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6

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8 Alcohol Use Disorder (AUD); alcohol consumption; alcohol psychopathology
9

10 **1. Abstract**

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

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

18 **Method.** Data of past-year alcohol users (N=1520) were analyzed from the nationally
19 representative sample of the National Survey on Addiction Problems in Hungary 2015 (NSAPH
20 2015). Latent Class Analysis (LCA) was conducted to identify subgroups of drinkers based on the
21 dichotomous indicator items of the Alcohol Use Disorders Identification Test (AUDIT)
22 questionnaire. Multinomial logistic regression and multiple comparisons were performed to
23 explore the relationship between latent classes and socio-demographical variables and
24 psychopathological symptoms.

25 **Results.** LCA suggested a three-class model: 'Light alcohol drinkers' (71.6%), 'Alcohol drinkers
26 with low risk of dependence' (19.3%) and 'Alcohol drinkers with severe dependence symptoms'
27 (9.1%). More severe subgroups showed significantly higher level of anxiety, depression, hostility,
28 obsessive-compulsivity, interpersonal sensitivity, and psychiatric or AUD-related treatment
29 involvement. Male gender, younger age, lower level of educational achievement, and earlier onset
30 of the first alcoholic drink were associated with membership of more severe subgroups.

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

35

36 **2. Introduction**

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

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

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

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

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

81 However, it is also important to note that some other typologies using general population samples
82 suggest qualitatively different item endorsement profiles between subgroups of alcohol drinkers
83 [16,17]. Furthermore, there has been evidence of subgroups characterized by a moderate to high
84 probability of harmful consequences, but without experiencing of dependence symptoms.
85 Similarly, Rist et al. [16] also discriminated a latent class showing a high probability of dependence
86 symptom endorsement without experiencing harmful consequences.

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

94 **3. Material and methods**

95 *3.1. Participants and procedure*

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

103 geographic locations, and size of residence. The sample group of younger adults (aged between 18
104 and 34 years) was overrepresented. The study had a gross sample of 2477 participants, and a net
105 sample of 2274 participants. For the present analyses, participants who had used alcohol in the past
106 12 months were selected for further analysis (N=1619). However, a further 99 participants were
107 excluded because of missing data on all of the indicator variables. Consequently, the final sample
108 comprised 1520 participants (52.2% male [n=794]; mean age = 33.14 years; [SD=12.32]).

109 **3.2. Measures**

110 *3.2.1. Alcohol Use Disorders Identification Test (AUDIT).* Items of the AUDIT were used to assess
111 the patterns of the participants' alcohol consumption and the harmful consequences experienced
112 [20,21]. The AUDIT is a widely used screening questionnaire in practice and research, which
113 identifies different risk-based groups of participants who show excessive alcohol consumption. It
114 contains 10 items, which cover three main aspects of drinking behavior in the past 12 months:
115 characteristics and level of alcohol consumption (Items 1-3), symptoms of alcohol dependence
116 (Items 4-7), and negative consequences due to alcohol consumption (Items 8-10). The instrument
117 displayed acceptable internal consistency in this sample (Cronbach's $\alpha=0.82$).

118 Due to the very high level of floor effect on the original response scales (Supplementary Table 1),
119 it was not feasible to consider the items of the AUDIT as continuous indicators during the analyses.
120 Consequently, items were transformed into dichotomous variables for further analysis. A previous
121 study also applied a similar approach of item transformation on AUDIT items [17]. For the first
122 question ("*How often do you have a drink containing alcohol?*"), the second response category
123 (*monthly or less*) was specified as the baseline category, while higher levels of responses (*3=Two*
124 *to four times a month, 4=Two to four times a week, 5=Four or more times a week*) were defined
125 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 $\alpha = 0.80\text{--}0.87$).

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

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

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

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

174 **4. Results**

175 ***4.1. Latent Class Analysis (LCA)***

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

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

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

200 ***4.2. Validation of the latent classes***

201 First, the identified latent classes were contrasted in terms of psychopathological symptoms. Table
202 2 summarizes the results of the multiple comparisons. Alcohol drinkers with low-risk of
203 dependence and severe dependence symptoms reported the highest scores on anxiety, depression,
204 hostility and interpersonal sensitivity. 'Light alcohol drinkers' showed the lowest levels of
205 psychopathological symptoms in each of the multiple comparisons. Multinomial logistic regression
206 was also conducted to validate the identified latent classes. Table 3 presents the results related to
207 the effects of socio-demographical and psychological covariates. The latent class of 'Light alcohol
208 drinkers' was specified as a reference category. In case of 'Alcohol drinkers with low risk of
209 dependence', male gender, younger age, economically active status, earlier onset related to the first
210 alcoholic drink, and a higher level of depression significantly increased the odds of membership
211 compared to Class 1. Significantly higher odds of membership were displayed for 'Alcohol
212 drinkers with severe dependence symptoms' compared to the reference category if the participant
213 was male, had a lower level of educational achievement, reported earlier onset related to the first
214 alcoholic drink, and showed a higher level of hostility.

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

217 membership of ‘Light alcohol drinkers’ and low-risk alcohol drinking was fully overlapped
218 (100%). The majority of ‘Alcohol drinkers with low risk of dependence’ (87.7%) were described
219 as low-risk drinkers based on the AUDIT, while only small proportion (12.3%) of the respondents
220 in this subgroup was categorized as hazardous drinkers. A high proportion of ‘Alcohol drinkers
221 with severe dependence symptoms’ were categorized with hazardous drinking (65.4%), or harmful
222 drinking and possible dependence (24.7%) based on the AUDIT.

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

233 **5. Discussion**

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

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

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

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

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

264 In the severity-based latent class solution, the alcohol dependence related items [4-7] and negative
265 consequences related items [8-10] were not separated, but were associated with each other.
266 Therefore, indicator variables differentiated the identified subgroups by two main aspects: level of
267 alcohol consumption (Items 1-3) and harmful consequences due to drinking (Items 4-10). At the
268 less severe level of the continuum (e.g., between Class 1 and Class 2), the indicators related to
269 alcohol consumption differentiated more predominantly, such as frequency and quantity of alcohol
270 drinking, and heavy episodic alcohol drinking. At the more severe level of the spectrum (e.g.,
271 between Class 2 and Class 3) similar rates of alcohol consumption were observed. Therefore,
272 indices of harmful consequences due to drinking isolated the differences between the latent classes
273 [18]. Similar patterns of differentiation have been found among participants in a national
274 representative sample [10], older adults [15], and college students [18]. However, the similar levels
275 of alcohol consumption in the cases of Class 2 and Class 3 is in contradiction with the
276 conceptualization of 'heavy use over time' for alcohol use problems [28]. According to Rehm and
277 colleagues, more severe levels of alcohol consumption can be accounted for by higher rates of
278 alcohol-related harmful consequences and AUD symptoms, therefore the amount and frequency of
279 heavy drinking should be considered as indicators of alcohol use disorder. The present study was
280 unable to demonstrate a clear dose-response association between measures of alcohol consumption
281 and harmful consequences. Therefore, it was not possible to distinguish latent classes of 'Alcohol
282 drinkers with low risk of dependence' and 'Alcohol drinkers with severe dependence symptoms'
283 solely based on dichotomous measures of alcohol consumption. It was also important to take into

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

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

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

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

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

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

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

332 *5.1. Limitations and future directions*

333 Four major limitations should be considered in relation to the interpretation of results in the present
334 study. First, the cross-sectional design of the research does not allow the determination of causal
335 pathways between psychopathological symptoms and membership of latent classes. Future
336 longitudinal studies should also examine the temporal stability and membership transitions of each
337 of the identified latent classes reported here. Second, it might be possible that the individuals who
338 showed more severe forms of alcohol consumption were under-represented in the present sample
339 [1], therefore the identified subgroups did not capture accurately the heterogeneity of alcohol-
340 related problems. Third, as latent classes of ‘Alcohol drinkers with low risk of dependence’ and
341 ‘Alcohol drinkers with severe dependence symptoms’ contained relatively few participants, the
342 generalization of the finding related to these subgroups is only possible in a limited manner. Fourth,
343 several important aspects of excessive alcohol drinking were not included in the LCA model. Thus,
344 future studies should take into account the effect of psychoactive substance use, and history and
345 presence of AUD among other family members. Additional methodological bias may also have
346 been present due to the dichotomous indicator variables used. As a consequence, it is possible that
347 the alcohol consumption-related variables might not have properly differentiated between the latent
348 classes. Finally, there is a possibility that the comparison between classification models were
349 limited due to measurement- and population-related differences [18].

350 *5.2. Conclusions*

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

360

361 **6. Appendix**

362 **6.1. Tables**

363

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

	AIC	BIC	SSA-BIC	Entropy	LMRT	<i>p</i>
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

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

369

370 Table 2. Class-based probability of endorsing each dichotomous items of the AUDIT and
371 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 (<i>p</i>)
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 (<i>p</i> <0.001)
Anxiety	9.13 (0.17) _a	9.94 (0.39) _{a,b}	10.94 (0.53) _b	13.01 (<i>p</i> =0.001)
Depression	9.23 (0.20) _a	10.48 (0.47) _b	11.89 (0.75) _b	16.28 (<i>p</i> <0.001)
Hostility	7.00 (0.12) _a	8.39 (0.39) _b	9.55 (0.45) _b	39.82 (<i>p</i> <0.001)
Interpersonal sensitivity	5.90 (0.12) _a	6.59 (0.25) _b	7.31 (0.37) _b	17.39 (<i>p</i> <0.001)
Obsessive-compulsive	9.25 (0.18) _a	10.05 (0.42) _a	11.80 (0.58) _b	19.39 (<i>p</i> <0.001)

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

374

375 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]

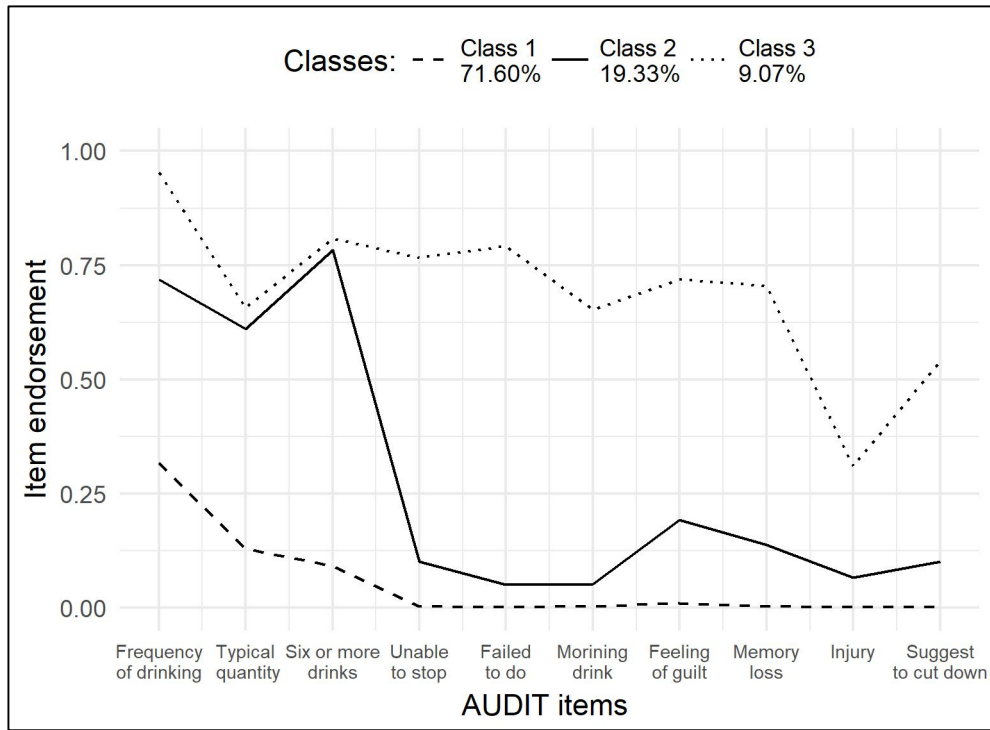
376 Note. Crude Odds Ratios (95% confidence intervals) of the association between validating
377 covariates and latent class membership relative to Class 1 ('Light alcohol drinkers'). Odds ratios
378 presented by bold figures are significant at least *p*<0.05 level. ¹Gender: 0=Female, 1=Male; ²Level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

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387 6.2. Figures

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389

390

Figure 1.

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392 **7. Supplementary Material**

393

394 Supplementary Table 1. Response distribution on the items of the AUDIT for active alcohol
395 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%)

396 Note. Analysis was performed in a weighted sample (N=989). Response categories: ¹0=Never,
397 1=Monthly or less, 2=Two to four times a month, 3=Two to four times a week, 4=Four or more
398 times a week; ²0=One or two drinks, 2=Three or four drinks, 3=Five or six drinks, 4=Seven to nine
399 drinks, 5=Ten or more drinks; ³0=Never, 1=Less than monthly, 2=One to three times a month,
400 3=One to three times a week, 4=At least four times a week, ⁴0=Never, 2=Yes, but not in the past
401 year, 4=Yes, during the past year.

402

403

404 Supplementary Table 2. Item endorsement of the AUDIT items in the total sample, and among
405 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%)

406 Note. Analysis was performed in a weighted sample (N=989). ¹Category of low-risk drinking: total
407 AUDIT score between 0-7 points; ²Category of hazardous alcohol use: total AUDIT score between
408 8-15 points; ³Category of harmful alcohol use: total AUDIT score between 16-19 points; ⁴Category
409 of possible dependence: at least 20 points on the total AUDIT scale

410

411 Supplementary Table 3. Odds ratios (95% Confidence Intervals) of the association between
412 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]

413 Note. Crude Odds ratios presented by bold figures are significant at least $p < 0.05$ level. ¹Gender:
414 0=Female, 1=Male; ²Level of education: 0=Participant had a graduation at vocational or high-

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

418

419 Supplementary Table 4. Association between the identified latent classes and the AUDIT-based
 420 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%)

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

427

428 Supplementary Table 5. Association between the identified latent classes and lifetime history of
 429 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%)
	No N=880 (93.4%)	645 (95.0%)	168 (93.3%)
Crude OR [95% CI]*		<i>Ref.</i>	1.36 [0.69–2.67]
			4.53 [2.38–8.64]

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

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

434

435 Supplementary Table 6. Association between the identified latent classes and lifetime history of
 436 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]*		<i>Ref.</i>	9.20 [2.35 – 35.94]	31.64 [8.51 – 117.65]

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

441

442

443 **8. Statements**

444 **8.1. Statement of Ethics**

445 Authors declare that all procedures followed the ethical standards of the Declarations of Helsinki.
446 Informed consent was obtained from all the participants for being included in the study. The study
447 protocol has been approved by the relevant Research and Ethical Committee.

448

449 **8.2. Disclosure Statement**

450 The authors have no conflicts of interest to declare.

451

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457

458 **8.4. Author Contributions**

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

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557

558 **10. Figure Legends**

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