order to assess factors that are associated with under-reporting bias as mentioned above, the current study investigated indicators of cross-country variations in total and beverage-specific coverage at an aggregated level. The following hypotheses were tested: (a) a higher non-response rate is associated with a lower coverage rate; (b) a shorter reference period, i.e. the period for which alcohol consumption was recorded is associated with a higher coverage rate and (c) a higher prevalence of HED is associated with a higher coverage rate. Regarding the latter, our hypothesis builds on the assumption that alcohol consumed in episodes of heavy drinking contributes to a large part of overall drinking. Consequently, a higher prevalence of HED would lead to higher survey-based estimates of alcohol consumption at the country level, associated with enhanced coverage rates. In addition, we examined the relative importance of the sampling frame and the mode of administration in coverage.

METHODS

Surveys

Survey data were used from 19 countries that participated in RARHA SEAS in 2015, including 32,576 adults aged 18–65 years, as well as from RARHA HARMES, which combines 24 surveys from 20 countries, including a total of 389,012 adults aged 15–64 years. While the RARHA SEAS represents a single alcohol questionnaire that is available in several languages, the RARHA HARMES compiles a collection of existing European nation-wide population surveys focusing either on alcohol, substance use or health. As multiple questionnaires were harmonized in RARHA HARMES, survey methodology and alcohol assessment differ across surveys. However, the majority of RARHA SEAS and RARHA HARMES surveys used a beverage-specific quantity frequency approach referring to the past 12 months to record alcohol consumption, with only two surveys using a generic quantity-frequency measure (Belgium 2013 and France 2010). Eight surveys covered a reference period either shorter or at least the past 30 days. Details on survey methodology are presented in Table 1. Further information on survey assessment is provided in the Supplementary Material S1 and the published synthesis report (Moskalewicz *et al*., 2016).

Data on the total alcohol consumption were available in all RARHA SEAS surveys and in 20 of the 24 RARHA HARMES surveys with the exception of Italy 2012, Northern Ireland 2010, Sweden 2012 and Wales 2013 (n = 53,569; total available surveys: 39). A beverage-specific breakdown of total alcohol consumption was missing in four additional RARHA HARMES surveys (Austria 2008, Belgium 2013, France 2010, Iceland 2012; n = 34,114; total available surveys: 35). HED was not recorded in Austria 2008, England 2013 and Scotland 2013 (n = 11,905). In Finland 2008, information on HED was missing in more than 20% of respondents, why the survey was excluded in analyses referring to HED (n = 2290). All respondents aged between 20 and 64 years were included to enable comparability between the surveys, as few national surveys covered respondents of a higher age, and to compare survey estimates to estimates for alcohol *per capita* consumption (APC) described below, which were available as age-specific estimates for the similar age group. Furthermore, respondents who did not report gender or any information on alcohol consumption were excluded (4.0% excluded).

The following survey-level characteristics were considered as covariates to predict coverage rates: the prevalence of HED, non-response rate, reference period (dichotomous: past 30 days or less vs. past 12 months), mode of administration (categorial: personal interview/CAPI, telephone interview/CATI, online/paper-pencil survey or mixed mode) and sampling frame (dichotomous: random sampling vs. complex sampling procedure). Four supranational regions, originally derived from Shield and colleagues (Shield *et al*., 2012), were determined (categorial: Nordic European region, Central-western European region, Mediterranean region and Central-eastern European region). An overview of all survey-level characteristics and country assignment to supranational regions is presented in Table 1.

Per capita consumption

APC data were based on the World Health Organization (Poznyak *et al*., 2013), which reports country-validated data on recorded consumption, estimated unrecorded consumption and corrections for tourist consumption, the sum of which constitutes total APC. Rather than using APC data for the entire population as reported by the WHO, we obtained APC-based consumption estimates split for recorded and total consumption by sex and age groups from a recent global modelling study (Manthey *et al*., 2019). In this study, the country-validated APC data for recorded and total consumption from the WHO were combined with survey data to estimate the breakup of APC by gender and several age groups (relevant for this study: 20–24, 25–34, 35–49 and 50–64 years). Importantly, no RARHA SEAS data but data from 9 of the 20 RARHA HARMES (Belgium 2013, England 2013, France 2010, Germany 2012, Hungary 2014, Iceland 2012, Latvia 2011, Portugal 2012 and Scotland 2013) were entered in the model, which served to split APC by gender and age (see Supplementary material of Manthey *et al*., 2019 for details on APC splitting). From the global modelling study, we obtained recorded and total APC estimates for adults aged 20–64 years, which served as denominator to calculate coverage rates. The same data were also used to recalculate beverage-specific APC estimates using the relative contribution of each beverage type as reported by the WHO (Poznyak *et al*., 2013). This approach assumed that the contribution of each beverage type would be the same across all age groups, which was implicitly tested in our analyses. Since APC estimates were available by age group, they were age-standardised on the basis of the UN Population Prospects for the respective years (United Nations, Department of Economic and Social Affairs, Population Division, 2019).

Statistical analysis

Annual alcohol consumption was defined as the average consumption among adults between 20 and 64 years of age in liters of pure alcohol in the past 12 months and was calculated for the total and the beverage-specific alcohol consumption. In respondents reporting to abstain from alcohol, the annual consumption was assumed to be 0 liters. Survey weights were applied in all analyses at the individual level (i.e., prevalence of HED, annual alcohol consumption estimates) to account for sampling bias in the surveys. The coverage rate was calculated by dividing the survey estimates of annual alcohol consumption by (a) the total APC and (b) the recorded APC estimates of the respective year. While total APC included information on unrecorded alcohol, recorded APC was used as a conservative estimate. In addition, beverage-specific coverage rates were estimated based on beverage-specific survey estimates of alcohol consumption and the respective recorded APC. Confidence intervals (CIs) were determined based on the standard errors derived from the alcohol consumption estimates and those reported for the modelled total APC estimates. In the case of recorded and beverage-specific recorded APC estimates, a standard error of 0 was used. Overall surveys, population-weighted averages and CIs of coverage rates were calculated weighted for population size. Additionally, population-weighted averages and CIs of coverage rates were determined for surveys which were not used in Manthey *et al*. (2019) in order to test if those surveys would affect the overall coverage. A change of more than 10% in the average coverage was used as criterion for determining restricted validity of the affected surveys, which would lead to exclusion from analysis.

In order to test our hypotheses, we analysed systematic differences in the coverage rates using fractional response regression models for each of the following dependent variables: (a) the total, (b) recorded, (c) beer-specific recorded, (d) wine-specific recorded and (e) spirits-specific recorded coverage rate. In a first set of regression analyses, supranational regions were included as independent variable. In a second set of analyses, prevalence of HED was analyzed as a

Table 1. Survey, survey characteristics, prevalence of HED and the number of respondents for countries in RARHA SEAS and/or RARHA HARMES included in the current analyses

Country	Survey	Year of survey	Mode of administration	Sampling frame	Reference period[b]	NRR (%)	HED (%)[c]	Number of respondents
Nordic region								
Finland	Finnish drinking habits survey	2008	Mixed mode	Simple random	Usual drink day[d]	26.4	78.1[e]	2290
Finland	RARHA SEAS	2015	CATI	Stratified/quota sample	Past 12 months	88.5	62.8	1456
Iceland	Alcohol survey[a]	2013	Online	Simple random	Past 12 months	33.7	71.0	1055
Iceland	Health and Wellbeing of Icelanders[a]	2012	Paper-and-pencil	Stratified/quota sample	Past 12 months	32.8	68.4	4246
Iceland	RARHA SEAS	2015	Online	Simple random	Past 12 months	52.3	62.2	846
Norway	Population survey on tobacco and substance use[a]	2012	Telephone	Simple random	Past 30 days	46.7	57.7	1459
Norway	RARHA SEAS	2015	CATI	Simple random	Past 12 months	88.0	60.3	1433
Sweden	RARHA SEAS	2015	Mixed mode	Simple random	Past 12 months	64.1	64.3	1538
Central-western region								
Austria	Austrian National Survey on Substance Use[a]	2008	Face-to-face	Other	Usual drink day	65.6	NA	2267
Austria	RARHA SEAS	2015	Mixed mode	Multi-stage sample	Past 12 months	58.5	53.9	3063
Belgium	Health Interview Survey[a]	2013	Mixed mode	Multi-stage sample	Past 12 months	45.0	53.5	3009
Denmark	Alcohol consumption in Denmark[a]	2008	Mixed mode	Stratified/quota sample	Typical week[d]	42.6	80.6	2735
Denmark	RARHA SEAS	2015	Mixed mode	Simple random	Past 12 months	47.5	66.2	1489
Denmark	The Danish National Health Survey[a]	2010	Mixed mode	Stratified/quota sample	Typical week[d]	40.5	79.8	121,584
Denmark	The Danish National Health Survey[a]	2013	Mixed mode	Stratified/quota sample	Typical week[d]	46.0	79.6	102,875
France	Health Barometer[a]	2010	Telephone	Multi-stage sample	Past 12 months	40.0	39.7	21,139
France	RARHA SEAS	2015	CATI	Multi-stage sample	Past 12 months	55.5	32.0	1642
Germany	Epidemiological Survey of Substance Abuse[a]	2009	Mixed mode	Multi-stage sample	Past 12 months	49.9	29.1	7283
Germany	Epidemiological Survey of Substance Abuse[a]	2012	Mixed mode	Multi-stage sample	Past 12 months	46.4	29.0	8287
UK	Health Survey of England[a]	2013	Mixed mode	Other	Past 12 months	44.0	NA	6136
UK	RARHA SEAS	2015	CATI	Simple random sample	Past 12 months	85.0	60.6	955
UK	Scottish Health Survey[a]	2013	Mixed mode	Other	Past 12 months	44.0	NA	3502
Mediterranean region								
Greece	RARHA SEAS	2015	CATI	Multi-stage sample	Past 12 months	73.0	20.8	1447
Italy	RARHA SEAS	2015	CATI	Simple random	Past 12 months	91.3	10.5	1398
Portugal	General Population Survey on Drugs[a]	2012	Face-to-face	Multi-stage sample	Past 12 months	52.5	12.8	4922
Portugal	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	39.0	10.5	1438
Spain	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	49.7	35.6	1595
Central-eastern region								
Bulgaria	RARHA SEAS	2015	Paper-and-pencil	Multi-stage sample	Past 12 months	25.0	34.5	2668
Croatia	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	49.4	24.1	1407

Continued

Table 1. Continued

Country	Survey	Year of survey	Mode of administration	Sampling frame	Reference period[b]	NRR (%)	HED (%)[c]	Number of respondents
Croatia	Substance abuse among the general population in the Republic of Croatia[a]	2008	Face-to-face	Multi-stage sample	Usual drink day[d]	46.9	32.7	3404
Estonia	RARHA SEAS	2015	CATI	Simple random	Past 12 months	39.6	48.2	2090
Hungary	European Health Interview Survey—EHIS2009[a]	2009	Face-to-face	Multi-stage sample	Past 7 days	27.9	24.0	2955
Hungary	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	57.0	12.5	1941
Latvia	Population Survey about Substance Use[a]	2011	Face-to-face	Stratified/quota sample	Past 12 months	37.7	44.9	3614
Lithuania	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	65.0	67.0	1451
Poland	Patterns of alcohol consumption in Poland[a]	2008	Face-to-face	Stratified/quota sample	Past 12 months	53.0	40.6	824
Poland	RARHA SEAS	2015	CAPI	Multi-stage sample	Past 12 months	36.4	39.6	1500
Romania	RARHA SEAS	2015	CATI	Stratified/quota sample	Past 12 months	69.0	27.8	1409
Slovenia	Survey on the Use of Tobacco, Alcohol and Other Drugs[a]	2012	Mixed mode	Multi-stage sample	Past 12 months	47.1	45.3	6668

[a]Part of the RARHA Harmonising Alcohol-related Measures in European Surveys.
[b]Time period for which alcohol consumption was recorded.
[c]At least one episode of heavy drinking (HED) in the past 12 months.
[d]No specific reference period.
[e]21.6% missings in HED; CAPI = computer-assisted personal interview.
CATI = computer-assisted telephone interview; NRR = Non-Response Rate; UK = United Kingdom of Great Britain and Northern Ireland; RARHA = Joint Action on Reducing Alcohol-Related Harm; SEAS = Standardised European Alcohol Survey; NA = not available.

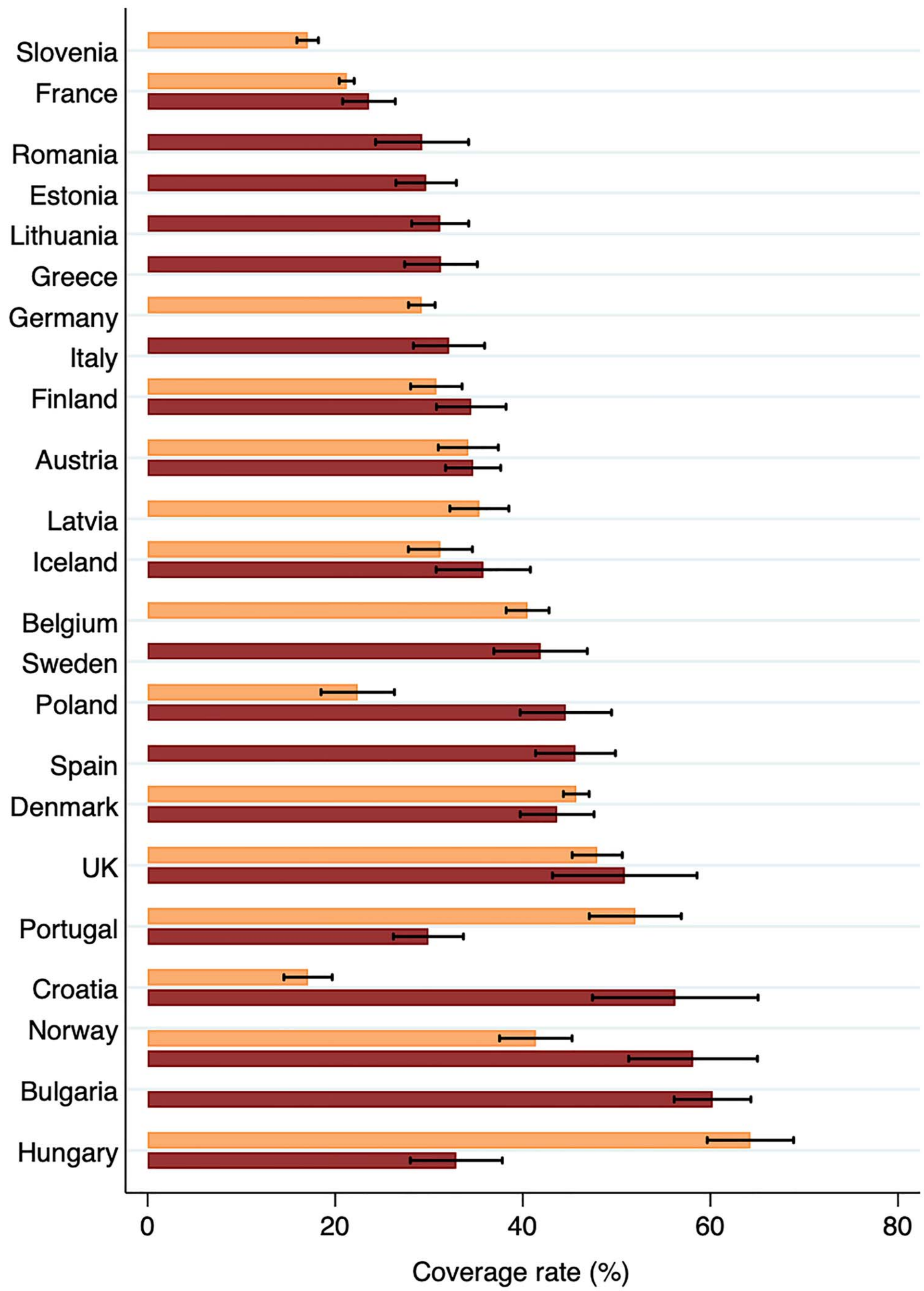

Fig. 1. Coverage rates for total alcohol consumption by country. Alcohol consumption coverage rates referring to total alcohol consumption are presented separately for the RARHA SEAS (red) and the RARHA HARMES surveys (orange), ordered by country. Most recent survey was used if multiple surveys were included in RARHA HARMES (Denmark 2013, Iceland 2013); coverage rates for England 2013 and Scotland 2013 were averaged (UK 2013). UK = United Kingdom of Great Britain and Northern Ireland; RARHA = Joint Action on Reducing Alcohol-Related Harm; SEAS = Standardised European Alcohol Survey; HARMES = Harmonising Alcohol-related Measures in European Surveys.

predictor for all countries with available data. In a third set, the following independent variables referring to survey methodology were considered: non-response rate, reference period, sampling frame and administration mode. ***Models were tested for the relative impact of the year of survey, data source (RARHA SEAS, RARHA HARMES) and country. A change of more than 10% in regression coefficients of the predictors was used as criterion to include control variables in a model. For each model, the variance in coverage explained by the predictors was determined. All statistical analyses were performed using Stata 15.1 (StataCorp, 2017).

RESULTS

Total coverage rates for RARHA SEAS and RARHA HARMES are presented by country and database in Fig. 1. The lowest coverage was observed in Croatia 2008 and Slovenia 2012 with 17.1% (Croatia 2008: 95% CI [14.5; 19.7]; Slovenia 2012: 95% CI [15.9; 18.2]) for total and 15.7% (Croatia 2008: 95% CI [13.4; 18.0]) for recorded alcohol consumption. Coverage was highest in Hungary 2009 with 64.3% (95% CI [59.7; 68.9]) for total and Norway 2015 with 72.2% (95% CI [63.9; 80.4]) for recorded alcohol consumption. For beverage-specific estimates, coverage was the highest for beer with an average coverage of 43.6% (95% CI [38.4; 48.8]) and the lowest for spirits with an average coverage of 26.3% (95% CI [21.4; 31.3]) across all surveys. Detailed information on the annual alcohol consumption derived from the surveys, age-standardised total, recorded and beverage-specific recorded APC estimates and the coverage rates by survey can be found in Supplementary Materials S2 and S3. No considerable differences between the average coverage estimates based on surveys, which were not used by Manthey *et al.* (2019), in reference to all surveys were observed (see Supplementary Material S3). The decrease in average coverage ranged between 1.0% in recorded and 8.7% in spirits-specific coverage.

Ten countries were covered in both databases and at different times, allowing descriptive comparisons of survey level characteristics within a country (see Fig. 1). In Hungary and Portugal, the coverage was considerably higher in surveys derived from RARHA HARMES compared with RARHA SEAS. Specifically, Hungarian coverage rate estimated using a 2009 survey (64.3, 95% CI [59.7; 68.9]) was twice as high as the coverage rate estimated using RARHA SEAS 2015 (32.9, 95% CI [28.0; 37.8]). The opposite was true in Croatia, Poland and Norway where the coverage was higher using RARHA SEAS compared with using RARHA HARMES. The greatest deviation was observed in Croatia where coverage based on RARHA SEAS 2015 (56.3, 95% CI [47.4; 65.1]) was approximately three times higher than coverage derived from a 2008 survey (17.1, 95% CI [14.5; 19.7]).

Results of the regression analyses for the different coverage estimates are shown in Table 2. In the majority of regression models, covariates did not lead to a significant change in regression coefficients so that no adjustments were made in any analyses. There were systematic differences in supranational regions for recorded beer consumption: the coverage was lower by 15% in the Central-eastern region compared with the Nordic region. However, variance explained by region was low (R^2 = 1.4%). No other regional differences in coverage were observed. Regarding the prevalence of HED, an increase of 1% was associated with a 0.09% increase and a 0.16% increase in the wine- and the spirits-specific coverage rate, respectively. The variance in beverage-specific coverage explained by HED prevalence ranged between 9.6% (wine) and 10.6% (spirit). The mode of administration was a significant predictor of spirits-specific coverage, which was higher in self-administered surveys compared with face-to-face interviews (Marginal effect = 0.22%; R^2 = 1.7%). Non-response rate, reference period and sampling frame were not found to be associated with any coverage rate.

DISCUSSION

On average, i.e. in all of the surveys, total adult alcohol consumption was underestimated by survey estimates at the coverage of 36.5 to 41.5% regardless of which scenario (i.e., total and recorded APC). When looking at different types of alcoholic beverage, underestimation reached a maximum at coverage of 26.3% on average for spirits-specific recorded APC. The coverage varied strongly across and within countries but not between supranational regions, with the exception for beer-specific coverage. The prevalence of HED explained substantial variance in spirits- and wine-specific coverage. The coverage rates for the entire adult population (15 years and older) will differ from these results due to different drinking and reporting behaviors in excluded age groups, as we estimated coverage for a restricted age range only (20–64 years).

Strengths and limitations

The article was the most comprehensive assessment of coverage in Europe at present. Including 39 surveys from 23 European countries, we were able to investigate regional differences and survey methodology, which were supposed to be associated with the underestimation of alcohol consumption. However, for the interpretation of findings, limitations have to be taken into account. First, while the APC is mainly based on sales or production, import and export, age-specific APC estimates for the considered populations on the basis of Manthey *et al.* (2019) were based on modelling assumptions regarding age-specific alcohol consumption and, therefore, may introduce bias. In particular, it must be taken into account that some RARHA HARMES surveys used in this study were also part of the modelling study by Manthey *et al.* (2019), which limits the interpretation of respective coverage estimates. Second, we were not able to assess whether respondents included unrecorded alcohol consumption such as homebrewed alcohol, alcohol brought over the border or that is not intended for drinking in their overall consumption estimates, nor were we able to estimate unrecorded consumption since it was only asked in a few surveys. In accordance to RARHA SEAS, unrecorded alcohol consumption does account for a substantial proportion of total alcohol consumption in five of seven European countries that were investigated by Manthey *et al.* (2020), such as Greece and Portugal. Third, RARHA HARMES includes various surveys, used different consumption measures, i.e. generic quantity-frequency or beverage-specific quantity frequency measures, and different definitions of HED, which limits comparability between those surveys and with the RARHA SEAS data. Moreover, annual consumption estimates in RARHA SEAS applied capping procedure to avoid the overestimation of individual consumption, while no RARHA HARMES survey reported any capping which must have led to higher consumption estimates in the latter group of surveys. Fourth, applied survey methodologies were very heterogeneous, which was an advantage of the study, but sometimes also led to low cell counts, e.g. only three surveys used a reference period of a single day (i.e., 'usual drink day' or 'yesterday'). Therefore, categories of variables were grouped, e.g. a reference period of a usual drink day, the past 7 days and the past 30 days, which means a loss of information. For example, recording alcohol intake in reference to the day before ('yesterday approach') in survey assessments has been shown to be the most reliable approach to estimate alcohol consumption at aggregate level (Stockwell *et al.*, 2008, 2014). However, due to the limited number of surveys employing this method, we were not able to investigate such level of detail. Lastly, we only investigated associations between predictors and coverage estimates and therefore cannot draw any conclusions about causality.

Interpretation of our findings

Our findings were in line with previous studies reporting low coverage in alcohol consumption (Midanik, 1982; Knibbe and Bloomfield, 2001; Stockwell *et al.*, 2008, 2014; Probst *et al.*, 2017). We further

Table 2. Results of fractional response regression analyses for different coverage estimates

Variables	Coverage rate referring to									
	Total alcohol consumption[a]		Recorded alcohol consumption[a]		Beer-specific alcohol consumption[b]		Wine-specific alcohol consumption[b]		Spirits-specific alcohol consumption[b]	
	ME	95% CI	ME	95% CI	ME	95% CI	ME	95% CI	ME	95% CI
European region (ref.: Nordic region)										
Central-western region	0.03	[−0.06; 0.12]	-0.02	[−0.13; 0.10]	-0.02	[−0.15; 0.10]	0.00	[−0.10; 0.10]	-0.06	[−0.20; 0.07]
Mediterranean region	0.01	[−0.09; 0.11]	0.00	[−0.13; 0.13]	0.01	[−0.13; 0.14]	-0.02	[−0.18; 0.13]	-0.09	[−0.22; 0.05]
Central-eastern region	0.00	[−0.12; 0.11]	-0.07	[−0.21; 0.06]	-0.15*	[−0.30; −0.01]	-0.10	[−0.22; 0.02]	-0.10	[−0.22; 0.03]
Prevalence of HED (%)[c]	0.05	[−0.04; 0.13]	0.06	[−0.04; 0.15]	0.04	[−0.05; 0.14]	0.09*	[0.01; 0.18]	0.16**	[0.07; 0.26]
Non-response rate	0.05	[−0.08; 0.19]	0.09	[−0.09; 0.28]	0.00	[−0.22; 0.23]	0.12	[−0.09; 0.32]	0.07	[−0.15; 0.29]
Reference period (ref.: Past 12 months)										
Past 30 days or less	0.05	[−0.07; 0.17]	0.06	[−0.08; 0.20]	-0.10	[−0.25; 0.03]	0.01	[−0.13; 0.14]	0.01	[−0.13; 0.14]
Administration mode (ref.: Face-to-face or CAPI)										
Telephone or CATI	-0.07	[−0.16; 0.03]	-0.05	[−0.18; 0.08]	0.01	[−0.17; 0.20]	-0.04	[−0.23; 0.16]	-0.01	[−0.17; 0.16]
Online or paper-pencil	0.04	[−0.10; 0.18]	0.06	[−0.09; 0.22]	0.14	[−0.02; 0.30]	0.04	[−0.09; 0.17]	0.21**	[0.05; 0.36]
Mixed mode	-0.03	[−0.13; 0.07]	0.00	[−0.12; 0.11]	0.00	[−0.15; 0.16]	0.02	[−0.13; 0.17]	0.00	[−0.13; 0.13]
Sampling frame (ref.: Random sample)										
Complex sampling	-0.03	[−0.11; 0.04]	-0.04	[−0.34; 0.05]	-0.05	[−0.17; 0.08]	-0.02	[−0.12; 0.07]	0.01	[−0.11; 0.13]

[a] $N = 39$ observations.
[b] $N = 35$ observations (no beverage-specific data available for Austria 2008, Belgium 2013, France 2010, Iceland 2012).
[c] a: $N = 35$, b: $N = 32$ observations (no data for HED available in Austria 2008, England 2013, Scotland 2013; Finland 2008 was excluded because of substantial missings).
* $P < 0.05$.
** $P < 0.01$.
ME = Marginal effect (interpretable as percentage points (categorial predictor) or % (continuous predictor) change of coverage rate corresponding to an increase of 1 unit in covariate); CAPI = computer-assisted personal interview; CATI = computer-assisted telephone interview; ref. = reference.

highlighted the relative importance of spirits consumption for total coverage rates. Higher underestimation of spirits drinking may be due to reasons such as the association of drinking strong alcohol with HED (Dawson, 1998), a higher irregularity of spirits drinking, which may result in an underestimation of drinking frequency (Sierosławski *et al*., 2013), or the missed assessment of drink size in on- and off-premise contexts in surveys, which differ greatly across countries and could impair respondents' evaluation of own drinking behavior (Kerr *et al*., 2009). Moreover, low spirits-specific coverage could be associated with age-specific beverage preference, while a uniform distribution across all age groups was assumed for APC calculations.

Our results suggested that coverage rates of spirits consumption were highest in countries with higher HED prevalence, with HED explaining about 10% in the variance of coverage. This result corroborated previous findings (Rogers and Greenfield, 2000; Stockwell *et al*., 2014; Livingston and Callinan, 2015) and could be related to the tendency to represent a positive self-presentation in light and moderate drinkers (Davis *et al*., 2010). However, given the lack of a gold standard, an unambiguous interpretation is not feasible at this stage, but there are at least two possible explanatory pathways to be considered in future research: First, assuming that HED prevalence would be correctly reported, in countries with higher HED prevalence, drinking spirits is more common and drinkers are more acquainted with gauging their spirits consumption on usual drinking days, as opposed to drinkers in countries where HED is rather uncommon. Second, assuming that HED prevalence would not be correctly reported, drinkers in some countries are better at recalling their heavy drinking occasions than drinkers in other countries. Most likely, the truth lies somewhere in between these two pathways, with both accuracy of recalling spirits quantities consumed on usual drinking days (pathway 1) and accuracy of recalling frequency of heavy drinking occasions (pathway 2) being relevant to the overall coverage rates. While alcohol under-reporting may be due to drinkers' recall bias to a considerable degree, it should also be acknowledged that (spirit) quantities may not be accurately assessed in surveys using simple quantity-frequency indices (e.g., Kuitunen-Paul *et al*., 2017). Furthermore, the association between coverage of spirits consumption and survey's mode of administration, indicating higher coverage rate when self-assessment methods were applied, needs to be highlighted. Our findings suggested that measures of self-reported spirits drinking are especially vulnerable to methods of survey implementation and could lead to low coverage.

With respect to methodological differences, neither non-response rate nor the reference period was associated with low coverage as hypothesized. The absence of systematic differences in survey methodologies substantially limits cross-national comparisons of alcohol survey data as alcohol consumption is underestimated to an uncertain degree. Such comparisons should therefore be conducted with caution (see also Knibbe and Bloomfield, 2001) and under consideration of coverage rates, if only for standardization (for methodologies to do this, see Rehm *et al*., 2010; Kehoe *et al*., 2012; Parish *et al*., 2017). Our data offered the chance to compare survey characteristics descriptively within countries. In Hungary, sampling frame and mode of administration did not differ between both surveys (Hungary 2009, Hungary 2015) in contrast to the reference period, which covered the past 7 days in Hungary 2009 and the past 12 months in the Hungary 2015. In addition, the number of respondents and response rate were considerable higher in the former compared with Hungary 2015. The opposite was observed in Croatia: the coverage rate derived from Croatia 2008, referring to a 'usual drink day', was considerably lower than in the 2015 survey. In conclusion, these findings underline that even within countries and under similar conditions of survey assessment, coverage of alcohol consumption can vary greatly, but true consumption is usually underestimated, with coverage not exceeding 75%. On the one hand, this is a major limitation in the comparability of aggregated-level data from population-based alcohol surveys, unless coverage rates are included in the modelling, and on the other hand, it is a call for more research investigating predictors of low coverage rates.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Alcohol and Alcoholism* online.

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CONFLICT OF INTEREST

None to declare.

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