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Short title: An empirically based typology of alcohol users in a community sample

Keywords: Latent Class Analysis (LCA); Alcohol Use Disorders Identification Test (AUDIT); Alcohol Use Disorder (AUD); alcohol consumption; alcohol psychopathology

1. Abstract

Background. Different classification models have been proposed to explain the heterogeneity of alcohol-related problems in general populations. Such models suggest quantitatively or qualitatively different symptom endorsement characteristics between subgroups of alcohol drinkers.

Objectives. The present study aimed to identify homogenous subgroups of drinkers in a general population sample in addition to examining the relationship between the subgroups and psychopathological symptoms.

Method. Data of past-year alcohol users (N=1520) were analyzed from the nationally representative sample of the National Survey on Addiction Problems in Hungary 2015 (NSAPH 2015). Latent Class Analysis (LCA) was conducted to identify subgroups of drinkers based on the dichotomous indicator items of the Alcohol Use Disorders Identification Test (AUDIT) questionnaire. Multinomial logistic regression and multiple comparisons were performed to explore the relationship between latent classes and socio-demographical variables and psychopathological symptoms.

Results. LCA suggested a three-class model: 'Light alcohol drinkers' (71.6%), 'Alcohol drinkers with low risk of dependence' (19.3%) and 'Alcohol drinkers with severe dependence symptoms' (9.1%). More severe subgroups showed significantly higher level of anxiety, depression, hostility, obsessive-compulsivity, interpersonal sensitivity, and psychiatric or AUD-related treatment involvement. Male gender, younger age, lower level of educational achievement, and earlier onset of the first alcoholic drink were associated with membership of more severe subgroups.

Conclusions. The present results indicated that severity-based subgroups of drinkers can be discriminated. Approximately 9% of the alcohol users showed severe symptoms of alcohol dependence. The present data also supported the association between more severe forms of alcohol consumption, and internalizing and externalizing characteristics.

2. Introduction

Excessive alcohol consumption is associated with several adverse physical and psychological health outcomes, as well as social harms [1]. From a public health perspective, it is essential to identify not only those who demonstrate harmful alcohol use patterns, but also those who might be at-risk of developing adverse alcohol-related consequences subsequently [2]. Furthermore, excessive alcohol consumption contributes to substantial alcohol attributable burden in Hungary. Compared with the European average levels, high prevalence of alcohol use disorders (17.7%), alcohol dependence (9.4%), and high rates of liver cirrhosis-related mortality (age-standardized death rate for males and females: 57.0 years and 16.8 years, respectively) has been presented in Hungary [1]. Due to these data and the lack of comprehensive national alcohol policy, there is a need to greater understand drinking patterns and alcohol-related problems in Hungary in a more detailed way.

Theoretical and empirically-based classification models aim to identify distinct and homogenous subgroups of drinkers which are both clinically meaningful and stable over time. Based on such classifications, it is possible to isolate differences among subgroups of individuals with alcohol use disorder (AUD) in terms of drinking patterns, associated adverse consequences, development of AUD, and comorbid substance use disorders or psychiatric symptoms. Although some of the identified subgroups show substantially similar characteristics across different models, none of the previous classification attempts have yet been considered as generally adequate in research and clinical environments [3,4].

Binary classification models have identified a severely and a mildly affected group of AUD patients based on psychopathological and AUD-related vulnerability indicators [3]. However, dichotomous models arguably have a restricted capability in providing a precise distinction between possible

classes. Therefore, various multiclass models have also been assumed [5]. Current taxonomies consistently posit four alcohol drinking subgroups: low-severity, chronic severe, negative affect, and antisocial subtype [6–8]. Additionally, these models highlight the role of comorbid externalizing and internalizing psychopathological symptoms among AUD individuals. Other typologies suggested that AUD can be examined on a continuum of severity, including subgroups that are likely to vary from each other quantitatively. This latter approach corresponds with the unidimensional concept in the latest (fifth) edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [9,10].

Previous classification models have predominantly relied upon clinical samples of AUD patients. However, typologies which focus on general population samples may cover a wider range of AUD severity compared to models based on clinical samples. By including non-treatment seeking individuals in classification models, they could more accurately represent the less severe forms of AUD [5,11]. Various studies which have used general population or community-based samples have identified severity-based subgroups of drinkers [4,10,12–15]. Here, each of the latent classes demonstrated quantitatively different item endorsement profiles on the indicators of alcohol consumption, dependence symptoms, and negative social consequences. Although these studies have sometimes suggested models with different numbers of subgroups, each of the related latent classes showed substantially similar characteristics across the models. Based on these models, alcohol drinkers can be separated into (i) a non-problematic class, (ii) a subgroup of regular drinkers with low probability of dependence symptoms, (iii) a subgroup of heavy drinkers with mild to moderate probability of dependence symptoms, and (iv) a highly symptomatic or severe subgroup.

However, it is also important to note that some other typologies using general population samples suggest qualitatively different item endorsement profiles between subgroups of alcohol drinkers [16,17]. Furthermore, there has been evidence of subgroups characterized by a moderate to high probability of harmful consequences, but without experiencing of dependence symptoms. Similarly, Rist et al. [16] also discriminated a latent class showing a high probability of dependence symptom endorsement without experiencing harmful consequences.

Given this background, the first aim of the present study was to (i) discriminate homogenous subgroups of drinkers on an empirical basis, based on the indicators of the Alcohol Use Disorders Identification Test (AUDIT) items. As some previous studies also used the items of the AUDIT as indicators [16–18], it provides an opportunity to directly compare the model in the present study with these previous classification solutions. The second aim was to (ii) validate the identified latent classes based on psychopathological symptoms, such as externalizing and internalizing characteristics and socio-demographical variables.

3. Material and methods

3.1. Participants and procedure

The present study utilized data from a nationally representative sample of the National Survey on Addiction Problems in Hungary 2015 (NSAPH 2015). A detailed introduction to the study and descriptive statistics related to the sample characteristics have been presented elsewhere [19]. The main aim of the NSAPH 2015 was to assess epidemiological prevalence and population trends related to psychoactive substance use disorders and specific behavioral addictions. The target population of the study was the Hungarian adult population aged between 18 and 64 years. The NSAPH 2015 sample ensured proportional distribution of the participants in terms of age, regional

geographic locations, and size of residence. The sample group of younger adults (aged between 18 and 34 years) was overrepresented. The study had a gross sample of 2477 participants, and a net sample of 2274 participants. For the present analyses, participants who had used alcohol in the past 12 months were selected for further analysis (N=1619). However, a further 99 participants were excluded because of missing data on all of the indicator variables. Consequently, the final sample comprised 1520 participants (52.2% male [n=794]; mean age = 33.14 years; [SD=12.32]).

3.2. Measures

3.2.1. Alcohol Use Disorders Identification Test (AUDIT). Items of the AUDIT were used to assess the patterns of the participants' alcohol consumption and the harmful consequences experienced [20,21]. The AUDIT is a widely used screening questionnaire in practice and research, which identifies different risk-based groups of participants who show excessive alcohol consumption. It contains 10 items, which cover three main aspects of drinking behavior in the past 12 months: characteristics and level of alcohol consumption (Items 1-3), symptoms of alcohol dependence (Items 4-7), and negative consequences due to alcohol consumption (Items 8-10). The instrument displayed acceptable internal consistency in this sample (Cronbach's α= 0.82).

Due to the very high level of floor effect on the original response scales (Supplementary Table 1), it was not feasible to consider the items of the AUDIT as continuous indicators during the analyses. Consequently, items were transformed into dichotomous variables for further analysis. A previous study also applied a similar approach of item transformation on AUDIT items [17]. For the first question (*"How often do you have a drink containing alcohol?"*), the second response category (*monthly or less*) was specified as the baseline category, while higher levels of responses (*3=Two to four times a month, 4=Two to four times a week, 5=Four or more times a week*) were defined as the second category. For the second question (*"How many drinks containing alcohol do you*

126 *have on a typical day when you are drinking?"*), the first response category (*One or two drinks*)
127 was specified as the baseline category, while higher level of responses (*2=Three or four drinks,*
128 *3=Five or six drinks, 4=Seven to nine drinks, 5=Ten or more drinks*) were defined as the second
129 category. In the case of Items 3 to 8 (e.g., Item 3: *"How often do you have six or more drink on*
130 *one occasion?"*), the first response category (*Never*) was specified as the baseline category, and
131 higher levels on the response scale (*2=Less than monthly, 3=One to three times a month, 4=One*
132 *to three times a week, 5=At least four times a week*) were coded as the second category. For
133 Questions 9 and 10 (e.g., Item 9: *"Have you or someone else been injured because of your*
134 *drinking?*), the first response category (*Never*) was specified as the baseline category, while higher
135 level of responses (*2=Yes, but not in the past year, 3=Yes, during the past year*) were defined as
136 the second category.

137 *3.2.2. Brief Symptom Inventory (BSI)*. A modified and abbreviated version of the Brief Symptom
138 Inventory [22,23] was used to assess different dimensions of psychopathological symptoms. This
139 self-report instrument is widely used to detect and monitor various dimensions of psychological
140 disorders in clinical practice and research. The current version of the instrument contains 27 items,
141 which reflect the symptoms of anxiety, depression, hostility, interpersonal sensitivity, and
142 obsessive-compulsivity. Therefore, the current version of the BSI does not cover all the conditions
143 of the original scale. Participants had to provide responses on a five-point scale for each question.
144 Subscales of the questionnaire presented satisfactory internal consistencies in the present sample
145 (Cronbach's α= 0.80–0.87).

146 ***3.3. Data analysis***

147 In order to identify homogenous subgroups of participants based on their characteristics of alcohol
148 consumption, a Latent Class Analysis (LCA) was conducted [24]. AUDIT items were specified as

dichotomous indicator variables. Model retention with the optimal number of latent classes was carried out iteratively. First, the most parsimonious model with only one latent class was fitted to the data. Thereafter, in case of the subsequent models, the number of latent classes was increased with one additional class in each of the stages. The series of model specification was viewed as complete if the model fit indices no longer indicated a more sufficient fit by the involvement of one additional subgroup. In order to retain the best fitting model, the results of multiple model fit indices were taken into account. Compared with other solutions, the best fitting model should show lower values of Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Sample Size Adjusted Bayesian Information Criteria (SSA-BIC), and higher rate of categorization accuracy which is assessed using the index of Entropy. Moreover, significant result of the Lo-Mendel-Rubin Adjusted Likelihood Ratio Test (LMRT) displays more optimal fit for a particular model, because an additional latent class describes the pattern of responses more closely contrasted to the previous model with fewer latent classes.

The next step of the analysis validated the identified latent classes. Therefore, multinomial logistic regression was performed with R3Step [25] to explore the effect of socio-demographical and psychological independent variables on the latent classes. The model included gender, age, level of education, employment status, age of onset related to the first alcoholic drink, and symptom levels of anxiety, depression, hostility, interpersonal sensitivity, and obsessive-compulsivity as covariates. Moreover, the level of psychopathological symptoms were also compared across the identified latent classes by using the BCH method [26]. Finally, the identified latent classes were cross-validated with AUDIT-based risk categories and lifetime history of psychiatric or AUD-related treatment involvement status. In the case of multinomial logistic regression and cross-validation with categorical variables, crude Odds Ratios (ORs) were calculated as an effect size

measure. Data were weighted for all analyses to ensure generalizability to the population. IBM SPSS Statistics 23.0 and Mplus 8.0 statistical software were used in the analyses [25].

4. Results

4.1. Latent Class Analysis (LCA)

The response distribution on the original items of the AUDIT for active drinkers and the item endorsement probabilities of the dichotomous AUDIT variables in the total sample, and among males and females are presented in Supplementary Tables 1 and 2. LCA was performed to identify subgroups of participants who showed similar patterns of item endorsement probabilities related to alcohol consumption and harmful consequences. Models with one to four latent classes were estimated and assessed in terms of model fit. Various model fit indices related to these models are summarized in Table 1. Although the index of AIC and SSA-BIC indicated that the four-class solution fitted the data most closely, measures of BIC and Entropy implied a reduction in the level of model fit by the inclusion of the fourth latent class. Moreover, LMRT yielded a non-significant (p>0.05) result in case of the model with four latent classes. Thus, the inclusion of an additional latent class over three subgroups did not provide a more parsimonious solution. Overall, the three class solution provided the most adequate degree of model fit. The average latent class probabilities for the most likely latent class membership were 0.95, 0.79 and 0.94, respectively. Further analyses were conducted with this model.

In order to interpret the three identified latent classes, item-endorsement probability characteristics were considered. Response patterns of the three latent classes are presented in Table 2 and Figure 1. Participants assigned to Class 1 (‘Light alcohol drinkers’) demonstrated the lowest rates of item endorsement probability related to indicators of alcohol consumption, dependence, and negative

consequences. Class 2 ('Alcohol drinkers with low risk of dependence') was described with medium to high probability of item endorsement on alcohol consumption-related indicators, and low probability of item endorsement related to dependence and negative consequences. The subgroup of Class 3 ('Alcohol drinkers with severe dependence symptoms') showed high probability of alcohol consumption-related item endorsement, and the highest rates of symptom endorsement probability on indicators of dependence and negative consequences.

4.2. Validation of the latent classes

First, the identified latent classes were contrasted in terms of psychopathological symptoms. Table 2 summarizes the results of the multiple comparisons. Alcohol drinkers with low-risk of dependence and severe dependence symptoms reported the highest scores on anxiety, depression, hostility and interpersonal sensitivity. 'Light alcohol drinkers' showed the lowest levels of psychopathological symptoms in each of the multiple comparisons. Multinomial logistic regression was also conducted to validate the identified latent classes. Table 3 presents the results related to the effects of socio-demographical and psychological covariates. The latent class of 'Light alcohol drinkers' was specified as a reference category. In case of 'Alcohol drinkers with low risk of dependence', male gender, younger age, economically active status, earlier onset related to the first alcoholic drink, and a higher level of depression significantly increased the odds of membership compared to Class 1. Significantly higher odds of membership were displayed for 'Alcohol drinkers with severe dependence symptoms' compared to the reference category if the participant was male, had a lower level of educational achievement, reported earlier onset related to the first alcoholic drink, and showed a higher level of hostility.

The identified latent classes were cross-validated with the AUDIT-based risk categories. Supplementary Table 4 summarizes the distribution of the participants across these categories. The

membership of 'Light alcohol drinkers' and low-risk alcohol drinking was fully overlapped (100%). The majority of 'Alcohol drinkers with low risk of dependence' (87.7%) were described as low-risk drinkers based on the AUDIT, while only small proportion (12.3%) of the respondents in this subgroup was categorized as hazardous drinkers. A high proportion of 'Alcohol drinkers with severe dependence symptoms' were categorized with hazardous drinking (65.4%), or harmful drinking and possible dependence (24.7%) based on the AUDIT.

Finally, the association between the identified latent classes and lifetime history of psychiatric and AUD-related treatment involvement were also analyzed. Frequencies of each category combinations are displayed in Supplementary Tables 5 and 6. The latent class of 'Alcohol drinkers with severe dependence symptoms' had the highest proportion of individuals who reported lifetime history of psychiatric treatment (19.3%) or AUD-related treatment (12.3%) treatment. In the cases of 'Alcohol drinkers with low risk of dependence' (3.9 and 6.7% respectively) and 'Light alcohol drinkers' (0.4 and 5.0% respectively), fewer participants had received previous psychiatric or AUD-related treatment. It was also found that a small proportion of abstinent and non-active alcohol drinkers reported lifetime psychiatric treatment (N=34; 5.2%) or AUD-related treatment (N=5; 0.8%).

5. Discussion

The present study explored subgroups of past-year alcohol users in a nationally representative population-based sample from Hungary where the prevalence of alcohol use disorder and rates of alcohol-related morbidity and mortality are among the highest in the world. Analyses demonstrated a three-class solution where each of the latent classes were heterogeneous in the level of alcohol consumption and harmful consequences due to alcohol drinking. The three latent classes identified were defined on the basis of alcohol-drinking severity. 'Light alcohol drinkers' were considered as

the least severe subgroup of alcohol drinkers. Although with higher rates of alcohol consumption, 'Alcohol drinkers with low risk of dependence' still showed a low level of alcohol-related dependence symptoms and harmful consequences. The subgroup of 'Alcohol drinkers with severe dependence symptoms' was described as the most severe subgroup due to high probability of alcohol dependence and harmful consequences item endorsement.

The present results indicate that alcohol-related harmful consequences sit on a continuum of severity in the general population. Instead of qualitatively different symptom profiles [16,17], subgroups of drinkers were discriminated by increasing probability of item endorsement related to alcohol dependence symptoms and negative consequences [9,27]. These findings complement the unidimensional AUD approach of DSM-5 [8]. Numerous previous models also suggested some forms of severity-based subgroups of alcohol drinkers based on general population and community samples [4,10,12].

These typologies typically distinguish three or four latent classes of drinkers, and which show parallel and quantitatively different symptom endorsement profiles. The identified subgroups based on the present study broadly corresponded with latent classes identified in previous classification models. 'Light alcohol drinkers' corresponded with the 'Non-symptomatic class' reported by Ko et al. [13] and Castaldelli-Maia et al. [12], and to the 'Non-problematic class' reported by Casey et al. [4], or the 'Baseline/Very Mild consumption' reported by Smith and Shelvin [17]. 'Alcohol drinkers with low risk of dependence' demonstrated similar characteristics to the 'Minimally dependent drinkers' reported by Jackson et al. [10] and the 'Moderate risk' group reported by Sacco et al. [15]. 'Alcohol drinkers with severe dependence symptoms' had comparable symptom profiles to the 'High symptomatic class' reported by Ko et al. [13] and Castaldelli-Maia et al. [12], and to

the ‘Extreme class’ reported by Casey et al. [4], and to the subgroup of ‘Heavy consumption with multiple negative consequences’ reported by Smith and Shelvin [17].

In the severity-based latent class solution, the alcohol dependence related items [4-7] and negative consequences related items [8-10] were not separated, but were associated with each other. Therefore, indicator variables differentiated the identified subgroups by two main aspects: level of alcohol consumption (Items 1-3) and harmful consequences due to drinking (Items 4-10). At the less severe level of the continuum (e.g., between Class 1 and Class 2), the indicators related to alcohol consumption differentiated more predominantly, such as frequency and quantity of alcohol drinking, and heavy episodic alcohol drinking. At the more severe level of the spectrum (e.g., between Class 2 and Class 3) similar rates of alcohol consumption were observed. Therefore, indices of harmful consequences due to drinking isolated the differences between the latent classes [18]. Similar patterns of differentiation have been found among participants in a national representative sample [10], older adults [15], and college students [18]. However, the similar levels of alcohol consumption in the cases of Class 2 and Class 3 is in contradiction with the conceptualization of ‘heavy use over time’ for alcohol use problems [28]. According to Rehm and colleagues, more severe levels of alcohol consumption can be accounted for by higher rates of alcohol-related harmful consequences and AUD symptoms, therefore the amount and frequency of heavy drinking should be considered as indicators of alcohol use disorder. The present study was unable to demonstrate a clear dose-response association between measures of alcohol consumption and harmful consequences. Therefore, it was not possible to distinguish latent classes of ‘Alcohol drinkers with low risk of dependence’ and ‘Alcohol drinkers with severe dependence symptoms’ solely based on dichotomous measures of alcohol consumption. It was also important to take into

account the indices of harmful consequences due to drinking in order to accurately identify those individuals who were characterized with more severe patterns of drinking.

Overall, based on the present analysis, approximately 9% of the alcohol users showed severe symptoms of alcohol dependence in the population. Similarly, previous studies based on population-based nationally representative samples also reported 5-7% of the active alcohol drinkers were classified in the highly affected subgroups [4,12,17]. However, compared with previous epidemiological findings which assessed alcohol drinking patterns in Hungary [1], lower prevalence rates of heavy episodic drinking and AUD among alcohol users were presented in the present study. Therefore, there is a need for future studies to obtain a more accordant view related to the different forms of problematic alcohol consumption in Hungary.

Follow-up analyses also illustrated significant differences between the subgroups of alcohol drinkers in terms of alcohol-related risk categories, psychiatric treatment, and AUD-related treatment. Cross-validation of the identified latent classes with the AUDIT-based risk categories also suggested that 'Alcohol drinkers with severe dependence symptoms' were mainly classified at least as someone who shows hazardous drinking. Similarly, members of this subgroup showed the highest rates of lifetime psychiatric treatment and AUD-related treatment. Similar rates of treatment involvement related to the most severe subgroup of drinkers were reported in a US-based study using a nationally representative population sample [13]. A substantial proportion of 'Alcohol drinkers with low risk of dependence' did not reach the threshold of hazardous drinking. Therefore, future prospective studies should examine whether this class shows a risk for developing more severe forms of problematic alcohol consumption [29].

Groups which were at the higher end of the severity-continuum also demonstrated psychopathological vulnerability. Alcohol drinkers with low-risk of alcohol dependence and severe

alcohol dependence symptoms showed the highest level of anxiety, depression, hostility, interpersonal sensitivity, and obsessive-compulsive symptoms. Present findings correspond with the theoretical and clinical concept that AUD is associated with internalizing and externalizing characteristics [7]. More specifically, a higher level of hostility and depression predicted membership of the more severe latent classes. In the case of negative affect (e.g., depression, anxiety), it is assumed that alcohol consumption might serve as a means for coping and/or mood regulation. Previous studies have also hypothesized that externalizing characteristics, such as antisocial behavior, contributes to AUD via general personality and behavioral traits of impulsivity, irresponsibility, and/or irritability [30]. Overall, the results of the present study suggest more attention is needed on externalizing symptoms when screening for AUD.

Alcohol drinkers with low-risk of dependence and severe dependence symptoms were also characterized with specific socio-demographic attributes. Males were more likely to be present in the most severe groups. Similar gender-related differences have been reported in various previous studies [4,17]. However, it is important to explore whether different pathways related to excessive alcohol drinking can be assumed for females [31]. In case of 'Alcohol drinkers with severe dependence symptoms', a lower level of educational achievement enhanced the odds of being in this group. The possible risk factor related for decreased educational achievement (i.e., dropping out from school early) has consistently been demonstrated by previous studies using LCA [12,29]. Finally, 'Alcohol drinkers with low risk of dependence' were younger than their severely dependent counterparts. Therefore, it is not clear if this status is a transient one, and what proportion of the members of this group may develop severe dependence symptoms in their latter life. Further research utilizing a longitudinal design would address the transition from one group to another either from low-risk of dependence to severe dependence group, or vice versa from severe

dependence group towards light use or no use at all [32]. The present study was unable capture this dynamic change among the community sample recruited.

5.1. Limitations and future directions

Four major limitations should be considered in relation to the interpretation of results in the present study. First, the cross-sectional design of the research does not allow the determination of causal pathways between psychopathological symptoms and membership of latent classes. Future longitudinal studies should also examine the temporal stability and membership transitions of each of the identified latent classes reported here. Second, it might be possible that the individuals who showed more severe forms of alcohol consumption were under-represented in the present sample [1], therefore the identified subgroups did not capture accurately the heterogeneity of alcohol-related problems. Third, as latent classes of 'Alcohol drinkers with low risk of dependence' and 'Alcohol drinkers with severe dependence symptoms' contained relatively few participants, the generalization of the finding related to these subgroups is only possible in a limited manner. Fourth, several important aspects of excessive alcohol drinking were not included in the LCA model. Thus, future studies should take into account the effect of psychoactive substance use, and history and presence of AUD among other family members. Additional methodological bias may also have been present due to the dichotomous indicator variables used. As a consequence, it is possible that the alcohol consumption-related variables might not have properly differentiated between the latent classes. Finally, there is a possibility that the comparison between classification models were limited due to measurement- and population-related differences [18].

5.2. Conclusions

The present study identified subgroups of past-year alcohol users in a nationally representative population-based sample. The three defined latent classes provided a range of alcohol use severity (with approximately 9% showing severe symptoms of alcohol dependence in the sample). The present sample might have incorporated a wider range of problematic alcoholic drinkers due to the sample characteristics. The psychopathological vulnerability of the more severe subgroups was also found, and the significant predictive effects of hostility and depression were demonstrated. The specification of homogenous and empirically-derived subgroups of alcohol drinkers might therefore contribute to the development of more tailored prevention and screening services for those with AUD [5].

6. Appendix

6.1. Tables

Table 1. Fit indices for the latent class analysis models based on dichotomous items of the AUDIT

	AIC	BIC	SSA-BIC	Entropy	LMRT	*p*
1-class model	11160.04	11213.30	11181.54			
2-class model	8807.54	8919.39	8852.68	0.932	2345.40	< 0.001
3-class model	8588.68	8759.13	8657.47	0.812	237.91	0.002
4-class model	8545.33	8774.37	8637.77	0.795	64.55	0.760

Note. AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; SSA-BIC = Sample Size Adjusted Bayesian Information Criteria; LRT = Lo-Mendel-Rubin Adjusted Likelihood Ratio Test.

Table 2. Class-based probability of endorsing each dichotomous items of the AUDIT and comparisons of latent classes.

	Class 1 'Light alcohol drinkers' N=1088 (71.60%)	Class 2 'Alcohol drinkers with low risk of dependence' N=294; (19.33%)	Class 3 'Alcohol drinkers with severe dependence symptoms' N=138 (9.07%)	Overall Wald test (*p*)
Frequency of alcohol consumption: at least two times a month	0.32	0.72	0.95	
Typical quantity of drinks: at least three drinks on a typical day	0.13	0.61	0.66	
Six or more drinks on one occasion	0.09	0.78	0.81	
Unable to stop drinking	< 0.01	0.10	0.77	
Failed to do what was normally expected	< 0.01	0.05	0.79	
Drink in the morning	< 0.01	0.05	0.65	
Feeling of guilt or remorse after drinking	0.01	0.19	0.72	
Unable to remember what happened because of drinking	< 0.01	0.14	0.71	
Somebody injured as a result of drinking	< 0.01	0.07	0.31	
Somebody concerned about drinking, suggested to cut down	< 0.01	0.10	0.54	
Comparisons				

Age	42.36 (0.48)$_a$	35.23 (1.21)$_b$	42.34 (1.36)$_a$	26.65 (p<0.001)
Anxiety	9.13 (0.17)$_a$	9.94 (0.39)$_{a,b}$	10.94 (0.53)$_b$	13.01 (p=0.001)
Depression	9.23 (0.20)$_a$	10.48 (0.47)$_b$	11.89 (0.75)$_b$	16.28 (p<0.001)
Hostility	7.00 (0.12)$_a$	8.39 (0.39)$_b$	9.55 (0.45)$_b$	39.82 (p<0.001)
Interpersonal sensitivity	5.90 (0.12)$_a$	6.59 (0.25)$_b$	7.31 (0.37)$_b$	17.39 (p<0.001)
Obsessive-compulsive	9.25 (0.18)$_a$	10.05 (0.42)$_a$	11.80 (0.58)$_b$	19.39 (p<0.001)

Note. Means in the same row that do not share subscripts differ at p<0.05 level. BCH method was used in the comparison [26].

Table 3. Predictors of class memberships: a multinomial logistic regression.

	Class 2 'Alcohol drinkers with low risk of dependence' Crude OR [95% CI]	Class 3 'Alcohol drinkers with severe dependence symptoms' Crude OR [95% CI]
Gender[1]	**4.45 [2.47 – 8.04]**	**3.75 [1.73 – 8.10]**
Age	**0.94 [0.91 – 0.96]**	0.98 [0.96 – 1.00]
Level of education[2]	1.24 [0.69 – 2.20]	**3.73 [1.97 – 7.07]**
Employment status[3]	**1.91 [1.02 – 3.56]**	1.12 [0.56 – 2.24]
Young age of onset: first drink[4]	**2.14 [1.16 – 3.94]**	**3.01 [1.57 – 5.76]**
Depression	**1.10 [1.02 – 1.20]**	1.02 [0.91 – 1.15]
Hostility	1.14 [0.97 – 1.33]	**1.24 [1.07 – 1.43]**
Interpersonal sensitivity	0.97 [0.85 – 1.11]	0.89 [0.74 – 1.07]
Obsessive-compulsive	0.93 [0.82 – 1.05]	1.02 [0.89 – 1.18]

Note. Crude Odds Ratios (95% confidence intervals) of the association between validating covariates and latent class membership relative to Class 1 ('Light alcohol drinkers'). Odds ratios presented by bold figures are significant at least p<0.05 level. [1]Gender: 0=Female, 1=Male; [2]Level of education: 0=Participant had a graduation at vocational or high-school at least, 1=Participant did not have vocational or high-school graduation; [3]Employment status: 0=Unemployed, economically inactive, 1=Working, economically active; [4]Age of onset: first alcoholic drink: 0=At least at the age of 15 years, or none, 1=At the age of 14 years or earlier. Anxiety was not included in the final analysis as a predictor, due to the negative suppressor effect of depression. Supplementary Table 3 contains the results of the analysis, when anxiety was also included as a predictor variable.

6.2. Figures

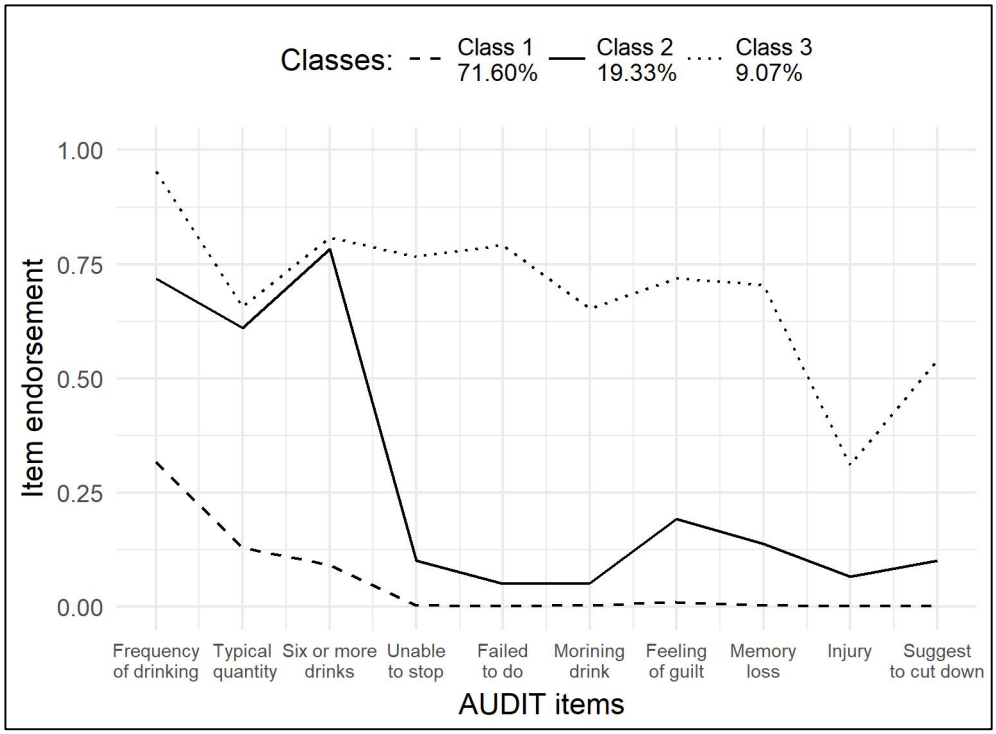

Figure 1.

7. Supplementary Material

Supplementary Table 1. Response distribution on the items of the AUDIT for active alcohol drinkers

Items	Response categories N (%)				
	0	1	2	3	4
1. Frequency of alcohol consumption: at least two times a month[1]	-	539 (54.5%)	288 (29.1%)	87 (8.8%)	73 (7.4%)
2. Typical quantity of drinks: at least three drinks on a typical day[2]	627 (63.4%)	161 (16.2%)	49 (4.9%)	7 (0.7%)	18 (1.8%)
3. Six or more drinks on one occasion[3]	876 (88.5%)	59 (5.9%)	20 (2.0%)	5 (0.5%)	3 (0.3%)
4. Unable to stop drinking[3]	876 (88.5%)	59 (5.9%)	20 (2.0%)	5 (0.5%)	3 (0.3%)
5. Failed to do what was normally expected[3]	884 (89.3%)	65 (6.5%)	9 (0.9%)	3 (0.3%)	2 (0.2%)
6. Drink in the morning[3]	892 (90.2%)	48 (4.9%)	11 (1.2%)	5 (0.5%)	4 (0.4%)
7. Feeling of guilt or remorse after drinking[3]	857 (86.7%)	74 (7.5%)	20 (2.0%)	8 (0.8%)	5 (0.5%)
8. Unable to remember what happened because of drinking[3]	874 (88.3%)	65 (6.5%)	16 (1.6%)	6 (0.6%)	2 (0.2%)
9. Somebody injured as a result of drinking[4]	932 (94.2%)	-	36 (3.7%)	-	5 (0.5%)
10. Somebody concerned about drinking, suggested to cut down[4]	900 (90.9%)	-	47 (4.7%)	-	21 (2.2%)

Note. Analysis was performed in a weighted sample (N=989). Response categories: [1]0=Never, 1=Monthly or less, 2=Two to four times a month, 3=Two to four times a week, 4=Four or more times a week; [2]0=One or two drinks, 2=Three or four drinks, 3=Five or six drinks, 4=Seven to nine drinks, 5=Ten or more drinks; [3]0=Never, 1=Less than monthly, 2=One to three times a month, 3=One to three times a week, 4=At least four times a week, [4]0=Never, 2=Yes, but not in the past year, 4=Yes, during the past year.

Supplementary Table 2. Item endorsement of the AUDIT items in the total sample, and among males and females.

Items	Endorsement in the total sample (N=989)	Endorsement among males (N=513)	Endorsement among females (N=476)
1. Frequency of alcohol consumption: at least two times a month	448 (45.3%)	328 (64.0%)	120 (25.1%)
2. Typical quantity of drinks: at least three drinks on a typical day	234 (23.7%)	166 (32.3%)	68 (14.4%)

3. Six or more drinks on one occasion	283 (28.6%)	204 (39.8%)	79 (16.5%)
4. Unable to stop drinking	87 (8.8%)	71 (13.8%)	16 (3.3%)
5. Failed to do what was normally expected	78 (7.9%)	59 (11.5%)	19 (4.1%)
6. Drink in the morning	68 (6.9%)	55 (10.8%)	13 (2.7%)
7. Feeling of guilt or remorse after drinking	106 (10.7%)	76 (14.8%)	30 (6.3%)
8. Unable to remember what happened because of drinking	88 (8.9%)	69 (13.4%)	20 (4.2%)
9. Somebody injured as a result of drinking	42 (4.2%)	34 (6.7%)	7 (1.5%)
10. Somebody concerned about drinking, suggested to cut down	68 (6.9%)	56 (10.9%)	12 (2.6%)
Total AUDIT score M (SD)	3.46 (3.93)	4.62 (4.62)	2.19 (2.44)
Category of low-risk drinking[1] N (%)	744 (75.2%)	360 (70.2%)	385 (80.7%)
Category of hazardous alcohol use[2] N (%)	73 (7.4%)	59 (11.5%)	14 (3.0%)
Category of harmful alcohol use[3] or possible dependence[4] N (%)	21 (2.1%)	19 (3.8%)	1 (0.2%)

Note. Analysis was performed in a weighted sample (N=989). [1]Category of low-risk drinking: total AUDIT score between 0-7 points; [2]Category of hazardous alcohol use: total AUDIT score between 8-15 points; [3]Category of harmful alcohol use: total AUDIT score between 16-19 points; [4]Category of possible dependence: at least 20 points on the total AUDIT scale

Supplementary Table 3. Odds ratios (95% Confidence Intervals) of the association between validating covariates and latent class membership relative to Class 1 ('Light alcohol drinkers').

	Class 2 (19.33%) 'Alcohol drinkers with low risk of dependence' Crude OR [95% CI]	Class 3 (9.07%) 'Alcohol drinkers with severe dependence symptoms' Crude OR [95% CI]
Gender[1]	**4.55 [2.52 – 8.22]**	**3.26 [1.51 – 7.03]**
Age	**0.94 [0.91 – 0.96]**	0.98 [0.96 – 1.00]
Level of education[2]	1.24 [0.69 – 2.22]	**3.83 [2.00 – 7.34]**
Employment status[3]	**1.90 [1.01 – 3.56]**	1.13 [0.55 – 2.31]
Young age of onset: first drink[4]	**2.13 [1.15 – 3.94]**	**3.02 [1.58 – 5.78]**
Anxiety	0.98 [0.82 – 1.17]	**0.80 [0.67 – 0.95]**
Depression	**1.11 [1.01 – 1.22]**	1.07 [0.96 – 1.21]
Hostility	1.15 [0.97 – 1.36]	**1.33 [1.14 – 1.55]**
Interpersonal sensitivity	0.98 [0.85 – 1.13]	0.96 [0.79 – 1.16]
Obsessive-compulsive	0.93 [0.81 – 1.06]	1.09 [0.94 – 1.27]

Note. Crude Odds ratios presented by bold figures are significant at least $p<0.05$ level. [1]Gender: 0=Female, 1=Male; [2]Level of education: 0=Participant had a graduation at vocational or high-

school at least, 1=Participant did not have vocational or high-school graduation; [3]Employment status: 0=Unemployed, economically inactive, 1=Working, economically active; [4]Age of onset: first drink: 0=At least at the age of 15 years, or none, 1=At the age of 14 years or earlier.

Supplementary Table 4. Association between the identified latent classes and the AUDIT-based risk categories.

	Class 1 'Light alcohol drinkers' N=594 (71.0%)	Class 2 'Alcohol drinkers with low risk of dependence' N=162 (19.3%)	Class 3 'Alcohol drinkers with severe dependence symptoms' N=81 (9.7%)
Category of low-risk alcohol drinking[1]; N=744 (88.9%)	594 (100.0%)	142 (87.7%)	8 (9.9%)
Category of hazardous alcohol use[2]; N=73 (8.7%)	0 (0.0%)	20 (12.3%)	53 (65.4%)
Category of harmful alcohol use[3] or possible alcohol dependence[4]; N=20 (2.4%)	0 (0.0%)	0 (0.0%)	20 (24.7%)

Note. Analysis was performed in a weighted sample (N=989). Percentages in each cells represents the proportion within each latent classes. $\chi^2(4)=604.77$; $p<0.001$; $\varphi=0.850$. Note. [1]Category of low-risk alcohol drinking: total AUDIT score between 0-7 points; [2]Category of hazardous alcohol use: total AUDIT score between 8-15 points; [3]Category of harmful alcohol use: total AUDIT score between 16-19 points; [4]Category of possible dependence: at least 20 points on the total AUDIT scale

Supplementary Table 5. Association between the identified latent classes and lifetime history of psychiatric treatment involvement.

		Class 1 'Light alcohol drinkers' N=679 (72.1%)	Class 2 'Alcohol drinkers with low risk of dependence' N=180 (19.1%)	Class 3 'Alcohol drinkers with severe dependence symptoms' N=83 (8.8%)
Lifetime history of psychiatric treatment	Yes N=62 (6.6%)	34 (5.0%)	12 (6.7%)	16 (19.3%)
	No N=880 (93.4%)	645 (95.0%)	168 (93.3%)	67 (80.7%)
Crude OR [95% CI]*		*Ref.*	1.36 [0.69–2.67]	4.53 [2.38–8.64]

Note. Analysis was performed in a weighted sample (N=989). Percentages in each cells represents the proportion within each latent classes. $\chi^2(2)=24.50$; $p<0.001$; $\varphi=0.161$. Crude OR=odds ratio

calculated without the missing values. CI=confidence interval*: Comparison group is Class 1 (*Ref.*=reference group).

Supplementary Table 6. Association between the identified latent classes and lifetime history of psychiatric and AUD-related treatment involvement.

		Class 1 'Light alcohol drinkers' N=677 (72.3%)	Class 2 'Alcohol drinkers with low risk of dependence' N=178 (19.0%)	Class 3 'Alcohol drinkers with severe dependence symptoms' N=81 (8.7%)
Lifetime history of AUD-related treatment	Yes N=20 (2.1%)	3 (0.4%)	7 (3.9%)	10 (12.3%)
	No N=916 (97.9%)	674 (99.6%)	171 (96.1%)	71 (87.7%)
Crude OR [95% CI]*		*Ref.*	9.20 [2.35 – 35.94]	31.64 [8.51 – 117.65]

Note. Analysis was performed in a weighted sample (N=989). Percentages in each cells represents the proportion within each latent classes. $\chi^2(2)=52.40$; $p<0.001$; $\varphi=0.237$. Crude OR=odds ratio calculated without the missing values. CI=confidence interval*: Comparison group is Class 1 (*Ref*=reference group).

8. Statements

8.1. Statement of Ethics

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. The study protocol has been approved by the relevant Research and Ethical Committee.

8.2. Disclosure Statement

The authors have no conflicts of interest to declare.

8.3. Funding Sources

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8.4. Author Contributions

ZsH, MG, ZsD and RU wrote the manuscript. BP and KF designed the study and performed data collection. ZsH conducted statistical analysis under RU's supervision. All authors have critically revised the manuscript and approved its final version.

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10. Figure Legends

Fig. 1. Class-based probability of endorsing each dichotomous items of the AUDIT