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A Latent Class Analysis of Age at Substance Use Initiation in Young Adults and its Association with Mental Health

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Abstract

This study aims to identify empirically-driven classes of age-of-onset across multiple substances (alcohol, tobacco, cannabis) and to characterize the different classes in relation to mental health and substance use severity. The sample comprised 1,051 young adults (aged 18–25; 61.9% women), recruited from universities and vocational schools in Spain, who reported lifetime alcohol, tobacco and cannabis use. Participants were asked to complete questionnaires about demographics, substance use and mental health. A latent class analysis (LCA) was conducted using the age of onset of alcohol, tobacco, and cannabis use as an indicator. Three distinct classes were identified: C1 (45%), characterized by early alcohol and late cannabis and tobacco use; C2 (49.1%) presenting early alcohol, cannabis and tobacco use; and C3 (5.9%) showing late alcohol, cannabis, and tobacco use. Classes 1 and 2 exhibited the poorest psychosocial functioning, and Class 2 showed the highest levels of impulsivity traits. There were within-class sex differences, which suggested poorer mental health in females. The findings support the idea that early-onset use of the three substances is common and that this pattern is associated with increased involvement in substance use and poor mental health.

Keyword Age of onset · Alcohol · Tobacco · Cannabis · Polysubstance use · Mental health

Introduction

Adolescence (10–19 years) and young adulthood (18–25 years) are critical periods of substantial cognitive, emotional, and physical changes, but also exposure to health-risk factors, such as substance use, that can influence the path of an individual's development and mental health (Cicchetti, 2022; Bonnie et al., 2015).

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Alcohol, cannabis, and tobacco are the most commonly used substances among young adults worldwide, including Spain, and represent a continued public health issue. The most recent national general population survey of young adults in Spain found that 79% reported using alcohol, 49.5% reported using tobacco (cigarettes), and 12.6% reported using cannabis within the past year (Spanish Observatory on Drugs and Addictions [OEDA], 2023). Age at first substance use is falling. The mean age at the first use of alcohol and tobacco is 14 and the mean age of first cannabis use is 15 (OEDA, 2022). Almost three-quarters (71%) of individuals aged 18–30 started drinking alcohol before the age of 17, while 62% started smoking tobacco and 42% started smoking cannabis at a younger age. Furthermore, the three substances are often used in combination. A third (33%) of young adults in Spain report polysubstance use (2 or more substances in the last month) and among them, the prevalence of alcohol, tobacco and cannabis use is 98%, 97.5% and 61.4% respectively (OEDA, 2023).

The early age of onset of using a specific substance is a well-documented risk factor for numerous poor psychological and social consequences, including risk for heavier substance use and substance use disorders (SUD). For instance, early onset of alcohol use is associated with increased risk for future substance-related problems, including alcohol use disorders (AOD), more externalizing and externalizing symptoms, academic difficulties, and employment problems in early adulthood (Behrendt et al., 2012; DeWit et al., 2000; Grant et al., 2001; Jun et al., 2015; May et al., 2021; Montemayor et al., 2022; Trenz et al., 2012). Early onset of tobacco use is associated with persistent cigarette smoking and dependence, school-dropout, attention-deficit/hyperactivity disorder and other psychiatric morbidities, respiratory and cardiovascular health effects, and suicidal behaviours (Behrendt et al., 2012; Kendler et al., 2013; May et al., 2021; McCabe et al., 2018; Milberger et al., 1997; Millar et al., 2021; Upadhyaya et al., 2002). Finally, early-onset cannabis use is related to an increased risk for psychosis, school-dropout, unemployment and socio-occupational difficulties, cannabis use disorders, other substance use disorders (SUD), and faster transition to SUD (Grant et al., 2010; Han et al., 2017, 2019; Hasin, 2018; Millar et al., 2021; Moss et al., 2014; Pocuca et al., 2023; Shephard et al., 2023; Sherman et al., 2021; Stefanis et al., 2004).

Despite significant contributions from previous studies, important questions remain regarding the patterns of substance use initiation. In particular, research on the specific patterns of the age of onset across multiple substances among individuals who co-use multiple substances is scarce, as much of the literature focuses solely on use of a single substance or analyses the effects of age of onset on each substance separately (i.e., Lin et al., 2016; Pocuca et al., 2023; Richmond-Rakerd et al., 2017; Strunin et al., 2017) or all substances together (i.e., Crouse et al., 2019). These studies preclude formal examination of the similarities and differences in terms of age of initiation across substances and whether these patterns of early exposure are linked to adverse psychosocial outcomes. Understanding whether unique types of age-initiation in poly-substance users—a common, normative pattern (Moss et al., 2014)—are differentially related to mental health may provide valuable information for developing empirically based interventions to reduce initiation of substance use.

Use of statistical techniques, such as latent class analysis (LCA), has helped identify common patterns or classes of age of substance use initiation in individuals who use multiple substances that may be at greater risk of other psychosocial symptoms. To the best of our knowledge, only a single study has used LCA to identify distinct classes regarding age of initiation among poly-users (Stamates et al., 2022). This study identified four age-of-

onset profiles that may signify risky patterns of substance use. Despite being valuable, the results from this study are limited as it used a voluntary sample recruited through an online platform (Craigslist) that may have been susceptible to bias, and in fact included unbalanced groups—since 89% of participants were men—limiting its generalizability to general populations. Additionally, that study did not use validated measures to assess substance use severity or impulsivity, an important contributor to various substance use outcomes, including onset of substance use at early ages (Kollins, 2003).

It is not clear whether there are sex differences in relation to the risk of onset of alcohol, tobacco, and cannabis use. Some evidence suggests sex differences in age of substance use initiation or in the effects of early substance use (Buu et al., 2014; Jun et al., 2015; Stueve & O'Donnell, 2005; Tomek et al., 2019). For example, in a previous study with young people in Spain, early use of tobacco and alcohol increased the likelihood of subsequent heavy and regular use of these substances, of using other illegal drugs, and of experiencing several psychosocial consequences—including fighting, family conflict, use of emergency medical services, and school-related problems. However, these effects were somewhat different for male and female participants, with a trend showing that early alcohol use was a stronger risk factor for the young men, whereas early tobacco use was a more powerful risk factor for the young women (Fernández-Artamendi et al., 2013). Despite that, other studies have reported contrasting findings or even absence of moderation by sex (May et al., 2021; Strunin et al., 2017; Thorner et al., 2007). Understanding how sex can interact with age of onset and patterns of substance use may help us design more tailored and effective prevention and treatment programs.

We sought to build on prior work by drawing on data from a large study of the young adult population in Spain. The main goals of this study were: (1) to identify distinct latent classes of the age of onset (early ≤ 16 years old vs. late > 16 years-old) across multiple substances (tobacco, alcohol and cannabis) among individuals with lifetime tobacco, alcohol and cannabis use; (2) to characterize the latent classes in terms of socio-demographics, mental health and substance use variables; and (3) to analyse the potential moderating effects of sex on the significant tested relationships.

Method

Participants and Procedure

The data came from a longitudinal prospective study of 2,980 young Spanish adults carried out in three Spanish regions (Asturias, Aragón, and the Balearic Islands). Participants were invited to participate in a total of three in-person or online assessments (T1: took place during September-November 2021; T2: March-May 2022; T3: September-November 2022). This study examined data from the sub-sample of 1,051 individuals who reported lifetime tobacco, alcohol, and cannabis (hashish and/or marijuana) use in the first assessment (September-November 2021). *A priori* power analysis was conducted to determine the power of the sample to detect group differences using a one-way ANOVA and an alpha of 0.05. The results showed that to achieve a power of 0.95, a minimum of 252 participants was required using a medium effect size ($d = 0.25$) and a sample of 102 participants using a large effect size ($d = 0.40$).

Respondents were recruited by print (flyers and posters) and mass media advertising (radio, tv, Instagram and Twitter). In addition, to collecting the data, evaluators presented the project to several classes. Participants completed the survey in-person and online. Raffle tickets for a €100 voucher were given to participants to encourage participation. Eligibility criteria for this study were: (1) being aged between 18 and 25 years old, and (2) having reported lifetime polysubstance use (i.e., tobacco, cannabis, and alcohol). Overall, 2,980 participants were initially recruited and completed the assessment battery. Based on the eligibility criteria, a total of 121 were discarded due to being aged 26 or over. An additional 1,711 were discarded because they reported no lifetime polysubstance use, 22 failed attentional control checks (see subsection 2.3), and 75 were duplicate cases. This left a total sample of 1,051 young adults.

The study protocol assessment and procedures were approved by the Ethics Review Committee of the University of the Balearic Islands (#191CER21). All participants gave their written informed consent before the study began.

Assessment Measures

The assessments lasted approximately 45 min and were conducted either online or in-person using participants' own devices or tablets from the research project (Lenovo® Tab M7). The assessment battery comprised sociodemographic measures (i.e., sex, age, and weekly discretionary income—meaning money earned by themselves or received from parents or other relatives), self-reported substance use measures and mental health measures.

Substance Use

Substance use measures included self-reported (yes/no) past-year and past-month use of alcohol, tobacco, and cannabis. Those reporting past-year substance use reported frequency of use during the previous twelve months using the following response categories: 1–11 times during the last year, 1–3 times during the last month, ≥1–3 times per week. Past-month occasions of heavy drinking and drunkenness were assessed using the Daily Drinking Questionnaire (DDQ; Collins et al., 1985). In this scale, an occasion of heavy drinking was defined as 4 drinks for women and ≥5 drinks for men at a single time. The scale had adequate internal consistency ($\alpha=0.60$) in the present sample.

Severity of substance use and problems were assessed using validated measures, including the Spanish version of the Cannabis Use Identification Test-revised (CUDIT-R; Adamson et al., 2010; Mezquita et al., 2022), the 24-item version of the Brief Young Adult Alcohol Consequences Questionnaire (B-YAACQ; Kahler et al., 2005; Espejo-Tort, 2020), and the Heaviness of Smoking Index (HIS; Borland et al., 2010). The CUDIT-R measures hazardous cannabis use and a threshold of 8 is used as an indicator of potentially hazardous use (Adamson et al., 2010; Mezquita et al., 2022). In the present sample this scale demonstrated good reliability ($\alpha=0.82$). The B-YAACQ evaluates a unidimensional construct of alcohol problem severity. In the current study, we used a timeframe of the previous six months. Its items refer to several consequences of drinking alcohol, which can be placed within an alcohol problem severity continuum, varying from signs of excessive drinking to symptoms of alcohol abuse and dependence. A total B-YAACQ score can be produced by adding the item scores together, which ranges from 0 to 24. Although there is no established cutoff

score at which individuals are considered to have problems with alcohol, some studies suggest individuals with a score of 10 present potentially important psychosocial consequences, whereas a score of 15 or more indicates that there may be alcohol abuse and dependence (Kahler et al., 2005). This scale has shown adequate internal consistency ($\alpha=0.80$), construct, criterion, and discriminant validity with a sample of university students (Tort, 2020). The B-YAACQ has shown good internal consistency ($\alpha=0.81$) in the present sample. The HSI is a two-item self-reported measure that includes two items from the Fagerström Test Questionnaire (Heatherton et al., 1991): time to first cigarette in the morning and number of cigarettes smoked per day. A HSI cut-off ≥4 indicates high nicotine dependence (Diaz et al., 2005). The measure has yielded adequate reliability (Borland et al., 2010). In the present sample the internal consistency was low ($\alpha=0.27$), probably due to the relatively low prevalence of monthly tobacco use and intensity of smoking.

Mental Health

Symptoms of stress, anxiety, and depression were assessed via the short form of the Depression, Anxiety and Stress Scale (DASS-21; Lovibond & Lovibond, 1995). A total of 21 items scored from 0 (did not apply to me at all) to 3 (applied to me very much or most of the time) measured participants' symptomatology over the previous week. The DASS-21 yields three subscales (depression, anxiety, and stress). The α coefficients for this measure in this sample were 0.89 for the depression subscale, 0.83 for the anxiety subscale and 0.80 for the stress subscale.

Impulsivity

Impulsivity was evaluated using the short version of the Impulsive Behavior Scale (UPPS-P; Cándido et al., 2012; Whiteside & Lynam, 2001). The Short Version of the UPPS-P has 20 items which assess five domains of impulsivity: lack of premeditation (LPREM), lack of perseverance (LPERS), sensation seeking (SS), negative (NU) and positive urgency (PU). Participants respond to the items on a 4-point Likert scale ranging from 0 (strongly agree) to 4 (strongly disagree). Higher scores in each subscale are representative of higher levels of impulsivity. In this sample, the reliability was 0.70 for the LPREM domain, 0.77 for the LPERS domain, 0.80 for the SS domain, 0.76 for the NU domain and 0.66 for the PU domain.

Data Analysis

The first step of data processing consisted of evaluating the attentional control checks. We implemented four attentional control items randomly within the assessment battery (e.g., For this question choose "sometimes"). The items had four response options (i.e., hardly ever, sometimes, half of the time, most of the time, almost always) used to detect lack of effort and understanding of the task. Participants were required to answer at least two out of four correctly. Based on this criterion we excluded 22 out of 1,073 participants, leaving a total sample of 1,051 participants who reported lifetime polysubstance use for the analyses that follow.

Descriptive statistics (mean, median, minimum, and maximum) were computed to inspect abnormal data values. No missing data were seen. Subsequently, we performed a LCA in SAS® to identify empirically driven classes of lifetime polysubstance users (alcohol, tobacco, cannabis), using age at substance use initiation as an indicator. Following prior studies, this variable was dichotomized as follows: 1=early substance use onset (≤16 years) and 2=late substance use onset (>16 years) (Poudel & Gautam, 2017; Clark et al., 1998; Pope et al., 2003). The PROC LCA package, as implemented in SAS, was used to identify empirically driven latent classes. PROC LCA uses the (expectation-maximization) algorithm to produce maximum likelihood estimates of all model parameters. Following existing guidelines (Lanza et al., 2007), we fit a total of four models with two, three, four, and five classes. Model selection was based on statistics (i.e., model fitting and statistically significant differences in the grouping variable at $p<.005$) and theoretical interpretation (sizable sample size [>5%], and labelling of classes) (Lanza et al., 2007). The model's statistical fit was tested using the Likelihood-ratio G^2 statistic (Dempster et al., 1977), Akaike's Information Criterion (AIC; Akaike, 1974), the Bayesian Information Criterion (BIC: Schwarz, 1978), the adjusted-Bayesian Information Criterion (SABIC) (Weller et al., 2020), and entropy (Sinha et al., 2021). Smaller values of AIC, BIC, and SABIC are preferable, whereas entropy values closer to 1 indicate optimal model fit (Weller et al., 2020). For the final LCA solution, we calculated latent class prevalences (i.e., percentage of the sample in each of the observed classes) and item-response probabilities (i.e., probability of reporting early and late initiation of alcohol, tobacco, and cannabis). The empirically driven latent classes were compared in terms of socio-demographics (i.e., sex, age, and weekly discretionary income), past-month substance use (alcohol, tobacco, and cannabis), substance use severity (nicotine dependence and hazardous cannabis use) and problems (alcohol), mental health (stress, anxiety, and depression), and impulsivity traits (LPREM, LPERS, SS, NU, and PU). The Gabriel pairwise comparison was used as it has good power and tight control of Type I error and is recommended in the event of differences in sample sizes (Field, 2013).

Lastly, we conducted a set of moderation analyses to look at the moderating effect of sex (W) on the significant relationships observed between class membership (Independent variable; X), substance use problems (Dependent Variable; Y) and psychological variables (Y). To do this, we dichotomized class membership, using "Class 2" (early onset on all substances) as a reference category. Model 1 was used in the PROCESS macro implemented in SPSS®. We used 5,000 resampled data points using bootstrap and 95% CI.

Results

LCA of Young Adults According to Early vs. late Substance Use Initiation

Table 1 shows each of the LCA models tested. The model fit statistics indicated that the two- and three-class models had the lowest AIC and SABIC, and the highest entropy values. Ultimately we retained the 3-class solution [N_{C1} = 473/1,051; N_{C2} = 516/1,051; N_{C3} = 62/1,051], with the highest entropy values and 100% of seeds. Selecting the model with higher entropy values ensures classes are well separated, meaning distinct, empirically observed subgroups are identified (Sinha et al., 2021).

Table 1 Fitting for the models tested

#Class	[a]LL	[b]AIC	[C]SABIC	Entropy
2	-1442.65	14	26.47	0.71
3	-1442.65	22	41.59	0.72
4	-1442.65	30	56.72	0.75
5	-1442.65	38	71.85	0.44

Note[a] LL=Log-likelihood; [b]AIC = Akaike's Information Criteria; [c]SABIC = The sample-adjusted Bayesian Information Criterion

Table 2 Item response probabilities by latent class membership

Observed variable	Class		
	I	II	III
	[a]Ip (%)	[a]Ip %	[a]Ip %
Age at alcohol use initiation			
Response category (1=onset ≤16)	**98.83**	**97.94**	20.2
Response category (2= onset>16)	1.17	2.06	**79.8**
Age at tobacco use initiation			
Response category (1=onset≤16)	38.59	**98.87**	25.33
Response category (2=onset>16)	**61.41**	1.13	**74.67**
Age at cannabis use initiation			
Response category (1=onset≤16)	11.32	**85.85**	3.72
Response category (2=onset>16)	**88.68**	14.15	**96.28**

Note[a]Ip = item-probabilities. Ip higher than 50% are highlighted for ease of interpretation

Table 2 shows the probability of item responses in each of the latent classes. The three classes differed in terms of age at substance use initiation. Class 1 was associated with a high probability (range 61.41–98.83) of alcohol use initiation at an early age [M (SD)=14.84 (1.10)] and a later age for initiation of tobacco [M (SD)=16.59 (1.49)] and cannabis use [M (SD)=17.63 (1.17)]. Class 2 was more likely to exhibit early initiation of alcohol [M (SD)=13.94 (1.29)], tobacco [M (SD)=15.18 (0.96)], and cannabis use [M (SD)=15.18 (0.96)], whereas Class 3 was characterized by late initiation of alcohol [M (SD)=17.44 (0.617)], tobacco [M (SD)=17.42 (2.04)], and cannabis use [M (SD)=18.34 (1.53)].

Characterization of Latent Classes

Table 3 presents socio-demographic, substance use, and mental health characteristics by class membership. Supplementary Table 1 shows differences by sex within each class.

Sociodemographic and Substance Use Variables

Women were represented at similarly high proportions in both Class 1 (61.9%) and Class 2 (64%), but slightly lower in Class 3 (45.2%) (p=.016). Members of Class 3 [M (SD)=20.68 (1.80)] were older than those in Class 1[M (SD)=19.88 (1.80)] or 2 [M (SD)=19.64 (1.79)]. All classes included a higher percentage of university students than vocational training students, with a higher proportion of the former in Class 1 (93%) than in Classes 2 (87.6%) or 3 (83.9%).

Regarding substance use, higher past-month alcohol and tobacco use were found in Class 1 (alcohol: 75.1%, tobacco: 50.5%) and Class 2 (alcohol: 73.3%, tobacco: 60.9%) than in

Table 3 Characteristics of the different classes

	Class			F, χ^2	P	Effect size
	I	II	III			
Socio-demographics						
Female sex (%, n)	61.9 (293)	64 (330)	45.2 (28)	8.29	**.016**	.089
Age [a]M ([b]SD)	19.88 (1.80)	19.64 (1.79)	20.68 (1.80)	9.83	**.001**	.018
Education level (%, n) University Vocational training	93 (440) 7 (33)	87.6 (452) 12.4 (64)	83.9 (52) 16.1 (10)	10.49	**.005**	.100
Working situation (%, n)				4.41	.353	.046
Student	78.2 (370)	78.1 (403)	77.4 (48)			
Part-time	19.5 (92)	20.9 (108)	22.6 (14)			
Full-time	2.3 (11)	1 (5)	0 (0)			
Substance use variables						
Alcohol						
Past-month alcohol use (% yes, n)	75.1 (355)	73.3 (378)	59.7 (37)	6.61	**.037**	.079
Frequency of alcohol use (%, n) 1–11 times per year 1–3 times per month 1–3 or more times per week	22.5 (105) 28.1 (131) 49.4 (230)	24.0 (121) 20.8 (105) 55.2 (279)	35 (21) 36.7 (22) 28.3 (17)	20.16	**<.001**	.099
[c]B-YAACQ: [a]M ([b]SD)	5.47 (4.74)	6.11 (5.32)	3.87 (4.31)	6.35	**.002**	.012
Heavy drinking occasions (past-month): [a]M ([b]SD)	1.21 (2.19)	1.55 (2.72)	.77 (1.63)	4.30	**.014**	.008
[d]DDQ: [a]M ([b]SD)	6.56 (7.05)	8.05 (10.28)	4.00 (5.13)	7.939	**<.001**	.015
Episodes of drunkenness in the last month	1.18 (2.06)	1.48 (2.53)	.71 (1.26)	4.317	**.014**	.008
Cannabis						
Past-month cannabis use (% yes, n)	24.5 (116)	32.8 (169)	25.8 (16)	8.43	**.015**	.090
Frequency of cannabis use (%, n)				33.07	**<.001**	.161
1–11 times per year	82.3 (241)	61.9 (190)	80 (28)			
1–3 times per month	8.5 (25)	16 (49)	5.7 (2)			
1–3 or more times per week	9.2 (27)	22.1 (68)	14.3 (5)			
[e]CUDIT-R: [a]M ([b]SD)	1.38 (3.37)	2.70 (5.31)	1.67 (4.60)	10.80	**<.001**	.020
Tobacco						
Past-month tobacco use (% yes, n)	50.5 (239)	60.9 (314)	27.4 (17)	29.68	**<.001**	.168
Frequency of tobacco use (%, n) 1–11 times per year 1–3 times per month 1–3 or more times per week	43.7 (139) 11 (35) 45.3 (144)	25.2 (92) 10.7 (39) 64.1 (234)	70 (21) 13.3 (4) 16.7 (5)	46.50	**<.001**	.181
[f]HSI: [a]M ([b]SD)	0.31 (0.82)	0.42 (0.89)	0.11 (0.51)	4.83	**.008**	.009
Mental health ([g]DASS)						
Anxiety	11.52 (9.32)	12.60 (9.39)	9.22 (9.22)	4.36	**.013**	.008
Stress	16.14 (8.8)	16.82 (8.67)	13.25 (8.01)	4.80	**.008**	.009
Depression	14.57 (11.16)	14.43 (10.06)	13.45 (10.96)	.30	.736	.001
Impulsivity ([h]UPPS)						
[i]NU	2.42 (.74)	2.53 (.73)	2.29 (.79)	4.38	**.013**	.008
[j]PU	2.58 (.62)	2.64 (.60)	2.51 (.62)	1.94	.143	.004

Table 3 (continued)

	Class			F, χ^2	P	Effect size
	I	II	III			
[k]SS	2.72 (.70)	2.74 (.70)	2.63 (.74)	.65	.521	.001
[l]LPREM	1.89 (.57)	1.99 (.58)	1.71 (.57)	8.19	**<.001**	.015
[m]LPERS	1.90 (.64)	2.04 (.63)	1.85 (.62)	7.41	**<.001**	.014

Note Statistically significant differences at $p<.05$ between groups are note in bold. [a]M = mean; [b]SD = standard deviation. [c]B-YAACQ=Brief Young Adult Alcohol Consequences Questionnaire; [d]DDQ = The daily Drinking Questionnaire; [e]CUDIT-R=Cannabis Use Identification Test-revised; [f]HSI = Heaviness of Smoking Index; [g]DASS = Depression, Anxiety and Stress Scale; [h]UPPS= Impulsive Behavior Scale; [i]NU = Negative Urgency; [j]PU = Positive Urgency; [k]SS = Sensation Seeking; [l]LPREM = Lack of Premeditation; [m]LPERS = Lack of Perseverance

Class 3 (alcohol: 59.7%, tobacco: 27.4%). Past-month cannabis use was statistically significantly higher in Class 2 (32.8%) than in Class 1 (24.5%), but there were no significant differences between those two classes and Class 3 (25.8%). It is worth noting that in Class 1, the proportion of male cannabis users (50.9%) was higher than female users (49.1%), whereas in Class 2, the proportion of female users was higher (56.2%) than male users (43.8%).

There were also differences in the frequency of monthly alcohol consumption. Monthly alcohol use was higher in Classes 1 and 3 than in Class 2 (28.1%, 36.7% vs. 20.8%). Weekly alcohol use was higher in Classes 1 and 2 than in Class 3 (49.4%, 55.2% vs. 28.3%). Severity of alcohol-related problems was higher in Class 2 than in Classes 1 and 3 [M $(SD)=6.11(5.32)$; M $(SD)=5.47$ (4.74); M $(SD)=3.87$ (4.31)]. Classes 1 and 2 showed the highest number of occasions of past-month heavy drinking, with significant differences between Class 2 [M $(SD)=1.55(2.72)$] and Class 3 [M $(SD)=0.77(1.63)$].

Frequency of cannabis use differed significantly between Classes 2 and 1, Class 2 reported higher monthly use (16% vs. 8.5%) and higher weekly use (22.1% vs. 9.2%). Hazardous cannabis use was higher in Class 2 [M $(SD)=2.70$ (5.31)] than Class 1 [M $(SD)=1.38$ (3.37)]. There were also sex differences within Class 1, with higher hazardous cannabis use in males [M $(SD)=2.03$ (3.87)] than females [M $(SD)=0.98$ (2.95)]. The three classes differed significantly in terms of weekly tobacco use, with Class 2 (64.1%) reporting higher use than Classes 1 (45.3%) or 3 (16.7%).

Frequency of weekly tobacco use was higher in Classes 2 (64.1%) and 1 (45.3%), than in Class 3 (16.7%). Class 2 showed higher nicotine dependence [M $(SD)=0.42$ (0.89)] than Class 3 [M $(SD)=0.11(0.51)$].

Psychological Variables

There were statistically significant differences between classes in anxiety and stress. Post-hoc comparisons showed that Class 2 [M $(SD)=12.60$ (9.39)] reported higher anxiety than Class 3 [M $(SD)=9.22$ (9.22)]. Class 2 [M $(SD)=16.82$ (8.67)] showed higher stress symptoms than Classes 1 [M $(SD)=16.14$ (8.8)] and 3 [M $(SD)=13.25$ (8.01)]. There were within class differences in terms of sex, with females in Class 1 and 2 showing higher depression, anxiety, and stress than their male counterparts. Anxiety was also higher in females than males in Class 3 (see Supplementary Table 1).

There were also differences in impulsivity traits between classes. Class 2 [M (SD)=2.53 (0.73)] reported higher NU than Class 3 [M (SD)=2.29 (0.79)]. Furthermore, the three classes differed between each other in LPREM [Class1: M (SD)=1.89 (0.57); Class2: M (SD)=1.99 (0.58); Class3: M (SD)=1.71 (0.57)] and LPERS [Class1: M (SD)=1.90 (0.64); Class2: M (SD)=2.04 (0.63); Class3: M (SD)=1.85 (0.62)], with Class 2 showing the highest levels of both impulsivity traits. Within class differences in terms of sex emerged in Class 2 (with males exhibiting higher SS than females, and females scoring higher than males in NU and PU). In Class 1, there were differences in NU (higher in females) and SS (higher in males).

Moderating Effects of Sex in the Relationship Between Class Membership, Substance Use and Psychological Variables

Table 4 shows the results of the models testing sex as a moderator in the relationship between class membership, hazardous cannabis use, nicotine dependence, alcohol problems, and psychological (i.e., anxiety and stress) and impulsivity (i.e., NU, LPREM, LPERS) variables. No significant effects were observed, meaning sex was not an effective moderator of the relationships observed.

Table 4 Results of the moderation models

Model path	b	SE	t	p	95% CI (Lower)	95% CI (Upper)
Model 1. Class 2 versus 1 membership (X) x Sex (W)◊ [a]B-YAACQ (Y)	.32	.59	.54	.59	−.84	1.48
Model 2. Class 2 versus 3 membership (X) x Sex (W)◊ [a]B-YAACQ (Y)	-1.89	1.42	-1.34	.18	-4.67	.89
Model 3. Class 2 versus 1 (X) x Sex (W) [b]HSI (Y)	.05	.11	.45	.65	−.17	.27
Model 4. Class 2 versus 3 (X) x Sex (W) [b]HSI (Y)	.12	.23	.56	.60	−.34	.58
Model 5. Class 2 versus 1 (X) x Sex (W) Anxiety (Y)	1.27	1.18	1.07	.28	-1.05	3.58
Model 6. Class 2 versus 3 (X) x Sex (W) Anxiety (Y)	-1.58	2.42	−.66	.51	-6.33	3.17
Model 7. Class 2 versus 1 (X) x Sex (W) Stress (Y)	.52	1.10	.48	.63	-1.63	2.68
Model 8. Class 2 versus 3 (X) x Sex (W) Stress (Y)	-1.77	2.22	−.80	.43	-6.13	2.60
Model 9. Class 2 versus 1 (X) x Sex (W) [c]NU (Y)	.09	.10	.88	.38	−.10	.28
Model 10. Class 2 versus 3 (X) x Sex (W) [c]NU (Y)	−.19	.20	−.95	.34	−.58	.20
Model 11. Class 2 versus 1 (X) x Sex (W) [d]LPREM (Y)	.11	.08	1.51	.13	−.03	.26
Model 12. Class 2 versus 3 (X) x Sex (W) [d]LPREM (Y)	−.18	.16	-1.16	.25	−.49	.13
Model 13. Class 2 versus 1 (X) x Sex (W) [e]LPERS (Y)	.10	.08	1.17	.24	−.07	.26
Model 14. Class 2 versus 3 (X) x Sex (W) [e]LPERS (Y)	−.05	.17	−.29	.78	−.39	.29

Note X=Independent variable; W=Moderator; Y=Dependent variable. [a]B-YAACQ=Brief Young Adult Alcohol Consequences Questionnaire; [b]HSI = Heaviness of Smoking index; [c]NU = Negative Urgency; [d]LPREM = Lack of Premeditation; [e]LPERS = Lack of Perseverance

Discussion

The present study used LCA to identify distinct groups of lifetime tobacco, alcohol, and cannabis users, using the age at which substance use began. We found support for a three-cluster solution of substance use initiation: Class 1 (45%) characterized by early initiation of alcohol use and late initiation of cannabis and tobacco use; class 2 (49.1%) characterized by early initiation of alcohol, cannabis, and tobacco use; and class 3 (5.9%) presented late alcohol, cannabis, and tobacco use. Women were overrepresented across classes, and no significant sex differences emerged between Class 1 and Class 2, although it did for Class 3, where male representation was higher than female representation. Classes 1 and 2 displayed the poorest psychosocial functioning, with Class 2 exhibiting the highest levels of impulsivity traits, including NU, LPREM, and LPERS. There was no evidence of variations in the tested relationships by sex, as this variable was not effective as a mediator.

The study findings revealed different pathways of early-starting substance use. Unlike a previous study by Stamates et al. (2022), we found three, rather than four, distinct classess presenting different ages for substance use initiation. However, the cited study grouped the classes according to the order of onset of substance use and not by age of onset (early vs. late).

A large proportion (almost 50%) of lifetime alcohol, tobacco and cannabis users started using all three substances before the age of 17, and 45% of the participants started using alcohol before the age of 17 and tobacco and cannabis once they were over 17. In contrast, the class of young adults with late-starting alcohol, cannabis, and tobacco use represented less than 6%. Data support the observation that late-onset substance experimentation of the three substances is rare and adds to the body of literature by clearly showing a temporal association between a single early substance use and an increased likelihood of other subsequent psychoactive substances. The high early-onset use of the three substances is consistent with the high prevalence of polysubstance use among young Spanish adults (OEDA, 2022) and the fact that most predictors of initiation are common across substances (Dodge et al., 2009). All three of the substances share high social acceptability and high availability, despite the illegal status of cannabis in Spain. Among the young Spanish population, there is a very low perceived risk for cannabis use (47.8% of them believe that occasional cannabis use has few or no health risks), and they also perceive ready accessibility to cannabis, as 61% believe that they could obtain cannabis easily or very easily (OEDA, 2022). Substance users are exposed to a social context that fosters both favorable attitudes to using all three substances and their availability, since both distribution channels and the places where the three substances are used frequently overlap (Mayet et al.,2016). In Spain, 23% of people between 14 and 18 years old—of both sexes—have a weekly habit of going out at night (OEDA, 2022), where peer influence means that any single substance use increases other opportunities for substance use. Both the frequency of nights out and time at which people return home are positively related to the prevalence of substance use, the intensity of substance use (i.e., binge drinking) and the probability of polydrug use (OEDA, 2022). In addition to environmental factors, cue-conditioned cross-reactivity (Roche et al., 2019) and the enhanced additive and synergistic effects (Berg et al., 2018) might explain early onset use of alcohol, tobacco, and cannabis and subsequent concurrent use. Neurobiological research has also suggested that alcohol, tobacco and other substances seem to apply to the same

neurotransmitters in the brain, proposing a chain of causation between the use of alcohol and cigarettes and subsequent use of cannabis and other drugs (Kandel & Kandel, 2014).

An interesting finding from this study is that no significant sex differences emerged between Class 1 and Class 2, but did for Class 3, where male representation was higher than female representation. Although contrary to several studies, this finding is consistent with recent epidemiologic surveys suggesting the gap between men and women has narrowed over time, including the age of substance use initiation (Cheng & Anthony, 2018; Grucza et al., 2008; Keyes et al., 2019; Moss et al., 2014). These changes in the patterns of age at onset of substance use may be attributable to changes in moral, cultural and social norms with regard to women's substance use, particularly among young people (i.e., reduced stigma toward female drinking and heavy drinking). Thus, as availability and favorable social norms increase, substance use may be expected to increase and sex differences may be expected to narrow (Ter Bogt et al., 2006).

In line with results from other studies (Moss et al., 2014; Pang et al., 2014; Hayatbakhsh et al., 2007; Fergusson et al., 1994), early-onset substance use was positively associated with increased involvement in substance use and poor mental health consequences in young adulthood, and this was particularly true for Class 2, characterized by early alcohol, cannabis, and tobacco use. In addition, our analyses indicated worse outcomes in terms of cannabis use involvement, mental health, and impulsivity for females vs. males in Class 2. It is possible that the early use of the three substances in Class 2 reflects their additive effect via several complementary pathways, involving biochemical and environmental factors. Exposure to various substances during early/mid-adolescence may affect social behavior, reward sensitivity, and affective measures that rely particularly strongly on subcortical limbic areas and that may be sensitive to pubertal timing (Spear, 2015). The earlier substance use is, the earlier sensitivity towards subsequent drug use may increase through changes in neurobiological processes that influence the transition to substance abuse and dependence (Weissman et al., 2015). Furthermore, early access and exposure to several drugs may increase the risk of a range of family and individual issues (educational failure, school dropout, loss of job, or involvement in crime) (Fergusson et al., 2008) and may lead to joining deviant and substance-using peer groups, which in turn increases the risk of escalating substance use and other mental health problems (Van Ryzin & Dishion, 2014; Hayatbakhsh et al., 2007). However, the interactions between substance use and mental health are complex and the causal direction is unclear. Future research investigating the sequence of events is necessary to draw any conclusions about causation.

On a related note, Class 2 (early-onset for all three substances) showed the highest levels of impulsivity, particularly higher NU, LPREM, and LPERS. The current findings highlight the complex interplay between impulsivity and substance use. All the above impulsivity traits have been linked to early substance use initiation (Rømer Thomsen et al., 2018). NU particularly confers risk for individuals suffering from emotional distress, including anxiety symptomatology, and makes them more likely to engage in early substance use to cope with or escape from negative emotions (Smith & Cyders, 2016; Wolitzky-Taylor et al., 2016). Additionally, high LPREM and LPERS enhances sensation-seeking and increases individuals' vulnerability to seeking immediate reward (i.e., using drugs) without considering the consequences that stem from substance use (McCabe et al., 2015; Vergés et al., 2019). This is particularly true for adolescents and young adults, and it is arguable that both confer risks of initiating substance use at an early age (Shin et al., 2013; Bos et al., 2019).

Overall, our findings point to an at-risk group warranting targeted prevention interventions—the early users of multiple substances, who appear to have a greater diversity of drug involvement and mental health problems by young adulthood than early users of single substances or late users. Prevention programs that emphasize delayed use of an individual drug (alcohol, tobacco, or cannabis) could therefore yield improved outcomes by having a broader focus across multiple substances. Enhanced prevention efforts to delay use would appear warranted, using measures to restrict access, increase both community and parental awareness of the hazards of early initiation (Spear, 2015). Of course, delaying the age of initiation of substance use must be considered within a broader range of sensible target intervention, including considering a range of adverse personal, environmental and social factors that are potentially important in the risk of mental health and substance use disorders in adulthood (Newton-Howes & Boden, 2016; Aiken et al., 2018).

The results of this study should be interpreted within the context of the following limitations common to most large-scale surveys. First, the cross-sectional nature of the study limits any causal inference. Second, the sample was recruited from universities and vocational schools, which is likely not generalizable to young adults not at university. On a related note, given the purpose of the study (collecting epidemiological data on substance use and related risks factors), we did not measure diagnoses of either substance use disorders or other clinical conditions, and the results cannot be representative of clinical samples. Furthermore, we focused on lifetime users of alcohol, tobacco and cannabis. Although this may be representative of the young adult population, our findings may not generalize to individuals who do not to meet this eligibility criterion. In addition, the data were self-reported, and so subject to potential inaccuracies, recall and reporting bias. However, self-reported data can accurately reflect a respondent's true behaviours when settings and conditions are designed to maximize response accuracy (e.g., anonymity). Additionally, the survey included four attentional control items randomly placed to identify lack of effort and understanding of the task.

Notwithstanding these limitations, the present findings provide a better characterization of the patterns of substance use initiation beyond a simple comparison of mean onset ages and thus provide new information about the crucial period for interventions. We identified three distinct categories of substance use initiation within a sample of young adults in Spain. Our study also found that starting to use the three substances early (before age 17) is a common pattern, and that it confers risk for involvement in substance use problems and poor mental health. Lastly, there were several within-class sex differences, with generally poorer outcomes (in terms of mental health and impulsivity) in early substance-using females. Identifying these classes helps to detect specific high-risk groups, setting a base for selective interventions across multiple settings to delay alcohol, tobacco and cannabis use initiation, and mitigate the risk of progression to regular use and other poor mental health outcomes.

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