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ORIGINAL ARTICLE

At-risk drinking and current cannabis use among medical students: a multivariable analysis of the role of personality traits

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Objective: To explore the role of personality traits in at-risk drinking and current cannabis use among medical students.
Methods: This cross-sectional study evaluated 707 medical students from two universities. Multiple logistic regression models for at-risk drinking and current cannabis use were constructed including sociodemographic, psychiatric, and personality variables.
Results: At-risk drinking and current cannabis use were reported by 19.3% and 14.9% of participants, respectively. Models including Big Five measures showed associations of at-risk drinking with higher extraversion ($p < 0.00001$, adjusted odds ratio [AOR] = 1.9) and lower conscientiousness ($p = 0.00001$, AOR = 0.5); cannabis use was also associated with lower conscientiousness ($p = 0.003$, AOR = 0.6), besides higher openness to experience ($p = 0.002$, AOR = 1.9). Models including measures of the Behavioral Inhibition and Activation Systems scales (BIS/BAS) showed associations of at-risk drinking with lower BIS ($p = 0.002$, AOR = 0.9) and higher BAS fun-seeking ($p = 0.0005$, AOR = 1.2); cannabis use was also associated with higher BAS fun-seeking ($p = 0.008$, AOR = 1.2). Personality variables had modest effects on model fit.
Conclusion: Specific personality traits were independently associated with at-risk drinking and current cannabis use, albeit with modest effect sizes.

Keywords: Alcohol drinking; alcohol abuse; marijuana use; personality; medical students

Introduction

Undergraduate students are highly exposed to substance use, particularly alcohol.[1] Nationwide U.S. data showed heavy drinking in 32% of college students, compared to 29% of their non-college peers and 16% of high school seniors.[2] The same survey found cannabis use in the past month in 22% of college students. In Brazil, a large nationwide survey of university students reported moderate- to high-risk drinking in 29% of males and 16% of females, as well as cannabis use in the past month in 13% of males and 6% of females.[3] Medical students are no exception in this scenario: a comprehensive review found rates of 24% for harmful alcohol use and almost 12% for cannabis use in the past month.[4] In addition to the potential health, social, and academic consequences of this phenomenon, there is concern that substance use during medical school may be a gateway for the development of substance use disorders among physicians, which have special professional implications.[5]

Personality traits have been implicated in myriad outcomes across the social and health sciences. One of the most prominent models of personality is the Five-Factor Model (the "Big Five" personality traits).[6] This model takes a lexical approach to personality, describing five high-order traits: openness to experience; conscientiousness; extraversion; agreeableness; and neuroticism. Another influential personality framework is based on the reinforcement sensitivity theory (RST), which takes a biological-behavioral approach.[7] In the original RST, behavior results from the interaction of three systems: the behavioral activation system (BAS), which is responsive predominantly for reward; the behavioral inhibition system (BIS), which responds mainly to punishment and negative stimuli; and the fight-flight system, which deals mainly with proximal threats. The revised version of the RST

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places conflict detection and resolution as the core function of the BIS.

Several studies have addressed the role of specific personality traits in substance use and substance-related problems. For example, a detailed meta-analysis reviewed studies on Big Five traits and substance use disorders and reported large-effect size reverse associations with conscientiousness and agreeableness, as well as direct associations with neuroticism.[8] Other personality theories and specific populations, such as medical students, have been studied comparatively less, as has the role of measures of different personality theories in the same population. The study of personality in specific populations is deemed important to inform preventive and therapeutic efforts, as well as for theory building.[8,9]

In this context, the present study assessed basic sociodemographic and psychiatric measures among medical students, as well as personality variables based on the Big Five traits and RST. Univariate associations of these variables with the outcomes of at-risk drinking and current cannabis use were explored, and multivariable models were built to define the independent role of personality measures.

Methods

Study design and participants

This cross-sectional study was designed to evaluate a non-random sample of medical students from two universities, one public (university A) public and one private (university B), in the Florianópolis metropolitan area, state of Santa Catarina, southern Brazil. Both medical schools offer 6-year programs, in accordance with the Brazilian medical education framework. Data were collected from April to July 2016, using an anonymous self-report questionnaire. We assessed each class of first- through eighth-semester students of each universities on one occasion, at the start or end of a lecture, on a date agreed upon in advance with the professor. The study was briefly explained to the class and students who agreed to participate filled out the informed consent form and questionnaires, which were then placed in a container. Ninth- through twelfth-semester students were assessed at their place of work, in small groups, as activities at this point in medical training are predominantly practical. Students took about 20-25 minutes to complete the questionnaires.

The study was approved by the local human research ethics committee (Plataforma Brasil accession number: CAAE 52982815.9.0000.5636; opinion 1.455.683).

Measures

At-risk drinking was defined by a score of five or higher for females and seven or higher for males in the Brazilian version of the Alcohol Use Disorders Identification Test-Consumption (AUDIT-C).[10,11] These cutoff points have been proposed as optimal for college students.[12] Current cannabis use was defined as use in the past 30 days, reported in questions constructed based on the Global Assessment Program on Drug Abuse Toolkit guidelines.[13] Depression and anxiety symptoms were measured using the Brazilian version of the Patient Health Questionnaire for Depression and Anxiety 4-items (PHQ-4).[11,14,15]

Sociodemographic measures included gender, age, marital status, monthly household income per capita, living situation, university (A and B), and academic term (first to twelfth semester; in both universities, the last four semesters are analogous to a medical internship in the United States).

Personality variables considered two prominent personality theories: the Big Five and the RST. Big Five traits were measured using the Brazilian version of the Big Five Inventory (BFI).[16-18] The BFI is a brief, widely employed questionnaire, and its Brazilian adaptation has been validated in a large sample of university and high-school students in the five Brazilian regions.[16] RST constructs of BIS and BAS, including the subconstructs of drive, fun-seeking, and reward sensitivity were measured using the Brazilian version of the BIS/BAS scales.[19,20]

Data analysis

Analyses were conducted using SPSS version 22.0. A significance level of 0.05 was adopted. Preliminary, univariate analyses compared participants who reported and did not report at-risk drinking or current cannabis use. Categorical variables were analyzed by the chi-square test or Cochran-Armitage test (for academic term only). Numerical variables were analyzed by the Mann-Whitney *U* test, considering the violation of normality assumptions as demonstrated by the Shapiro-Wilk test.

Variables with a p-value < 0.1 on preliminary analyses were simultaneously included as explanatory variables in multivariable binary logistic regression for the outcomes mentioned above (the logit linearity assumption was checked by the Box-Tidwell test; absence of multicollinearity was verified using the variance inflation factor and tolerance statistic; outliers and influential cases were detected using Cook's distance, standardized residuals, and leverage statistic). For each outcome, three models were built: model #1 included only sociodemographic and psychiatric explanatory variables; model #2 added BFI variables to model #1; and model #3 added BIS/BAS variables to model #1. Adjusted odds ratios (AOR) were calculated, and model fit was assessed by the Hosmer-Lemeshow test, *c* statistic, Nagelkerke's pseudo-R^2, and McFadden adjusted pseudo-R^2 (which penalizes for the number of explanatory variables in the model).

Results

At-risk drinking as outcome

Of 707 participants enrolled in the study, 704 (99.6%) completed the AUDIT-C and were categorized for at-risk drinking. The column ''All participants'' in Table 1 shows characteristics of these participants. Table 1 also shows the comparison of participants according to at-risk drinking status. Participants who reported at-risk drinking were

Table 1 Univariate comparison of medical students who reported and did not report at-risk drinking

Variable*	All subjects	At-risk drinking†		p-value
		No	Yes	
Number of participants	704 (100.0)	568 (80.7)	136 (19.3)	
Sociodemographic				
Gender (1)				
Female	410 (58.3)	322 (78.5)	88 (21.5)	
Male	293 (41.7)	245 (83.6)	48 (16.4)	0.09
Age (years)	23.0 (21.0-25.0)	23.0 (21.0-25.0)	23.0 (21.0-25.0)	0.8
Marital status (1)				
Single, separated, or divorced	644 (91.6)	512 (79.5)	132 (20.5)	
Married or domestic partnership	59 (8.4)	55 (93.2)	4 (6.8)	0.01
Living situation (1)				
Alone	225 (32.0)	178 (79.1)	47 (20.9)	
With friend	344 (48.9)	286 (83.1)	58 (16.9)	
With family	134 (19.1)	104 (77.6)	30 (22.4)	0.3
Household monthly income per capita (US$ thousands) (77)	0.8 (0.4-1.5)	0.8 (0.4-1.5)	0.8 (0.5-1.5)	0.8
University				
A (public)	385 (54.7)	323 (83.9)	62 (16.1)	
B (private)	319 (45.3)	245 (76.8)	74 (23.2)	0.02
Academic semester (5)				
1st to 4th	264 (37.8)	212 (80.3)	52 (19.7)	
5th to 8th	267 (38.2)	215 (80.5)	52 (19.5)	
9th to 12th	168 (24.0)	137 (81.5)	31 (18.5)	0.8
Psychiatric				
PHQ-4 (score)				
Anxiety (7)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.5
Depression (5)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	0.3
Total (9)	4.0 (2.0-6.0)	4.0 (2.0-6.0)	4.0 (2.0-6.0)	0.6
Current cannabis use (1)				
No	598 (85.1)	502 (83.9)	65 (16.1)	
Yes	105 (14.9)	96 (61.9)	40 (38.1)	< 0.00001
Personality				
BFI (score)				
Openness to experience (14)	3.5 (3.0-3.9)	3.5 (3.0-3.9)	3.5 (3.1-4.1)	0.3
Conscientiousness (29)	3.2 (2.9-3.8)	3.3 (2.9-3.9)	3.1 (2.7-3.6)	0.00001
Extraversion (25)	3.1 (2.6-3.8)	3.0 (2.6-3.6)	3.6 (2.9-4.1)	< 0.00001
Agreeableness (21)	3.6 (3.2-3.9)	3.6 (3.2-3.9)	3.6 (3.1-3.9)	0.9
Neuroticism (32)	3.1 (2.5-3.9)	3.2 (2.5-3.9)	3.1 (2.4-3.8)	0.3
BIS/BAS (score)				
BIS total (12)	22.0 (20.0-25.0)	22.5 (20.0-25.0)	22.0 (19.0-24.0)	0.02
BAS				
Drive (8)	9.0 (8.0-11.0)	9.0 (8.0-11.0)	10.0 (8.0-12.0)	0.006
Fun-seeking (7)	11.0 (10.0-13.0)	11.0 (10.0-12.0)	12.0 (11.0-14.0)	< 0.00001
Reward responsiveness (13)	17.0 (16.0-19.0)	17.0 (16.0-19.0)	18.0 (16.0-19.0)	0.2
Total (17)	38.0 (35.0-42.0)	38.0 (35.0-41.0)	40.0 (36.0-43.0)	0.00006

Data presented as n (%) or median (interquartile range).
BFI = Big Five Inventory; BIS/BAS = Behavioral Inhibition and Activation Systems scales; PHQ-4 = Patient Health Questionnaire for Depression and Anxiety 4-items.
* Categorical variables were analyzed using the chi-square test (no cell had an expected count less than 5), with the exception of academic term, which was analyzed using the Cochran-Armitage test. Numerical variables were analyzed using the Mann-Whitney *U* (Shapiro-Wilk test $p < 0.05$). Numbers in parentheses indicate number of cases with missing data.
† At-risk drinking was defined by an Alcohol Use Disorders Identification Test-Consumption (AUDIT-C) score of 5 or higher in females and of 7 or higher in males. Missing data are indicated in parentheses in column 1.

three times more likely to be single, separated, or divorced, 1.4 times more likely to be students of university B, and 2.4 times more likely to currently use cannabis. A trend for a higher proportion of females was also found. Statistically significant differences were also observed in personality measures: on the BFI, participants who

Table 2 Multiple logistic regression models for at-risk drinking among medical students

Variable*	Regression coefficient	AOR (95%CI)	p-value
Model #1: Sociodemographic and psychiatric explanatory variables **Outcome:** At-risk drinking: no, n=565; yes, n=136; total, n=701 **Summary:** Hosmer-Lemeshow p = 0.37; Nagelkerke's R^2 = 0.10; McFadden R^2 (adjusted) = 0.05; *c* = 0.68			
Gender (male)	-0.52	0.60 (0.39-0.91)	**0.02**
Marital status (married or domestic partnership)	-1.29	0.28 (0.10-0.79)	**0.02**
University (B)	0.49	1.63 (1.10-2.42)	**0.01**
Current cannabis use (yes)	1.36	3.89 (2.41-6.28)	< **0.00001**
Constant = -1.65			
Model #2: Sociodemographic, psychiatric, and BFI explanatory variables **Outcome:** At-risk drinking: no, n=523; yes, n=128; total, n=651 **Summary:** Hosmer-Lemeshow p = 0.21; Nagelkerke's R^2 = 0.19; McFadden R^2 (adjusted) = 0.10; *c* = 0.74			
Gender (male)	-0.57	0.57 (0.36-0.89)	**0.01**
Marital status (married or domestic partnership)	-1.59	0.20 (0.06-0.68)	**0.01**
University (private)	0.55	1.74 (1.14-2.65)	**0.01**
Current cannabis use (yes)	0.99	2.69 (1.59-4.56)	**0.0002**
BFI conscientiousness	-0.72	0.48 (0.35-0.67)	**0.00001**
BFI extraversion	0.62	1.86 (1.42-2.44)	< **0.00001**
Constant = -1.26			
Model #3: Sociodemographic, psychiatric, and BIS/BAS explanatory variables **Outcome:** At-risk drinking: no, n=552; yes, n=132; total, n=684 **Summary:** Hosmer-Lemeshow p = 0.77; Nagelkerke's R^2 = 0.16; McFadden R^2 (adjusted) = 0.08; *c* = 0.73			
Gender (male)	-0.84	0.43 (0.27-0.69)	**0.0004**
Marital status (married or domestic partnership)	-1.27	0.28 (0.10-0.82)	**0.02**
University (private)	0.31	1.36 (0.90-2.05)	**0.1**
Current cannabis use (yes)	1.14	3.11 (1.87-5.17)	**0.00001**
BIS total	-0.09	0.91 (0.86-0.97)	**0.002**
BAS drive	0.06	1.06 (0.98-1.16)	**0.2**
BAS fun-seeking	0.19	1.21 (1.09-1.35)	**0.0005**
Constant = -2.13			

95%CI = 95% confidence interval; AOR = adjusted odds ratio; BFI = Big Five Inventory; BIS/BAS = Behavioral Inhibition and Activation Systems scales.
Bold font indicates statistical significance.
Numerical variables met the logit linearity assumption in the Box-Tidwell test ($p > 0.05$); no numerical variables showed tolerance < 0.1 or variance inflation factor > 5; no cases had Cook's distance > 1 or absolute standardized residual > 3; seven cases in model #1, three cases in model #2, and one case in model #3 had a high leverage, but their removal did not substantially change the models.
* Category of comparison in parentheses.

reported at-risk drinking had lower scores of conscientiousness and higher scores of extraversion; on the BIS/BAS, they had lower BIS scores as well as higher BAS total, drive, and fun-seeking scores. Analyses of all numerical variables were nonparametric due to violation of normality assumptions, but parametric testing led to the same patterns of statistical significance (not shown).

Table 2 shows multivariable models for at-risk drinking. Model #1 revealed an association of at-risk drinking with female gender, marital status of single, separated or divorced, university B, and current cannabis use. In model #2 (which added BFI variables), these associations remained, and additional associations with lower scores of conscientiousness and higher scores of extraversion were present. In model #3 (which included BIS/BAS variables), associations with gender, marital status, and current cannabis use also remained, but there was no association with university; in addition, associations with BIS total and fun-seeking scores were observed. The Hosmer-Lemeshow test showed that all three models fit the data well ($p > 0.05$). The *c* statistic showed acceptable discriminatory ability, with little difference between models comprising personality measures: in model #2, *c* (95% confidence interval [95%CI]) was 0.74 (0.70-0.79), while in model #3, it was 0.73 (0.69-0.78). The discriminatory ability of model #1 was somewhat lower, with *c* = 0.68 (0.63-0.73). Nagelkerke's pseudo-R^2 and McFadden adjusted pseudo-R^2 values showed that including personality variables modestly improved the explanatory ability of the model.

Because university was important in model #2, we aimed to investigate school specificities, performing separate analyses by university for the outcome of at-risk drinking while considering BFI measures. For university A, univariate analyses showed $p < 0.1$ for current cannabis use, conscientiousness, and extraversion. These three variables retained significant multivariable associations: current cannabis use p = 0.01, AOR = 2.41 (95%CI 1.22-4.78); conscientiousness p = 0.009, AOR = 0.54 (0.34-0.86); and extraversion p = 0.0001, AOR = 2.11 (1.45-3.08); model fit: Hosmer-Lemeshow p = 0.89, Nagelkerke's R^2 = 0.15, adjusted McFadden R^2 = 0.08; and *c* = 0.73 (0.66-0.81). For university B, univariate analyses showed $p < 0.1$ for marital status, living situation, current cannabis use, conscientiousness and extraversion. In the multivariable model, current cannabis use had a

marginal association (p = 0.05, AOR = 2.13 [1.00-4.55]), while the following variables showed significant associations: living situation p = 0.03, AOR = 0.49 (0.26-0.93) for living with family (living alone as reference); conscientiousness p = 0.0005, AOR 0.45 (0.28-0.70); and extraversion p = 0.006, AOR = 1.73 (1.17-2.57); model fit: Hosmer-Lemeshow p = 0.19, Nagelkerke's R^2 = 0.18, adjusted McFadden R^2 = 0.08; *c* = 0.72 (0.65-0.79).

Current cannabis use as outcome

Of 707 participants enrolled in the study, 705 (99.7%) completed the questions about cannabis use. The column "All participants" in Table 3 shows the characteristics of these participants. Table 3 also shows a comparison of participants according to current cannabis use. Participants who reported current cannabis use were 2.1 times more likely to be male. A statistically significant difference was observed in the distribution of AUDIT-C scores, with higher scores for those who reported current cannabis use. There were also several statistically significant differences in personality measures: in the BFI, those who reported current cannabis use had higher scores of openness to experience and extraversion, lower scores of conscientiousness, and a trend for lower scores of neuroticism; in the BIS/BAS, they showed lower BIS scores, as well as higher BAS total and fun-seeking scores. Analysis of all numerical variables were nonparametric due to violation of normality assumptions, but parametric testing showed the same patterns of statistical significance (not shown).

Table 4 shows multivariable models for current cannabis use. AUDIT-C scores in the three models were summed with 1 and log-transformed at base 2 to meet the logit linearity assumption. Model #1 showed an association of current cannabis use with higher transformed AUDIT-C scores, as well as a trend for association with male gender. In model #2 (which added BFI variables), the association with higher transformed AUDIT-C scores remained highly statistically significant, and there were additional associations with higher scores of openness to experience and lower scores of conscientiousness. In model #3 (which included BIS/BAS variables), the association with higher transformed AUDIT-C scores also remained highly statistically significant, and there was an association with higher BAS fun-seeking scores as well. The Hosmer-Lemeshow test indicated that all three models fit the data well ($p > 0.05$). The *c* statistic showed acceptable discriminatory ability, with little difference between models: model #1, *c* = 0.76 (0.71-0.80); model #2, *c* = 0.79 (0.74-0.83); model #3, *c* = 0.78 (0.74-0.82). Including personality variables nearly doubled the Nagelkerke's pseudo-R^2, suggesting substantial improvement of explanatory ability, but only small increases were observed in the McFadden adjusted pseudo-R^2.

Discussion

This exploratory study assessed sociodemographic, psychiatric, and personality variables among medical students and found independent associations of specific personality traits with at-risk drinking and current cannabis use. Measures of model fit demonstrated improvements in discriminatory and explanatory ability when personality variables were added to basic models with sociodemographic and psychiatric variables, but as a whole, these increments were modest.

These findings should be interpreted considering some limitations. For example, the cross-sectional design of the study precludes any conclusions about causality. The non-random nature of the sampling strategy, with data obtained only from students attending classes, may have led to underrepresentation of students with greater absenteeism or with disabling psychiatric symptoms. Psychiatric measures were obtained by brief, self-report symptom scales, without any formal diagnosis using structured interviews, and encompassed only highly prevalent problems, such as anxiety, depression, and use of alcohol, cannabis, and tobacco; this approach limits conclusions on the role of psychiatric comorbidities in the outcomes of interest. Finally, the relatively high prevalence of missing data for income and BFI measures may have had a relevant impact on the power of analyses. Despite these limitations, this study expands current knowledge on substance use among medical students, particularly regarding the quantitative role of personality traits of different personality theories.

The association patterns in the models which included only sociodemographic and psychiatric variables remained after adding personality variables, with the exception of the association of at-risk drinking with university when BIS/BAS variables were added. The association between at-risk drinking and female gender seems paradoxical at first glance, as males generally consume more alcohol. However, this could be explained by the different cutoff points (which are justified by gender differences in alcohol metabolism) and perhaps reflects the general trend of approximation of alcohol consumption between the genders observed in recent decades.[2] Of note, no independent association was found between gender and current cannabis use, which may also reflect this trend. Thus, female students may now constitute a group at risk of harmful drinking. At-risk drinking was also independently associated with not being married/in a domestic partnership; this result replicates in medical students a long-standing, consistent finding of other populations.[21]

Studying at University B (private) was independently associated with at-risk drinking in the models which included sociodemographic and psychiatric variables (model #1), as well as BFI measures (model #2). However, the association was not independent of BIS/BAS measures (model #3), suggesting a more complex relationship between these variables. The already cited nationwide Brazilian survey of university students[3] found a somewhat complex scenario when comparing public and private institutions: in the latter, a higher prevalence of last-month cannabis use and high-risk drinking was observed, whereas binge drinking was more frequent in public institutions. Our results are partially aligned with these findings. Specific institutional and environmental factors have been shown to influence drinking habits among college students.[22] Our analyses disaggregating

Table 3 Univariate comparison of medical students who reported and did not report current cannabis use

Variable*	All subjects	Current cannabis use		p-value
		No	Yes	
Number of participants	705 (100.0)	600 (85.1)	105 (14.9)	
Sociodemographic				
Gender (1)				
Female	412 (58.5)	370 (89.8)	42 (10.2)	
Male	292 (41.5)	231 (78.4)	63 (21.6)	0.00003
Age (years)	23.0 (21.0-25.0)	23.0 (21.0-25.0)	23.0 (21.0-25.0)	0.5
Marital status (1)				
Single, separated, or divorced	646 (91.8)	549 (85.0)	97 (15.0)	
Married or domestic partnership	58 (8.2)	51 (87.9)	7 (12.1)	0.6
Living situation (1)				
Alone	226 (32.1)	192 (85.0)	34 (15.0)	
With friends	134 (19.0)	108 (80.6)	26 (19.0)	
With family	344 (48.9)	300 (87.2)	44 (12.8)	0.2
Household monthly income per capita (US$ thousands) (78)	0.8 (0.5-1.5)	0.8 (0.5-1.5)	0.9 (0.4-1.5)	1.0
University				
A (public)	386 (54.8)	322 (83.4)	64 (16.6)	
B (private)	319 (45.2)	278 (87.1)	41 (12.9)	0.2
Academic semester (5)				
1st to 4th	266 (38.0)	229 (86.1)	3 (13.9)	
5th to 8th	266 (38.0)	225 (84.6)	41 (15.4)	
9th to 12th	168 (24.0)	142 (84.5)	26 (15.5)	0.6
Psychiatric				
PHQ-4 (score)				
Anxiety (7)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	2.0 (1.0-3.0)	1.0
Depression (5)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	2.0 (1.0-4.0)	0.7
Total (9)	4.0 (2.0-6.0)	4.0 (2.0-6.0)	4.0 (2.0-7.0)	0.7
AUDIT-C (score) (2)	4.0 (1.0-5.0)	3.0 (1.0-5.0)	5.0 (4.0-6.0)	$<$ 0.00001
Personality				
BFI (score)				
Openness to experience (14)	3.5 (3.0-3.9)	3.4 (3.0-3.9)	3.8 (3.4-4.2)	0.00003
Conscientiousness (29)	3.3 (2.9-3.8)	3.3 (2.9-3.9)	3.0 (2.7-3.4)	$<$ 0.00001
Extraversion (25)	3.1 (2.6-3.8)	3.1 (2.6-3.8)	3.4 (2.8-4.0)	0.02
Agreeableness (21)	3.6 (3.2-3.9)	3.6 (3.2-3.9)	3.4 (3.1-3.9)	0.5
Neuroticism (32)	3.1 (2.5-3.9)	3.2 (2.5-3.9)	2.9 (2.3-3.8)	0.07
BIS/BAS (score)				
BIS total (12)	22.0 (20.0-25.0)	23.0 (20.0-25.0)	21.0 (19.0-23.0)	0.002
BAS				
Drive (8)	9.0 (8.0-11.0)	9.0 (8.0-11.0)	10.0 (8.0-11.0)	0.2
Fun-seeking (7)	11.0 (10.0-13.0)	11.0 (10.0-13.0)	12.0 (11.0-14.0)	$<$ 0.00001
Reward responsiveness (13)	17.0 (16.0-19.0)	17.0 (16.0-19.0)	18.0 (16.0-19.0)	0.8
Total (17)	38.0 (35.0-42.0)	38.0 (35.0-41.0)	38.0 (36.0-43.0)	0.01

Data presented as n (%) or median (1st-3rd quartile).
AUDIT-C = Alcohol Use Disorders Identification Test-Consumption; BFI = Big Five Inventory; BIS/BAS = Behavioral Inhibition and Activation Systems scales; PHQ-4 = Patient Health Questionnaire for Depression and Anxiety 4-items.
* Categorical variables were analyzed using the chi-square test (no cell had an expected count less than 5), with the exception of academic term, which was analyzed using the Cochran-Armitage test. Numerical variables were analyzed using the Mann-Whitney *U* (Shapiro-Wilk test $p < 0.05$). Numbers in parentheses indicate number of cases with missing data.

data by university suggest that these differences are related to sociodemographic factors, whereas the role of personality tends to be stable across institutions.

The lack of association between PHQ-4 scores and at-risk drinking or current cannabis use is noteworthy, considering the well-known comorbidity of substance use disorders and depressive and anxiety disorders. This may reflect the aforementioned limitations of using screening instruments, but agrees with previous research on medical students showing this lack of association[23] or association with alcohol dependence, but not alcohol abuse.[24] Community studies have also shown that comorbidity with

Table 4 Multiple logistic regression models for current cannabis use among medical students.

Variable*	Regression coefficient	AOR (95%CI)	p-value
Model #1: Sociodemographic and psychiatric explanatory variables **Outcome:** Current cannabis use: no, n=597; yes, n=105; total, n=702 **Summary:** Hosmer-Lemeshow p = 0.70; Nagelkerke's R^2 = 0.11; McFadden R^2 (adjusted) = 0.13; *c* = 0.76			
Gender (male)	0.44	1.55 (0.98-2.45)	0.06
AUDIT-C†	1.39	4.00 (2.62-6.12)	< **0.00001**
Constant = -3.47			
Model #2: Sociodemographic, psychiatric, and BFI explanatory variables **Outcome:** Current cannabis use: no, n=532; yes, n=93; total, n=625 **Summary:** Hosmer-Lemeshow p = 0.76; Nagelkerke's R^2 = 0.25; McFadden R^2 (adjusted) = 0.15; *c* = 0.79			
Gender (male)	0.38	1.47 (0.87-2.47)	0.2
AUDIT-C†	1.27	3.56 (2.24-5.66)	< **0.00001**
BFI openness to experience	0.67	1.95 (1.29-2.94)	**0.002**
BFI conscientiousness	-0.58	0.56 (0.38-0.82)	**0.003**
BFI extraversion	0.06	1.06 (0.77-1.46)	0.7
BFI neuroticism	-0.10	0.91 (0.68-1.21)	0.5
Constant = -5.21			
Model #3: sociodemographic, psychiatric, and BIS/BAS explanatory variables **Outcome:** Current cannabis use: no, n=588; yes, n=100; total, n=688 **Summary:** Hosmer-Lemeshow p = 0.12; Nagelkerke's R^2 = 0.22; McFadden R^2 adjusted = 0.14; *c* = 0.78			
Gender (male)	0.36	1.44 (0.88-2.35)	0.2
AUDIT-C†	1.34	3.80 (2.42-5.98)	< **0.00001**
BIS total	-0.04	0.96 (0.90-1.03)	0.2
BAS fun seeking	0.16	1.18 (1.04-1.33)	**0.008**
Constant = -5.92			

95%CI = 95% confidence interval; AOR = adjusted odds ratio; AUDIT-C = Alcohol Use Disorders Identification Test-Consumption; BFI = Big Five Inventory; BIS/BAS = Behavioral Inhibition and Activation Systems scales.
Numerical variables met the logit linearity assumption in the Box-Tidwell test ($p > 0.05$); no numerical variables showed tolerance < 0.1 or variance inflation factor > 5; no cases had Cook's distance > 1 or absolute standardized residual > 3; one case in model #3 had a high leverage, but its removal did not substantially change the model.
Bold font indicates statistical significance.
* Category of comparison in parentheses.
† AUDIT-C scores were summed with 1 and log-transformed at base 2 to meet the logit linearity assumption.

depressive and anxiety disorders is most marked in heavy users of alcohol or cannabis.[25,26]

At-risk drinking and current cannabis use were independently and substantially associated with each other in all analyses. In fact, alcohol consumption as a numerical measure was the only non-personality variable independently associated with current cannabis use. Data from college students in the United States in recent decades have shown a gradual dissociation in the prevalence of use of these substances, with increased use of cannabis and decreased use of alcohol.[2] However, the use of alcohol and cannabis simultaneously (at the same time) or concurrently (on different occasions) remains very common and has been associated with additional negative social and health outcomes (such as driving under the influence, mood and anxiety disorders) than isolated use of either substance.[27] It is noteworthy that knowledge about interventions to mitigate the use of alcohol when consumed simultaneously or concurrently with other drugs is limited.[28]

The associations of personality traits with at-risk drinking and current cannabis use in the present study were mostly in agreement with the literature. The reverse association of conscientiousness with both outcomes is largely consistent with meta-analyses of subjects with substance use disorders[8,29] and large studies of non-clinical samples.[30,31] Another finding that replicated the literature is the association of the outcomes of interest with greater BAS sensitivity.[32] In the present study, only the fun-seeking subscale of the BAS showed an independent association with at-risk drinking and current cannabis use. This is consistent, for example, with research on college students which reported associations with greater alcohol use, frequency of binge drinking, and number of illicit drugs already used,[33,34] as well as a large epidemiological study which found BAS fun-seeking to be a vulnerability factor for substance-related problems.[35] Similarly, a recent systematic review showed associations of binge drinking with higher impulsivity and sensation-seeking, as well as with lower conscientiousness.[36] Thus, lower conscientiousness and higher BAS sensitivity (fun-seeking in particular) stand out as factors consistently associated with greater use of different substances in distinct populations. The RST postulates that the neural substrates of the BAS include mesocorticolimbic dopamine pathways.[37] These pathways are conceptualized as major components of the brain reward system, and play a central role in neurobiological models of substance use disorders. The reward response has the distinct components of ''wanting'' (related to motivation) and ''liking'' (related to actual pleasure). The incentive-sensitization theory of addiction states that addiction is

caused by substance-induced changes in the brain's mesocorticolimbic circuitry, leading to amplification of the "wanting" component.[38]

The findings of independent, direct associations between at-risk drinking and extraversion, as well as current cannabis use and openness to experience, are not aligned with previous meta-analyses of substance use disorders.[8,29] However, they are partially aligned with other studies of non-clinical samples. For example, a systematic review found a direct association between higher extraversion and binge drinking,[36] and a large community-based study directly correlated cannabis use with openness to experience.[31] Thus, one may speculate that clinical and non-clinical samples (such as undergraduate students) differ in their personality profile in the context of substance use, but this hypothesis remains to be directly addressed. BIS sensitivity and neuroticism are conceptually related constructs to some extent; nevertheless, in the present study, participants with at-risk drinking showed lower BIS scores, but not lower neuroticism. An association of substance use and lower BIS sensitivity has been described previously among college students.[33] However, higher neuroticism in alcohol use has been found more consistently.[36] In addition, higher neuroticism has been associated with several psychiatric disorders.[8]

Research on personality traits of medical students has focused mainly on their role in stress and academic achievement, suggesting that conscientiousness is important to success in early years, while more prosocial traits are relevant in later clinical years.[39] Consistently, in our study conscientiousness was inversely related to potentially harmful behavioral outcomes. While studies relating personality traits and substance use have been frequently conducted among college students, research specifically addressing medical students in this regard is much scarcer. A nationwide, prospective study in Norway[40] assessed medical students at different time points and reported that impulsiveness at the first time point predicted binge drinking at the second time point. Another study in England[23] found direct associations between a measure of the psychoticism construct in Eysenck's personality model (which is considered inversely related to agreeableness and conscientiousness in the Five-Factor Model) and alcohol and illicit drug intake. As in the present study, an investigation conducted in another region of Brazil[41] evaluated Big Five traits related to alcohol dependence in medical residents and found an independent direct association with extraversion.

A systematic review of Big Five traits across different academic majors reported consistent group differences with medium to high effect sizes.[42] Therefore, understanding the role of personality traits in substance use in specific student populations may have implications for mitigation strategies. At the collective level, personality traits may inform the design of preventive campaigns. For example, dramatic portrayals of the possible consequences of cannabis use have been shown to reduce last-month cannabis use, specifically in youths with high sensation-seeking.[43] At the individual level, measures of personality traits could be used to identify individuals at risk of substance-related problems and to develop specific interventions. Interventional studies conducted to date generally found positive results with moderate effect sizes for interventions with psychoeducational, motivational, and cognitive-behavioral components, addressing traits of impulsivity, sensation-seeking, anxiety, and hopelessness.[44]

Our results showed independent associations of specific personality traits with the outcomes of interest, but with modest effect sizes. At first glance, this suggests that taking personality into account in preventive or therapeutic approaches would have a modest impact as well. However, we assessed a non-clinical sample, and the role of personality traits may differ in medical students with a formal diagnosis of substance use disorders. This is a relevant topic to be addressed by future studies. On the other hand, our results also demonstrated modest effect sizes for sociodemographic and psychiatric variables. This is consistent with the idea that preventive and therapeutic approaches should consider the multifactorial, complex nature of substance-related problems.[45] Although we found stability of the role of personality traits in at-risk drinking across the two participant universities, a "one-size-fits-all" approach does not seem appropriate, as research also suggests that medical school specificities are important.[22] For example, subgroups within a medical school could be identified for specific interventions, as illustrated by our results showing that living alone was a risk factor for at-risk drinking in only one of the universities.

To conclude, substance misuse is an important issue to be addressed in medical student populations, as it may be a gateway to substance use disorders and other substance-related problems. This may ultimately impact public health due to the specific implications of substance-related problems among physicians, which range from difficulties to seek treatment to impaired patient care and legal problems. Our findings and the literature discussed above indicate that personality traits have a significant role in substance use among medical students, and may be useful to inform preventive and therapeutic approaches. Evidence-based interventions informed by personality characteristics, however, are a relatively new area of research, and more studies in specific populations are needed. Personality traits linked to substance misuse may be more stable across institutions than sociodemographic factors, but specific local characteristics should not be overlooked. Medical schools can use evidence from the literature, together with their own quantitative or qualitative data, to define strategies consistent with their realities.

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