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ORIGINAL ARTICLE

The information capacity of adolescent alcohol consumption indicators along a continuum of severity: A cross-national comparison of sixteen Central and Eastern European countries

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Abstract

Background: Because there is high variability among European countries in prevalence levels of various alcohol consumption measures, the informational value of adolescent's alcohol consumption indicators is uncertain. The present study aimed to examine information capacity and measurement invariance of different alcohol consumption indicators in adolescents from countries of the former Soviet (Eastern) Bloc in Central and Eastern Europe (CEE).

Methods: Data were collected in 16 CEE countries, as part of the 2013/2014 wave of the Health Behavior in School-aged Children study. Data from adolescents (age 15) who reported having consumed alcohol at least once in their lifetime were analyzed. Four binary items selected for analysis measured the presence or absence of alcohol consumption in the last 30 days, lifetime drunkenness, weekly drinking frequency, and binge drinking on a typical occasion. Multiple group confirmatory factor analysis and item response theory analysis were used to examine the data.

Results: In most of the included countries, alcohol consumption in the last 30 days and lifetime drunkenness were indicative at lower severity levels, while binge drinking and weekly drinking frequency were informative at higher levels of alcohol use severity. A low proportion of the estimated intercepts and factor loadings were noninvariant, which indicated approximate cross-national invariance of these indicators.

Conclusions: Adolescent alcohol consumption indicators are informative for different severity levels and enable cross-nationally invariant measurement. However, different indicators suggested the presence of diverging drinking cultures in the CEE regions, with the highest discrimination capacity at the lower and higher ends of the continuum of alcohol use severity.

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KEYWORDS
adolescents, alcohol consumption, alignment method, item response theory, measurement invariance

INTRODUCTION

Adolescent alcohol use is one of the major public health concerns in many European and North American countries (Marshall, 2014). Alcohol consumption during adolescence contributes to significant health and social burden: Among others, it is associated with an increased risk of suffering injuries, being involved in physical and sexual aggression, having unwanted sexual outcomes, experiencing school-related negative consequences, and impaired brain development (Chung et al., 2018; Hingson & White, 2014; Jones et al., 2018). Previous studies identified several protective and risk factors which can explain outcomes of adolescent alcohol use, such as parental and peer effects, externalizing and internalizing symptoms and characteristics, drinking motives (Crews et al., 2007; Kuntsche et al., 2005; Patrick & Schulenberg, 2013).

Alcohol consumption is a heterogeneous phenomenon as various forms of alcohol consumption can be shown in this period, such as drinking alcohol for the first time, starting to use alcohol regularly and showing excessive consumption patterns (e.g., drunkenness, binge drinking; ESPAD Group, 2020; Inchley et al., 2018). To capture the multidimensional nature but also potential problematic patterns of alcohol use, multiple indicators (e.g., frequency of alcohol consumption in an overall or beverage-specific way, a quantity of alcohol consumption on a typical occasion, frequency of drunkenness or binge drinking, age of onset of alcohol use) are usually considered and assessed in research (Thompson et al., 2014).

Different forms of alcohol use (e.g., alcohol use and drunkenness ever in a lifetime) are present to varying degrees in the adolescent population. For example, in the European region, among 15-year-olds, the lifetime average prevalence rates of ever using alcohol and being drunk at least twice are 59% and 20%, respectively (Inchley et al., 2020). That difference means that, while more than half of adolescents experiment with alcohol, one in five is at risk for problematic alcohol use. Thus, different indices concerning alcohol use might inform about different severity levels of alcohol involvement continuum (i.e., from light alcohol drinking to problematic alcohol use).

One way to examine differences between indicators of different severity levels of alcohol use is to use Item Response Theory (IRT). In an IRT model with binary items and with 2 parameters (2PL), discrimination and difficulty functions for each item are estimated. In the cases of items which measure different aspects of alcohol use, (i) the discrimination parameter represents how well a given alcohol use-related item differentiates between individuals at different levels of the underlying latent continuum of alcohol involvement, and (ii) the difficulty parameter defines the severity and position of a given alcohol consumption-related item along the latent continuum of alcohol involvement (i.e., where 50% of the participants endorse the given item). To the authors' best knowledge, only very few previous studies investigated with IRT different alcohol consumption indicators along the severity continuum of alcohol involvement in adolescents (Hoeppner et al., 2011; Kahler et al., 2009). These papers focused on the possible diagnostic role of alcohol consumption indicators besides problematic alcohol use indicators (i.e., withdrawal symptoms etc.). In these studies, indicators of risky episodic drinking (e.g., presence of binge drinking and drunkenness) were indicative of lower severity levels (i.e., heavy alcohol use without symptoms of alcohol use disorder), while indices concerning frequent alcohol use (e.g., weekly and daily drinking, excessive drinking for several consecutive days) covered medium- and high-severity levels of the alcohol involvement continuum (i.e., heavy and frequent alcohol consumption with symptoms of alcohol use disorder).

The high variability between European countries in prevalence rates of alcohol drinking involvement further complicates cross-country research on alcohol involvement (Inchley et al., 2020; Leal-López et al., 2020). It is substantial to explore cross-national differences in the information capacity of the different alcohol consumption indicators among adolescents. Specifically, adolescents from some of the countries of the former Soviet (Eastern) Bloc (e.g., Bulgaria, Hungary) might show elevated rates of alcohol use. In contrast, in other countries from this region lower levels of alcohol consumption are presented (e.g., Albania, North Macedonia; Inchley et al., 2020; Soellner et al., 2014). Previous studies applied classification models to capture the heterogeneity of drinking habits between European countries. Popova and her colleagues discriminated three drinking cultures in the Central and Eastern European (CEE) region: (i) the Mediterranean pattern (e.g., Bulgaria, Hungary) with frequent and regular alcohol consumption and disapproval of public intoxication, (ii) the Central European pattern (e.g., Czech Republic, Slovakia) with a preference for drinking beer, and (iii) the Northern European pattern (e.g., Baltic countries) with a preference for drinking spirits, showing patterns of nonfrequent, excessive drinking (e.g., drunkenness; Popova et al., 2007). The proposed Mediterranean and Northern European alcohol drinking styles show similarities to Room's "wet" (i.e., regular drinking with moderate quantities, non-intoxication oriented) and "dry" (i.e., nonregular drinking with high rates of drunkenness, intoxication oriented) drinking cultures, respectively (Aresi et al., 2020; Room, 2001; Soellner et al., 2014).

However, existing studies did not assess cross-national invariance or differential item function of the different alcohol consumption indicators among adolescents (only among adults, e.g., Borges et al., 2010; Sznitman et al., 2017) and specifically among CEE countries from the former Soviet (Eastern) Bloc. Globally, the highest levels of alcohol consumption and alcohol-attributable burden of disease were shown in CEE countries from the former Soviet (Eastern) Bloc (Manthey et al.,

2019; Peacock et al., 2018; Shield et al., 2020). This harmful pattern of alcohol use highlights the importance of examining further alcohol consumption patterns in these countries. Moreover, as various studies aimed to explore cross-national differences in alcohol use among European adolescents (e.g., Kuntsche et al., 2011), it would be important to assess invariance of alcohol consumption indices (e.g., to see whether alcohol consumption-related items behave differently or similarly across countries) before performing cross-national comparisons on correlations and means (Jang et al., 2017). In the cases of cross-culturally noninvariant measurement parameters of alcohol consumption indicators, it is not possible to determine whether the observed cross-country difference on a given indicator of alcohol use represents valid cross-national divergence or there is a cross-culturally differential item functioning which leads to a measurement bias (Cieciuch et al., 2019; Sznitman et al., 2017). However, the traditional exact invariance approach (i.e., constraining factor loadings and thresholds equal across groups) with many groups or countries shows significant limitations. Therefore, the use of the alignment method was recommended to determine the level of invariance more accurately. The alignment method aims to find a solution that minimizes the number of noninvariant parameters of factor loadings and thresholds between the groups (Jang et al., 2017; Muthén & Asparouhov, 2014).

The present study had two main aims. First, to examine information capacity (i.e., discrimination and difficulty functions) of different alcohol use indicators of adolescents in sixteen CEE countries from the former Soviet (Eastern) Bloc by using IRT. Second, to examine measurement invariance of factor loadings and thresholds of different alcohol consumption indicators between the included countries with the alignment method. By using these approaches, it is possible to gain further and more accurate understanding regarding the source of the differences in adolescent's reported alcohol drinking habits, observed in the countries of former Soviet (Eastern) Bloc. For example, cross-national patterns can be explored on indicators of alcohol use that have high information capacity at high-severity levels of alcohol involvement, in addition to establishing the level of cross-national measurement equivalence of alcohol consumption parameters, which might provide useful details for studies aiming comparisons among adolescents at cross-national level. In other words, findings of the present study can broaden our knowledge on the comparison of different forms of alcohol use (e.g., in terms of the severity of alcohol consumption), as well as to examine the cross-cultural differences and similarities related to adolescent alcohol use (e.g., exploring overall and item-level divergences in alcohol use across countries).

MATERIALS AND METHODS

Participants and procedures

Data for this study were collected during the 2013/2014 Health Behavior in School-aged Children (HBSC) survey, the World Health Organization Regional Office's collaborative project for Europe (Inchley et al., 2016). The HBSC survey is a large-scale, cross-national study that aims to examine patterns of health behavior of 11-, 13- and 15-year-old adolescents in European and North American countries (Inchley et al., 2016). HBSC uses findings at national/regional and international levels to gain new insight into young people's health and well-being; understand the social determinants of health; and inform policy and practice to improve young people's lives (Inchley et al., 2016). Although data of the 2017/2018 HBSC survey were available on alcohol consumption (Inchley et al., 2020), the present study used the data from the 2013/2014 survey because its mandatory questionnaire contained more alcohol consumption-specific items which also measured more various aspects of alcohol use patterns (e.g., typical quantity, beverage-specific frequency). To address the present study's aims, only responses of adolescents coming from 16 countries from the former Soviet (Eastern) Bloc were included the following: Albania, Armenia, Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Moldova, North Macedonia, Romania, Russia, Slovakia, Slovenia, and Ukraine. We did not include Polish adolescents' data as the question regarding the quantity of alcohol consumption was not included in the Polish survey. The present study only focused on 15-year-old adolescents as the question measuring the quantity of alcohol consumption was queried only in this age category in some of the participating countries. Moreover, only participants who have ever consumed alcohol during lifetime were included in the final analyses. Sample size and descriptive statistics regarding age and gender distributions in each of the included countries are presented in Table 1.

For data collection in each country, a standard international study protocol is used (Currie et al., 2014). In each country, the sample was either drawn from a list of schools (e.g., Estonia, Romania) or a list of school classes (e.g., Czech Republic). Random (e.g., Lithuania) or systematic selection (e.g., Slovenia, Romania) of school classes was performed for each region. Stratification was applied in some of the included countries (e.g., Hungary), based on geographical regions, settlement type (e.g., capital city, cities, villages), or educational institutes' characteristics (e.g., educational level, school types). Sampling procedure contributed to a representative sample of schools or classes in the country as a whole (e.g., Bulgaria) or in specific geographical regions (e.g., Moldova). In each country, informed or passive consent was required from school representatives, parents, and students before data collection. Except for Bulgaria and North Macedonia, in all participating countries the survey obtained appropriate ethical approval (e.g., from national- and university-level ethics committees). Data from Bulgaria and North Macedonia were included based on the HBSC study protocol stating that "where ethics committees are not in place, countries should adhere to national ethical guidelines concerning research with children" (Inchley et al., 2016, p. 16). Further details regarding the research methodology of the HBSC study from 2013/2014 are presented elsewhere (Currie et al., 2014).

Measures

Four binary indicators of alcohol consumption were included for the present analyses: (i) alcohol consumption in the last 30 days (0 = No,

TABLE 1 Sample characteristics of the included countries

	Sample size of 15-year-olds	Final sample size: 15-year-olds who have ever consumed alcohol	Female gender N (within country %)	Alcohol consumption in the last 30 days N (within country %)	Lifetime drunkenness N (within country %)	Binge drinking on a typical occasion N (within country %)	Weekly drinking frequency N (within country %)
Albania	1699	716	299 (41.8%)	365 (52.1%)	403 (56.5%)	41 (5.8%)	170 (24.0%)
Armenia	1044	531	283 (53.3%)	257 (54.0%)	198 (37.4%)	37 (7.2%)	65 (13.1%)
Bulgaria	1650	1241	565 (45.5%)	859 (71.9%)	812 (66.1%)	211 (17.1%)	349 (28.4%)
Croatia	1946	1302	577 (44.3%)	772 (64.1%)	818 (64.2%)	457 (35.5%)	357 (27.9%)
Czechia	1760	1424	749 (52.6%)	826 (58.5%)	805 (56.8%)	198 (14.0%)	248 (17.5%)
Estonia	1269	991	493 (49.7%)	542 (56.6%)	562 (57.2%)	238 (24.2%)	64 (6.5%)
Hungary	1100	859	444 (51.7%)	588 (69.2%)	542 (63.3%)	221 (26.0%)	211 (24.7%)
Latvia	1726	1268	712 (56.2%)	568 (46.5%)	771 (61.4%)	229 (18.5%)	72 (5.8%)
Lithuania	1698	1294	603 (46.6%)	590 (48.0%)	935 (72.4%)	203 (15.9%)	120 (9.5%)
Moldova	1556	1137	533 (46.9%)	580 (51.5%)	674 (59.4%)	46 (4.1%)	129 (11.4%)
North Macedonia	1457	621	276 (44.4%)	411 (67.8%)	299 (48.9%)	40 (6.6%)	168 (27.5%)
Romania	1442	857	414 (48.3%)	571 (69.0%)	477 (55.9%)	93 (10.9%)	200 (23.7%)
Russia	1445	597	341 (57.1%)	260 (44.8%)	283 (48.6%)	72 (12.3%)	64 (10.9%)
Slovakia	1835	1229	578 (47.0%)	639 (53.8%)	749 (61.4%)	193 (15.9%)	232 (19.2%)
Slovenia	1615	1292	702 (54.3%)	756 (60.0%)	756 (58.7%)	332 (25.7%)	179 (14.1%)
Ukraine	1694	973	533 (54.8%)	506 (54.1%)	565 (58.1%)	80 (8.4%)	151 (15.9%)

1 = Yes), (ii) drunkenness ever in a lifetime (0 = No, 1 = Yes), (iii) weekly alcohol drinking frequency currently (based on the combined drinking frequency of beer, wine, and spirits; 0 = No, 1 = Yes), and (iv) binge drinking (consumed quantity of at least four [for females] and five [for males] drinks of alcohol, as these gender-based cutoffs are typically associated with reaching the threshold of 0.08 g/dl blood alcohol concentration among females and males; Chung et al., 2018) on a typical occasion (0 = No, 1 = Yes). Originally, alcohol consumption-related items were assessed on polytomous response scales: (i) frequency of alcohol consumption in the last 30 days on a 7-point scale (1 = never, 7 = 30 days or more), (ii) frequency of lifetime drunkenness on a 5-point scale (1 = never, 5 = more than 10 times), (iii) beverage-specific frequency of alcohol use on a 5-point scale (1 = never, 5 = every day), (iv) typical quantity of alcohol use on a 7-point scale (1 = I never drink alcohol, 2 = less than 1 drink, 7 = 5 or more drinks). However, variables were dichotomized to ease interpretation of the findings, facilitate comparability of the included countries (e.g., missing values for some response categories in some countries), and avoid statistical issues (e.g., low response frequencies might contribute to empty cells in bivariate tables of the variables in IRT analysis). Previous studies among adolescents also used dichotomous indicators for measuring the presence of drunkenness, weekly alcohol drinking, and binge drinking when applied IRT to examine the possible diagnostic function of different alcohol consumption indices along the latent continuum of alcohol involvement (Hoeppner et al., 2011; Kahler et al., 2009). Acceptable rates of validity and reliability were shown in previous studies with similar measures for the abovementioned constructs of alcohol use. Cross-sectional and longitudinal findings supported the validity of indicators of alcohol consumption quantity and frequency measures of alcohol drinking in the last 30 days, drunkenness, weekly drinking, binge drinking: Higher rates on these indicators were associated with elevated alcohol use levels and alcohol use-related and social problems (D'Amico et al., 2016; Miller et al., 2016; Olsson et al., 2016; Rose et al., 2012; Silins et al., 2018; Thompson et al., 2014). Other studies reported high levels of internal consistency and test–retest reliability for composite measures of alcohol use which incorporate various alcohol consumption indicators (e.g., alcohol drinking frequency, typical quantity, binge drinking; Horváth et al., 2020; Källmén et al., 2019).

Data analysis

Similarly to previous studies that analyzed differences in measurement parameters in a high number of groups (Jang et al., 2017), multiple group confirmatory factor analysis (MG-CFA) and alignment method were used to assess the measurement level invariance regarding indicators of alcohol consumption. In both analytical approaches, a unidimensional latent structure of alcohol consumption based on the four binary alcohol consumption indicators was defined in line with previous findings (Horváth et al., 2020). All analyses were performed by using Mplus 8.0 software and took into account cluster effects (Muthén & Muthén, 2017).

In the case of the MG-CFA, two levels of exact invariance (i.e., fixing parameters as equal across groups) were tested with the weighted least-squares means and variance-adjusted estimation method: configural (i.e., testing the invariance of the latent structure, whereas equality of factor loadings and thresholds are not assumed across the groups) and scalar invariance (i.e., testing the invariance of the factor loadings and thresholds). The model of metric invariance (i.e., testing the factor loadings' invariance in addition to freely estimated thresholds) was not estimated as this model was not identified (Muthén & Muthén, 2017). The scalar invariance model is a more restrictive model and assumes higher level of invariance than the metric invariance model. The latter model assumes equivalence of factor loadings (i.e., it can indicate similarity of the unit of the factor and approve comparison of correlations across the groups), whereas the scalar invariance model assumes simultaneous equivalence of factor loadings and thresholds (i.e., it can allow testing differences in latent factor means across groups, not just differences in correlations; Jang et al., 2017). Degree of model fit was evaluated based on values of the comparative fit index (CFI) and the root-mean-square error of approximation (RMSEA). Optimal model fit was indicated by CFI values ≥0.950 and RMSEA values ≤0.050. However, with a high number of groups, some studies suggested less strict cutoff values for RMSEA (i.e., ≤0.100 and 0.150 with more than 10 and 20 groups, respectively) to determine acceptable rates of model fit (Jang et al., 2017; Rutkowski & Svetina, 2014). The level of invariance can be determined by examining the decrease in model fit between consecutive invariance models: Changes in CFI and RMSEA values ≤0.010 and ≤0.015, respectively, are considered acceptable for a more restrictive invariance model (Chen, 2007).

However, the present study assumed that instead of the exact invariance approach, the approximate invariance approach could represent more accurately cross-national differences and measurement invariance in alcohol consumption indicators. Thus, in an IRT model, factor loading/discrimination and threshold/difficulty parameters were freely estimated in all countries (i.e., 2PL-IRT model) by using the alignment method (Muthén & Asparouhov, 2014). The alignment optimization aims to find a solution with the smallest overall amount of invariance in factor loadings and thresholds between the groups. In this method, noninvariant factor loadings and thresholds are detected simultaneously, not by fixing parameters equal across groups in hierarchical invariance models. To ensure the approximate invariance model's validity, it was suggested that the proportion of noninvariant parameters relative to the total estimated parameters should not exceed 25%. Moreover, values of fit function contribution and R^2 reflect the amount of invariance in each factor loadings and thresholds. Lower absolute values on the former and higher rates on R^2 represent higher levels of invariance.

Two types of alignment method were estimated with robust maximum likelihood (MLR) method: (i) Latent factor means and variances were freely estimated in all countries, and (ii) the first group's (i.e., in alphabetical order: Albania) factor mean and variance were constrained at 0 and 1, respectively. Due to a possibility of unreliable standard error values presented in the first solution, parameters from the fixed model were reported and interpreted (Jang et al., 2017; Munck et al., 2018; Muthén & Asparouhov, 2014).

RESULTS

Descriptive statistics

Prevalence levels on the indicators of alcohol consumption in the included countries are presented in Table 1. The highest prevalence levels were shown in Bulgaria in terms of presence of alcohol consumption in the last 30 days and weekly drinking frequency. Alcohol consumption in the last 30 days was the least prevalent in Russia, and for the presence of weekly drinking frequency the lowest prevalence level was shown for Latvia. The presence of lifetime drunkenness and binge drinking on a typical occasion was the most prevalent in Lithuania and Croatia, respectively, while lifetime drunkenness was the least prevalent in Armenia, and Moldova had the lowest prevalence level for presence of binge drinking on a typical occasion.

Examining information capacity of alcohol consumption indicators (Aim 1)

Discrimination and difficulty parameters in each group from the 2PL-IRT model by using the alignment optimization are presented in Table 2, while item characteristic curves are displayed in Figure 1. Based on difficulty parameters, alcohol consumption in the last 30 days and lifetime drunkenness were located at moderately low (e.g., both indicators in Czechia) and low (e.g., both indicators in Bulgaria) severity levels of alcohol involvement in the majority of the countries, except for some cases where these alcohol involvement forms covered medium levels of severity (e.g., both indicators in Russia). Countries differed which indicator was the least severe (e.g., in Hungary alcohol consumption in the last 30 days, in Lithuania lifetime drunkenness). In Croatia, very similar difficulty parameters were shown for both indicators. Both binge drinking and weekly drinking frequency were located at moderately high (e.g., binge drinking in Croatia) and high (e.g., both indicators in Moldova) severity levels of alcohol use in all countries. However, countries were distinguished based on whether binge drinking (e.g., Albania) or weekly drinking frequency (e.g., Latvia) was the most severe alcohol consumption indicator. In each country, the alcohol consumption indicators' discrimination parameters ranged between moderately high and very high levels (Baker, 2001). Based on indicators with the highest discrimination parameters at the lower and at the higher ends of the continuum severity, three main classes of the countries were differentiated. In Albania, Armenia, and Russia, alcohol consumption in the last 30 days had the highest discrimination capacity at low and moderate severity levels, and binge drinking was highly discriminative at higher severity levels. Second, in Moldova, North Macedonia, Romania, and Ukraine alcohol consumption in the last 30 days had the highest discrimination capacity at moderately low severity levels and weekly drinking frequency had the highest discrimination capacity at higher severity levels. Third, in Czechia, Estonia, Hungary, Latvia, Lithuania, Slovakia, and Slovenia lifetime drunkenness had the highest discrimination capacity at moderate, and moderately low severity levels and binge drinking had the highest discrimination capacity at higher severity levels. Bulgaria and Croatia somewhat differed from these patterns. In Bulgaria, alcohol consumption in the last 30 days was highly discriminative at moderately low severity levels, while at high-severity levels binge drinking and weekly drinking frequency had similar discrimination capacity. In Croatia, lifetime drunkenness had the highest discrimination capacity at moderately low severity levels, and weekly drinking had the highest discrimination capacity at higher severity levels. These patterns are also shown by the country-specific item information curves in Figure 2. Total information curves in each country are presented in Figure S1.

Examining measurement invariance of alcohol consumption indicators (Aim 2)

The configural invariance MG-CFA model showed acceptable levels of model fit based on CFI, while the level of RMSEA was also considered as acceptable based on criteria suggested for analyses with a high number of groups ($\chi^2(32) = 445.34$; $p < 0.001$; CFI = 0.961; RMSEA [90% CI] = 0.112 [0.103 to 0.122]). That is, the invariance of the unidimensional structure was accepted between the countries. Table S1 presents standardized factor loadings and reliability estimates in each country based on the configural model. All factor loadings ($\lambda = 0.46$ to 0.92) and reliability indices ($\omega = 0.69$ to 0.87) were ranged between moderately strong and strong levels.

However, in the case of the scalar invariance MG-CFA model lower levels of model fit was presented based on indices of CFI and RMSEA ($\chi^2(62) = 985.15$; $p < 0.001$; CFI = 0.913; RMSEA [90% CI] = 0.121 [0.114 to 0.127]). Compared with the configural invariance model, the value of CFI decreased considerably, while the change on RMSEA was considered as acceptable ($\Delta\chi^2(30) = 548.73$; $p < 0.001$; ΔCFI = 0.048; ΔRMSEA = 0.009). Thus, it was impossible to determine the invariance of factor loadings and thresholds between the sixteen countries unequivocally by using the traditional exact invariance approach.

Next, the alignment method was used to assess the level of measurement invariance. Alignment fit statistics are displayed in Table 3. Approximate measurement invariance held for all countries in the cases of all factor loadings and the intercept of lifetime drunkenness. Approximate noninvariance was presented for five countries regarding the intercepts of alcohol consumption in the last 30 days, binge drinking, and weekly drinking frequency. Overall, 7.81% of the estimated intercepts were noninvariant, while 0% of the estimated factor loadings were noninvariant. As both values are below the suggested cutoff of 25% for the maximum proportion of noninvariant parameters, the alignment method suggested approximate invariance of the factor loadings and thresholds between the countries. Based on the indices of fit function contribution and R^2, the item of weekly drinking frequency showed the least invariant threshold. These fit indices suggested that the indicator of lifetime drunkenness had the most invariant threshold: It had the lowest absolute value of fit function contribution, and the corresponding R^2 was close to the highest value presented for binge drinking on a typical occasion. However, in the cases of item factor loadings, it was not possible to

TABLE 2 Item response theory parameters in the included countries

	Discrimination parameters (α)				Difficulty parameters (β)			
	Alcohol consumption in the last 30 days α (SE)	Lifetime drunkenness α (SE)	Binge drinking on a typical occasion α (SE)	Weekly drinking frequency α (SE)	Alcohol consumption in the last 30 days β (SE)	Lifetime drunkenness β (SE)	Binge drinking on a typical occasion β (SE)	Weekly drinking frequency β (SE)
Albania	2.04 (0.46)***	1.03 (0.20)***	1.89 (0.50)***	1.71 (0.28)***	−0.07 (0.07)	−0.31 (0.09)**	2.16 (0.33)***	1.00 (0.12)***
Armenia	1.59 (0.48)**	1.31 (0.37)***	2.61 (1.15)*	1.24 (0.28)***	−0.14 (0.09)	0.52 (0.14)***	1.78 (0.28)***	1.93 (0.33)***
Bulgaria	1.96 (0.34)***	0.97 (0.15)***	1.65 (0.25)***	1.63 (0.23)***	−0.78 (0.08)***	−0.83 (0.13)***	1.38 (0.13)***	0.82 (0.09)***
Croatia	2.08 (0.28)***	2.26 (0.31)***	1.77 (0.22)***	2.22 (0.34)***	−0.47 (0.08)***	−0.45 (0.07)***	0.52 (0.07)***	0.75 (0.10)***
Czechia	1.22 (0.21)***	2.29 (0.56)***	1.90 (0.33)***	1.25 (0.22)***	−0.36 (0.08)***	−0.22 (0.06)***	1.47 (0.14)***	1.59 (0.21)***
Estonia	1.44 (0.18)***	4.07 (0.92)***	2.10 (0.28)***	2.01 (0.37)***	−0.25 (0.07)***	−0.20 (0.05)***	0.91 (0.07)***	2.03 (0.21)***
Hungary	0.98 (0.14)***	3.63 (0.95)***	3.24 (0.62)***	1.19 (0.16)***	−0.99 (0.14)***	−0.38 (0.07)***	0.73 (0.07)***	1.19 (0.16)***
Latvia	1.57 (0.18)***	2.74 (0.44)***	2.61 (0.37)***	1.67 (0.21)***	0.12 (0.06)	−0.35 (0.05)***	1.08 (0.07)***	2.31 (0.18)***
Lithuania	1.01 (0.19)***	1.75 (0.35)***	2.02 (0.43)***	1.50 (0.29)***	0.09 (0.08)	−0.83 (0.09)***	1.32 (0.15)***	2.02 (0.23)***
Moldova	1.20 (0.21)***	0.84 (0.18)***	1.35 (0.29)***	2.22 (0.57)***	−0.06 (0.09)	−0.52 (0.14)***	2.92 (0.44)***	1.54 (0.19)***
North Macedonia	2.04 (0.41)***	1.09 (0.16)***	2.41 (0.61)***	4.05 (1.92)*	−0.61 (0.09)***	0.05 (0.11)	1.89 (0.21)***	0.66 (0.10)***
Romania	1.65 (0.34)***	1.34 (0.30)***	1.40 (0.30)***	2.27 (0.55)***	−0.72 (0.11)***	−0.24 (0.10)*	1.97 (0.28)***	0.91 (0.11)***
Russia	1.85 (0.41)***	1.68 (0.35)***	2.41 (0.55)***	1.97 (0.43)***	0.17 (0.09)	0.05 (0.08)	1.42 (0.16)***	1.65 (0.19)***
Slovakia	1.36 (0.26)***	1.68 (0.34)***	2.81 (0.79)***	1.34 (0.26)***	−0.16 (0.07)*	−0.42 (0.08)***	1.18 (0.12)***	1.41 (0.18)***
Slovenia	1.52 (0.15)***	2.35 (0.29)***	2.56 (0.32)***	1.86 (0.21)***	−0.38 (0.07)***	−0.28 (0.07)***	0.79 (0.07)***	1.48 (0.12)***
Ukraine	2.00 (0.33)***	1.23 (0.18)***	2.12 (0.39)***	2.43 (0.42)***	−0.14 (0.06)*	−0.35 (0.09)***	1.79 (0.15)***	1.23 (0.11)***

Note.: Level of significance: *$p < 0.050$; **$p < 0.010$; ***$p < 0.001$.

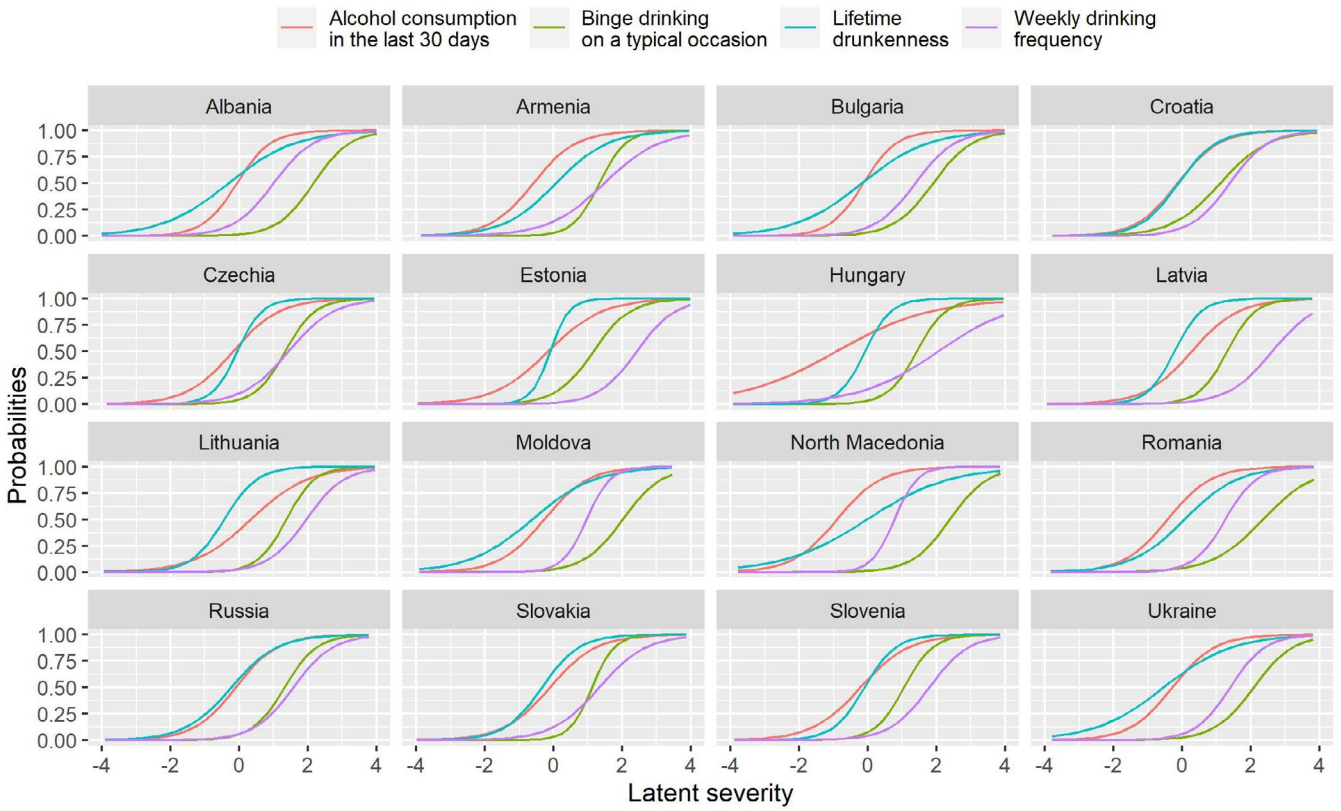

FIGURE 1 Item characteristic curves in each country

unequivocally determine which indicators were the most and least invariant based on indices of fit function contribution and R^2.

Due to the relatively low proportion of the noninvariant factor loadings and thresholds, comparison of the factor means might be valid between the countries. Rank order and comparison of the countries are shown in Table 4. Bulgaria, Croatia, and Hungary had the highest latent factor means, and these countries showed significantly higher factor means than multiple countries.

DISCUSSION

Findings of the IRT analysis revealed that in most of the included countries alcohol consumption in the last 30 days and lifetime drunkenness were located at moderately low and low severity levels, while binge drinking on a typical occasion and weekly drinking frequency was in the range of moderately high and high-severity levels of alcohol use. Previous studies which investigated the possible diagnostic role of alcohol consumption indicators with IRT in adolescent samples also showed similar patterns: The presence of drunkenness informed about lower severity levels, in addition to weekly drinking which was indicative of moderately high-severity levels of alcohol involvement (Hoeppner et al., 2011; Kahler et al., 2009). As opposed to previous IRT studies which measured the occurrence of binge drinking within a given timeframe, the present study assessed the presence of binge drinking on a typical occasion which represented a more severe drinking pattern along the alcohol consumption continuum (i.e., binge drinking in previous studies reflected on lower severity levels). However, it is important to consider that previous IRT studies among adolescents assumed a combined latent continuum of alcohol involvement based on criteria measuring alcohol consumption as well as symptoms of alcohol use disorder, while the present study only focused on indicators of alcohol consumption (Hoeppner et al., 2011; Kahler et al., 2009). The relevance of weekly alcohol frequency and binge drinking was also highlighted by longitudinal studies which showed that higher rates on these indicators during adolescence predicted elevated rates of subsequent adolescent and adult alcohol use and problems (Olsson et al., 2016; Silins et al., 2018; Thompson et al., 2014). Moreover, these dimensions of alcohol use are also covered by some screening instruments which aim to identify adolescents with at-risk alcohol drinking patterns. For example, the abbreviated form of the Alcohol Use Disorders Identification Test (Bush, 1998) assesses risk levels based on the frequency, on the quantity of alcohol consumption on a typical occasion, and on the frequency of binge drinking (Bush, 1998; Liskola et al., 2018).

Patterns of indicators with the highest discrimination capacity at the lower and at the higher ends of the continuum severity were different among CEE countries. Lifetime drunkenness had the highest discrimination capacity at moderate and moderately low severity levels and binge drinking had the highest discrimination capacity at higher severity levels in Czechia, Estonia, Hungary, Latvia, Lithuania,

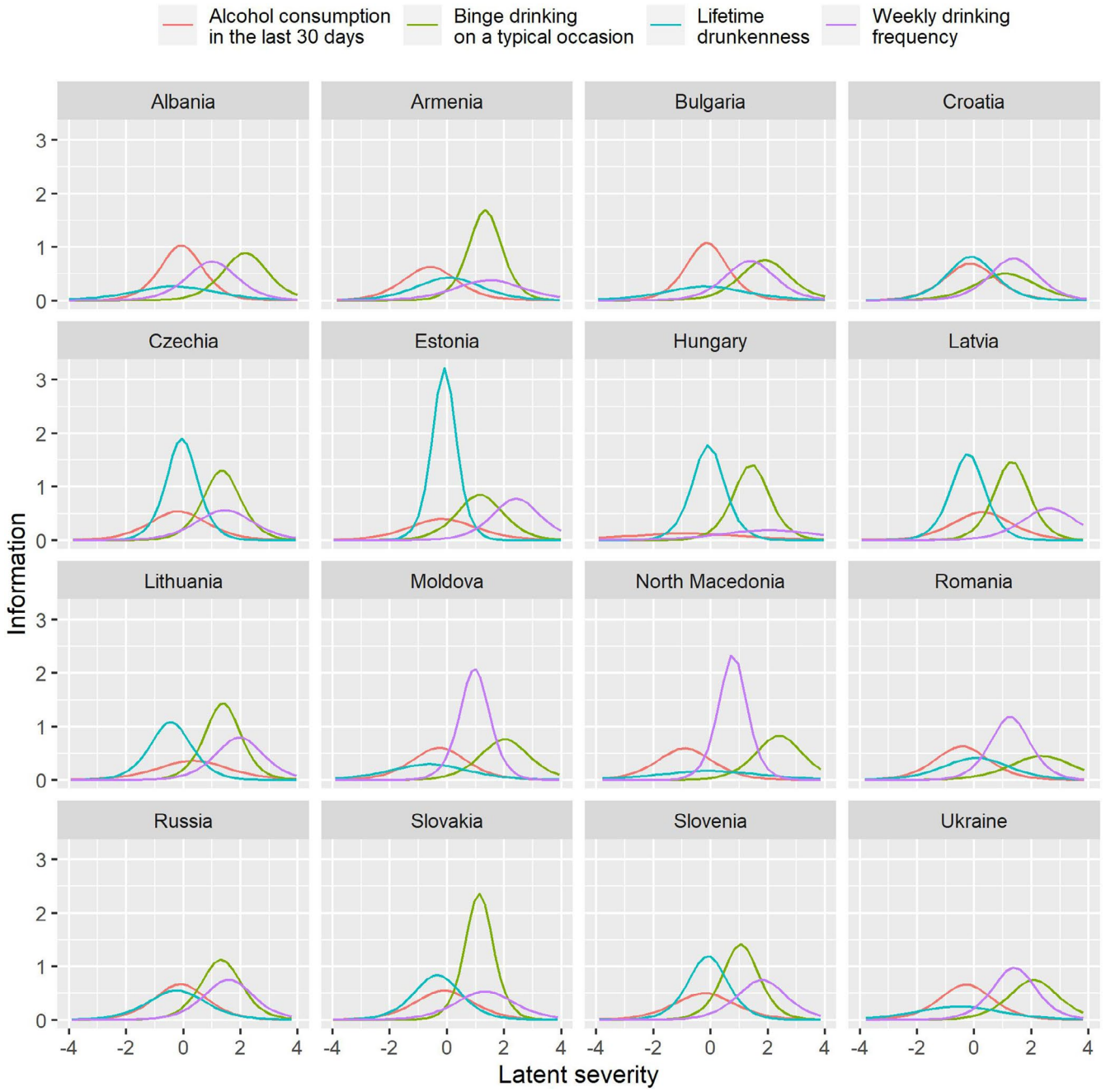

FIGURE 2 Item information curves in each country

Slovakia, and Slovenia. Moreover, in the group consisted of Albania, Armenia, and Russia, alcohol consumption in the last 30 days had the highest discrimination capacity at low and moderate severity levels and binge drinking was highly discriminative at higher severity levels. These patterns might show similarities with the "Northern European" and "dry" drinking cultures that were characterized with high rates of heavy episodic drinking (Popova et al., 2007; Room, 2001; Soellner et al., 2014). In Moldova, North Macedonia, Romania, and Ukraine alcohol consumption in the last 30 days had the highest discrimination capacity at moderately low severity levels and weekly drinking frequency had the highest discrimination capacity at higher severity levels. Weekly drinking frequency was also showed high information capacity at high-severity levels in Bulgaria and Croatia. Drinking patterns of these countries might show similarities to the "Mediterranean" and "wet" drinking cultures that display a pattern of frequent albeit moderate drinking (Popova et al., 2007; Room, 2001; Soellner et al., 2014).

To the authors' best knowledge, the present study was the first to use the alignment method to examine cross-national measurement invariance of indicators of alcohol use in adolescents. The low proportion of the estimated intercepts and factor loadings were noninvariant, which indicated cross-national invariance of

TABLE 3 Alignment fit statistics

	Countries with approximate measurement noninvariance	Weighted average estimate across invariant groups	Fit function contribution	Explained variance (R^2) (%)
Threshold				
Alcohol consumption in the last 30 days	Latvia	−0.33	−64.45	33
Lifetime drunkenness	Approximate measurement invariance held for all countries	−0.36	−53.54	58
Binge drinking on a typical occasion	Croatia, Estonia	3.32	−68.79	60
Weekly drinking frequency	Estonia, Latvia	2.50	−78.71	19
Factor loadings				
Alcohol consumption in the last 30 days	Approximate measurement invariance held for all countries	1.51	−57.38	5
Lifetime drunkenness	Approximate measurement invariance held for all countries	1.87	−82.10	14
Binge drinking on a typical occasion	Approximate measurement invariance held for all countries	2.09	−61.95	17
Weekly drinking frequency	Approximate measurement invariance held for all countries	1.80	−64.33	19

TABLE 4 Comparison of latent factor means across the included countries

Ranking	Country	Latent factor mean	Countries with significantly smaller factor mean
1	Bulgaria (BGR)	0.60	SVN, LVA, EST, CZE, SVK, ALB, MKD, UKR, MDA, RUS, ARM
2	Croatia (HRV)	0.45	EST, CZE, SVK, ALB, MDA, RUS, ARM
3	Hungary (HUN)	0.43	CZE, ALB, MDA, RUS, ARM
4	Romania (ROU)	0.32	MDA
5	Lithuania (LTU)	0.26	
6	Slovenia (SVN)	0.20	RUS
7	Latvia (LVA)	0.15	RUS
8	Estonia (EST)	0.13	RUS
9	Czechia (CZE)	0.12	RUS
10	Slovakia (SVK)	0.04	
11	Albania (ALB)	0.00	
12	North Macedonia (MKD)	−0.09	
13	Ukraine (UKR)	−0.12	
14	Moldova (MDA)	−0.22	
15	Russia (RUS)	−0.29	
16	Armenia (ARM)	−0.45	

the four studied alcohol consumption indicators. In other words, cross-nationally differential item functioning was only detected in a few countries (i.e., Croatia, Estonia, Latvia) for item intercepts, whereas in the cases of factor loadings cross-nationally differential item functioning was not presented. Thus, the selected alcohol consumption indicators might behave and measure similarly across CEE countries from the former Soviet (Eastern) Bloc. As approximate invariance of the alcohol consumption indicators was indicated between CEE countries, comparisons between these countries can represent valid (and not measurement-related) cross-national differences. This finding can support international reports and cross-national studies that aim to compare adolescents from this region on these alcohol consumption indicators. In the present study, the highest latent factor means were presented for Bulgaria, Croatia, and Hungary. Findings of the European School Survey Project on Alcohol and Other Drugs (ESPAD) from 2015 also showed that these countries have high and above average prevalence rates of alcohol use in the last 30 days and the highest prevalence levels of intoxication in the last 30 days in the region of the former Soviet (Eastern) Bloc (ESPAD Group, 2016).

Limitations

First, as self-reported alcohol use measures were applied, it might be possible that social desirability or recall bias influenced the findings. However, the HBSC study attempted to minimize the magnitude of bias by keeping the answers anonymous, ensuring privacy, and sealing the response forms in envelopes. Second, the present study did not cover all CEE countries from the former Soviet (Eastern) Bloc (e.g., Belarus, Poland, Serbia) which hampers a more comprehensive view on country-level differences in this region. It might be possible that in these countries a different pattern of alcohol consumption indicators with the highest information capacity at the lower and the higher ends of the continuum severity would have shown. Third, adolescents from the included CEE countries might have had considerably different cultural and economic backgrounds (e.g., differences in socioeconomic development, Muslim religion, variations in "social clock" of alcohol use across countries) which was not controlled by the present study but should be considered when interpreting cross-country differences. For example, previous studies reported that lower socioeconomic status (e.g., poverty, neighborhood disadvantage, educational drawbacks) is associated with more harmful use of alcohol, while religiosity can be protective against high levels of alcohol use among both Christians and Muslims (Burazeri & Kark, 2010a, 2010b; Collins, 2016; Grigsby et al., 2016). Although alcohol use is prohibited in Islam, which might explain some country-level differences in alcohol use in this region, findings from Albania (a predominantly Muslim country from the former Soviet [Eastern] Bloc) showed nonsignificant differences between Christians and Muslims on alcohol consumption-related outcomes (Burazeri & Kark, 2010a, 2010b). Fourth, the included statistical analyses had some limitations also, such as only using a limited set of alcohol consumption indicators (e.g., it was not possible to include the presence of drunkenness in the past 30 days in the analyses as it was dependent from the presence of drunkenness in a lifetime) and not covering problems related to alcohol use. Further, using only binary indicators of alcohol consumption reduces the range of information about each alcohol consumption measure (e.g., the information capacity of lifetime drunkenness was limited in absence of response categories measuring higher frequency); thus, future studies might consider using indicators with polytomous response categories to gain more accurate picture on the information capacity of alcohol consumption indicators. Lastly, not controlling for gender and not measuring the predictive utility of the included indicators of alcohol use restrict the breath of interpretations we can draw from these results. As the primary aim of the present study was to test cross-national invariance of different alcohol consumption indicators, the analyses might have become overcomplex by examining gender-based differences also. Further, for various alcohol consumption indices (e.g., alcohol use in a lifetime and in the past 30 days), gender differences attenuate among 15-year-old adolescents (Inchley et al., 2020), which might support our analytical approach. Regarding the predictive role of the included alcohol consumption indicators, it might be possible that some measures of alcohol use more strongly related to alcohol use-related problems (e.g., injuries, social problems, dependence symptoms) than other indicators, and exponential and nonlinear relationships between alcohol consumption indicators and alcohol use-related problems can also be assumed. Therefore, future studies are needed to examine more precisely the value of the included alcohol use indicators as measures of adverse outcomes. Fifth, it is important to consider the possibility of selection bias stemming from sample selection in each country. Sixth, due to the cross-sectional nature of the study, it was not possible to examine causal relationships between the selected alcohol consumption indicators and longitudinal patterns and invariance across the countries. For example, regional differences were presented between Eastern Europe and the Balkans in longitudinal trends of weekly alcohol drinking and heavy episodic drinking among adolescents (i.e., increasing trends in the Balkans and decreasing trends in Eastern Europe; Kraus et al., 2018).

CONCLUSIONS

Findings of the present study confirmed that alcohol consumption indicators lie along a severity continuum, inform about different severity levels, and provide invariant measurement in countries from the former Soviet (Eastern) Bloc. Although there is no consensus which assessment approach (i.e., quantity frequency, graduated frequency, beverage-specific measures, heavy episodic drinking) can be considered as the most optimal self-report measurement of alcohol consumption (Bloomfield et al., 2013; Gmel et al., 2006; Greenfield & Kerr, 2008), future studies should also consider selecting assessments which cover a broad range of severity levels of adolescent alcohol use (e.g., presence of lifetime drunkenness informs about low severity levels, while regular alcohol drinking refers to high-severity levels) as well as providing cross-culturally invariant measurement (i.e., constructs of alcohol use which measure similarly in different countries). The present study also highlights the importance of using the alignment method when examining cross-cultural differences in alcohol use. This statistical approach can help to understand better patterns of cross-national convergences and divergences in alcohol use, how alcohol consumption-related constructs vary across countries, and to perform more accurate cross-national comparisons in terms of alcohol use. Finally, cross-national prevention and intervention programs should also consider cross-national heterogeneity in alcohol drinking habits as countries differ which forms of alcohol use have high information capacity.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

ETHICAL APPROVAL

Authors declare that all procedures followed the ethical standards of the Declarations of Helsinki. Informed consent was obtained from all the participants for being included in the study.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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