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Substance use and academic performance among university students: systematic review and meta-analysis

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Abstract

Background Substance use is a widespread concern among young adults and is particularly significant among college students. Substance use in this population is associated with several academic, physical, mental, and social difficulties. This systematic review and metanalysis explores whether there is an effect of the legal and illegal substance and alcohol consumption behaviors on academic achievement among university students.

Methods The databases searched were MEDLINE, CINHAL, Scopus, ERIC, and PROSPERO, updated in January 2025. The risk of bias was assessed using the Edwards score. We used a random-effects model. The protocol of this review was registered in the Open Science Framework.

Results The systematic review included 21 studies, while the meta-analysis included four studies. In a sample of 1,219 subjects in the control group and 350 legal and illegal substances consumers, there is a negative and significant association of substances consumption on academic achievement [SMD = −0.61 (95% CI −0.84 to −0.38; $p = 0.008$). In a subgroup analysis, a sample of 2,479 subjects in the control group and 7,134 alcohol consumers, there is a non-statistically significative association of alcohol consumption on academic achievement [SMD = −0.24 (95% CI -0.51 to 0.04; $p = 0.073$).

Conclusions Despite the limitations of this study, this systematic review provides quantitative evidence on the relationship between legal and illegal use of substances among university students and academic achievement. Specifically, we found a significant medium association of substance use in general and a small effect for alcohol consumption on academic achievement.

Clinical trial number Not applicable.

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Keywords Alcohol drinking, Substances use disorders, University student, Academic achievement

Introduction

Substance use (the use of selected substances, including alcohol, tobacco products, illicit substances, inhalants, and other substances that can be consumed, inhaled, injected, or otherwise absorbed into the body with possible dependence and other detrimental effects) [1] is a widespread concern among young adults [2–4] and is particularly significant among college students. University students represent a high-risk group for both legal and illegal substances use, as this academic period often marks their first experience with reduced parental oversight [5] and introduces stressors related to new relationships and the challenges of successful adaptation [6]. Substance use in this population is linked to numerous academic, physical, mental, and social difficulties. Research indicates that nearly half of college students meet the criteria for at least one substance use disorder (SUD), and young adults aged 19–30 report elevated rates of cannabis use, vaping (both cannabis and nicotine), and hallucinogen use [7, 8]. This issue presents serious public health implications, contributing to increased rates of morbidity and mortality [2–4]. Specifically, alcohol use is associated with mental disorders [9, 10], highly disabling outcomes [11], and physical and psychiatric comorbidities [12]. Some studies have shown that excessive alcohol consumption and substance use are associated with difficulties in adapting to academic life, poor working memory and reasoning [13], lower intelligence, and reduced attention in both adolescents and college students [14]. In addition, other consequences are decreased academic performance [15, 16], less time studying, disengagement from academic duties [17], and increased academic procrastination [18]. High levels of academic failure are a great problem for universities' reputation because they can lose potential new students [19, 20]. Contrasting academic failure means also promoting human development and increasing the social and cultural capital of the country, creating the conditions for economic development and the progress of society [21]. In addition, students generally do not use only one substances but more substances together [22], and these associations can further aggravate the negative consequences of academic failure of university students.

Consumption of alcohol and other substances among university students

Alcohol

Alcohol consumers, representing an estimated 155 million individuals [23]. Among all World Health Organization (WHO) regions, the highest prevalence is observed in Europe (43.8%), followed by the Americas (38.2%) and the Western Pacific (37.9%) [23]. Furthermore, projections suggest that by 2025, per capita alcohol consumption among individuals aged 15 years and older will increase in the WHO regions of the Americas, South-East Asia, and the Western Pacific [23].

In the United States, alcohol consumption is reported by 30.7% of college students, compared to 27.4% of their non-college peers. Binge drinking—defined as consuming four or more drinks for women and five or more for men—is notably common, with a reported prevalence ranging from 30 to 40% [24, 25]. In Finland, 41% of college students are classified as high-frequency drinkers [26].

In Spain, heavy alcohol consumption among university students is reported at 17.9% for women and 35.6% overall at baseline, with a significant increase to 54.6% during the course of the study [27, 28]. Risky alcohol use is especially prevalent among individuals aged 18 to 24 years [29].

In Egypt, Kabbash et al. [30] reported a 2.7% prevalence of alcohol use among university students. In Africa, high-risk alcohol consumption and alcohol use disorder were reported among Tunisian university students at rates of 52.5% and 79.1%, respectively [31]. In Ethiopia, the prevalence of alcohol consumption among university students is estimated at 35.5% [32].

Tobacco

In Finland, 22% of college student smoke [26]. In Spain, the prevalence of tobacco consumption at baseline was 31% among women and 27.5% among men, and it declined after two and nine years [27]. In Egypt, 16.4% of students reported having ever smoked tobacco, with a significantly higher prevalence among males (33.1%) compared to females (3.3%) [30]. Cigarette smoking was also significantly more prevalent among students in practical faculties (10.6%) than among those in theoretical (9.9%) and medical (3.75%) faculties [30].

Cannabis

In Spain, cannabis use reported by Busto-Miramontes et al. [27] was 18.6% among women and 27% among men at the beginning of the study. These rates declined after two years to 16.1% for women and 19.9% for men and further decreased after nine years to 4% and 8.9%, respectively [27]. Similarly, Caamaño-Isorna et al. [28] reported a prevalence of 20.8% at the initial assessment, which declined to 17% after two years [28].

Sedative substances/tranquilisers

Fadhel [33] assessed substance use among university students in Yemen and Saudi Arabia and found that 12.5% of students used sedative substances. In Egypt, Kabbash et al. [30] reported that 4.3% of university students used tranquilizers.

Hashish/bhang/tramadol

In Egypt, Kabbash et al. [30] reported that 3.6% of university students used hashish, 1.4% used bhang, and 1% used tramadol.

Therefore, numerous studies have examined the association between academic achievement and the use of legal or illegal substances among university students. While some research suggests that substance use and alcohol consumption negatively affect academic performance [34], other studies have found no significant relationship between these variables [35, 36]. To address these conflicting findings, we aim to conduct a meta-analysis, which represents the highest level of evidence available for informing healthcare policy and clinical practice [37]. Meta-analyses enhance the strength of evidence by aggregating data from multiple studies, thereby increasing both sample size and statistical power [38].

This study aims to systematically review quantitative literature exploring the relationship between legal and illegal substances use among university students and academic achievement. Specifically, it seeks to determine whether substance consumption behaviors have a measurable impact on academic performance.

We chose to focus on alcohol use vs. other substances due to the high prevalence of alcohol use, legal accessibility, and its strong association with a range of negative outcomes. In fact, research has linked alcohol use to mental health disorders such as depression and anxiety [9, 10], as well as to physical and psychiatric comorbidities [12]. It is also associated with impairments in cognitive functioning, including deficits in working memory, reasoning [13], and attention [14], particularly in college students. These effects can contribute to long-term functional impairment [11], making alcohol use a critical area of concern for public health and cognitive development.

Moreover, we choose to consider university students inside young adults because university students represent a high-risk group for both legal and illegal substances use, as this academic period often marks their first experience with reduced parental oversight [5] and introduces stressors related to new relationships and the challenges of successful adaptation [6]; research indicates that nearly half of college students meet the criteria for at least one substance use disorder (SUD) [7, 8] and because high levels of academic failure are a great problem for universities' reputation that can lose potential new students [19, 20]. In addition, contrasting substance use and academic failure means promoting human development, increasing the social and cultural capital, economic development and the progress of society [21].

Methods

A systematic literature review and meta-analysis was conducted. The PRISMA guidelines guided the processes of source selection, data extraction, and data presentation [39].

This review protocol was registered in the Open Science Framework.

Eligibility criteria

We formulate a research question based on the PECO method: Population (university student), Exposure (legal or illegal substances use), Comparison (no substance use), and Outcome (academic achievement). For the topic, we decided on the following inclusion criteria: any empirical quantitative study design (cross-sectional, longitudinal, descriptive, retrospective and prospective, etc…), including university students' of any course, investigating substance use (alcohol, tobacco, cannabis, and other legal and illegal substances) and academic achievement in peer-reviewed journals in any language. Exclusion criteria are empirical studies regarding substance use and academic achievement in non-university students, articles without full text available, conferences, editorials, theses and books, case reports, case series, and systematic review studies. These sources are typically not peer-reviewed in the same rigorous and standardized manner as journal articles, which may compromise the reliability and reproducibility of findings. Furthermore, books and theses often lack standardized reporting frameworks such as PRISMA or CONSORT, making it difficult to assess methodological quality or compare results across studies. By focusing solely on peer-reviewed articles, this review ensures a higher level of methodological rigor, credibility, and consistency in the evidence base, in line with systematic review best practices [40]. No data frame was considered.

Information sources

The literature search was developed based on medical subject headings (MeSH), and keywords, related to university students, substance use, and academic achievement. We performed the electronic search in MEDLINE, CINHAL, Scopus, and ERIC databases in January 2025. We researched ongoing or recently completed systematic reviews.

Search strategy

The mesh terms used with related keywords in the search strategy were combined with the Boolean operator "AND"/"OR" and below we reported some examples of

research strategies: "Students", AND "Universities") AND (Alcohol-Induced Disorders", OR "Alcohol drinking", OR "Alcohol drinking College", OR "Binge Drinking", OR "Abuse, Marijuana") AND (Academic success", OR "Academic performance") (Additional file 1).

Selection process

Three researchers (I. S., R. M., G. B.) independently examined the studies based on the title and abstract. All records obtained from the literature search were collected into the Endnote library to delete duplicates. In this phase, the researchers decided the studies to include based on eligibility criteria (empirical studies, concerning university students, evaluating substance use and academic achievement, written in all languages). We scanned the references of all included studies. The studies were excluded for lack of precision of the research question, a different population from that of interest (adolescent, primary and secondary students), and academic success not measured quantitatively. Academic achievement was defined as the performance obtained in the programme by the student as the Grade Point Average (GPA) in every situation (course, cumulative GPA at the end of the year and from one year to another). Substance use was defined as the use of selected substances, including alcohol, tobacco products, illicit substances, inhalants, and other substances that can be consumed, inhaled, injected, or otherwise absorbed into the body with possible dependence and other detrimental effects [1] assumed by the university student. In cases where there was uncertainty regarding the inclusion of a study, the study was retained for further discussion during the final selection process, with consensus sought among all researchers. In instances of disagreement, the matter was escalated to a senior researcher for resolution. For each excluded study, the specific rationale for exclusion was documented. Additionally, a manual search was conducted by examining the reference lists of all included studies to identify any relevant articles that may have been missed during the initial screening. All steps of the study selection process were conducted independently and subsequently reviewed collectively to ensure agreement among the full research team.

Data collection process

All data extracted were collected in an Excel sheet. Three researchers (I. S., R. M., G. B.) extracted data independently; disagreements were resolved by consensus.

Data items

From each study, the following data were collected: author name, year of publication, country, aim of the study, study design, overall sample size, demographic characteristics, instrument used to measure the substance use, instrument to measure the academic achievement, the number of students with substance use (any definition: only alcohol use, alcohol + any substances use, binge drinking, etc.), the number of students without substance use. In case of a longitudinal study, we collected the time at which the analysis was performed. When a study consisted of multiple groups, such as a different group based on substance consumption frequency, the groups were combined in such a way to have only one group of substance consumers. Data on the quantitative modality of the assessment of academic achievement was also collected, considering average, standard deviation, standard error (SE), median, range, and interquartile range of academic success in students not consuming substances and those consuming substances. If effect sizes could not be calculated, we contacted the authors for additional data. In case of no answer, the study was excluded from meta-analysis but included in the narrative synthesis.

Outcomes and prioritisation

The primary outcome was the association of substance use and academic achievement.

Risk of bias assessment

The risk of bias was assessed using the Edwards score [41] for observational studies. The 11 items of the assessment tool are as follows: definition of aims, sample formation, description of inclusion and exclusion criteria, description of subject characteristics, power calculation, objectivity of outcome measures used, adequacy of follow-up, adequacy of analysis (intention to treat), adjustment for baseline differences between groups, appropriate unit of allocation to groups, and randomisation method. Each item is scored from 0 to 2 for adequacy, and a high score indicates a study's high methodological quality. The total score possible ranges from 0 to 22 for experimental studies and from 0 to 16 for observational studies.

Effect measures

The standardized mean difference (SMD) was chosen as a summary statistic to synthesize the association of substance consumption behaviour on academic achievement. Results were categorized as suggested by Higgins et al., with a magnitude of 0.2 representing a small effect; 0.5 a moderate effect: and 0.8 a large effect [42].

Data synthesis

If the studies are sufficiently homogeneous in terms of substance consumption definition and sample population, we conducted meta-analyses using a random-effects model. Meta-analysis was the statistical technique used to synthesise results when mean and standard deviation (SD) of academic achievement in substances/alcohol

consumers group and in non-consumers group were available. A random-effects model was performed, with DerSimonian and Laird estimation of the between-study variance.

A forest plot was used to represent the meta-analysis results. The heterogeneity between the studies was assessed by visual inspection of the forest plot and by the overlap of the CIs and possible outliers, and it was quantified through the I^2 index. The I^2 statistic describes the percentage of variation across studies that is due to heterogeneity rather than chance. We considered that an I^2 of 25% indicated low heterogeneity, 50% moderate, and 75% high [43]. A p-value of the chi-squared (χ^2) test, a statistical test for heterogeneity, was included in the forest plot.

A possible source of heterogeneity (e.g., mean age) was not investigated by meta-regression since there are fewer than 10 studies [44]. Publication bias was assessed with visual inspection of the funnel plot, that is, a scatter plot of the effect size estimates from individual studies against SE. The funnel plot asymmetry was not verified due to the small number of studies included in the meta-analysis.

Further analysis

To further explore the meta-analysis results from included studies, we also performed a Random-Effects analysis using studies that provided quantitative information between low/high academic performance and substance consumption. We used Odds Ratios (OR) for effect size estimation and separated each group by substance type.

Results

Study selection

We combined the three search strings (1#2#3), retrieving a total of 1,477 records. After removing 48 duplicates, 1,429 unique records remained. The last search was conducted in January 2025. After screening titles and abstracts, 1,370 records were excluded as they were not relevant to our research aims. The remaining 59 studies underwent full-text evaluation. Of these, 38 studies were excluded for the following reasons: they did not focus on academic achievement ($n = 11$), were not empirical studies ($n = 8$), did not consider university students ($n = 8$), did not quantify academic success ($n = 4$), or were reviews ($n = 7$). As a result, 21 studies were included in the final selection (Fig. 1), of which four were deemed suitable for meta-analysis.

Study characteristics

We included 21 studies (Additional file 2). The time frame for publication is from 2007 to 2023. The countries more represented were the USA with eight studies [16, 46–52], Spain with three studies [36, 53, 54], the United Kingdom with two studies [55, 56], and one study each in Qatar [35], Ethiopia [57], Nigeria [58], Brasil [59], Romania [60], Hungary [61], Lithuania [62] and Australia [34]. The studies considered different types of university students coming from different courses, public or private universities, and different sample sizes, with a minimum of 129 students [54] and a maximum of 23,518 [52].

The consumption of legal or illegal substances was measured with different instruments, and different substances were considered with single or aggregate data. An et al. [16], El Ansari et al. [35], El Ansari et al. [55], Liguori and Lonbaken [48], Mercado et al. [50], Nasui et al. [60], Pascarella et al. [51], Piazza-Gardner et al. [52], and Tembo et al. [56] evaluated only alcohol consumption. An et al. [16], El Ansari et al. [55], Liguori and Lonbaken [48], Pascarella et al. [51], and Piazza-Gardner et al. [52] classify the level of user behaviours with one or more items. El Ansari et al. [35] use the CAGE [63]; Mercado et al. [50] use the Short Alcohol Dependence Data Questionnaire (SADD) Raistrick et al. [64]; Portero de la Cruz [54] use AUDIT [65]; Tembo et al. [56] use the AUDIT [66, 67]; and Nasui et al. [60] use the Romanian version of the Student Alcohol Questionnaire [68]. Ache Akua and Samek [46] evaluate alcohol and cannabis consumption with two items. Olorunleke et al. [58] considered alcohol and tabacco and evaluated them with a structured questionnaire. Petkeviciene et al. [62] considered alcohol, substances use (ecstasy, cocaine, LSD, cannabis,…) and smoking and evaluated them with a questionnaire for substances and smoking, while used the CAGE questionnaire for alcohol use and dependence [63]. Arria et al. [47], Hernandez-Serrano et al. [36], Lukacs et al. [61], Meda et al. [49], Mekonen et al. [57], Ong et al. [34], Paramo et al. [53], and de Souza et al. [59] assess more than one substance use. Arria et al. [47] evaluates alcohol and marijuana, inhalants, heroin, cocaine, hallucinogens, amphetamine/methamphetamine, and ecstasy consumption. For alcohol dependence, Arria et al. [47] use the DSM-IV criteria based on the questionnaire from the Substance Abuse and Mental Health Services Administration [69], while they use some questions for the other substances. de Souza et al. [59] assess alcohol, marijuana, and cocaine use with the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST) [70]. Hernandez-Serrano et al. [36] assess alcohol, cannabis and tobacco use; Lukacs et al. [61] assess alcohol, tobacco, ecstasy, depressant, and herbal substance use; Meda et al. [49] assesses alcohol and marijuana use; and Mekonen et al. [57] assess alcohol, smoking, and other substances with the ASSIST [70]. Ong et al. [34] assess alcohol and smoking use with the NSW questionnaire [71], and Paramo et al. [53] assess alcohol use with the AUDIT-C [67, 72] and cannabis use with the CAST [73, 74].

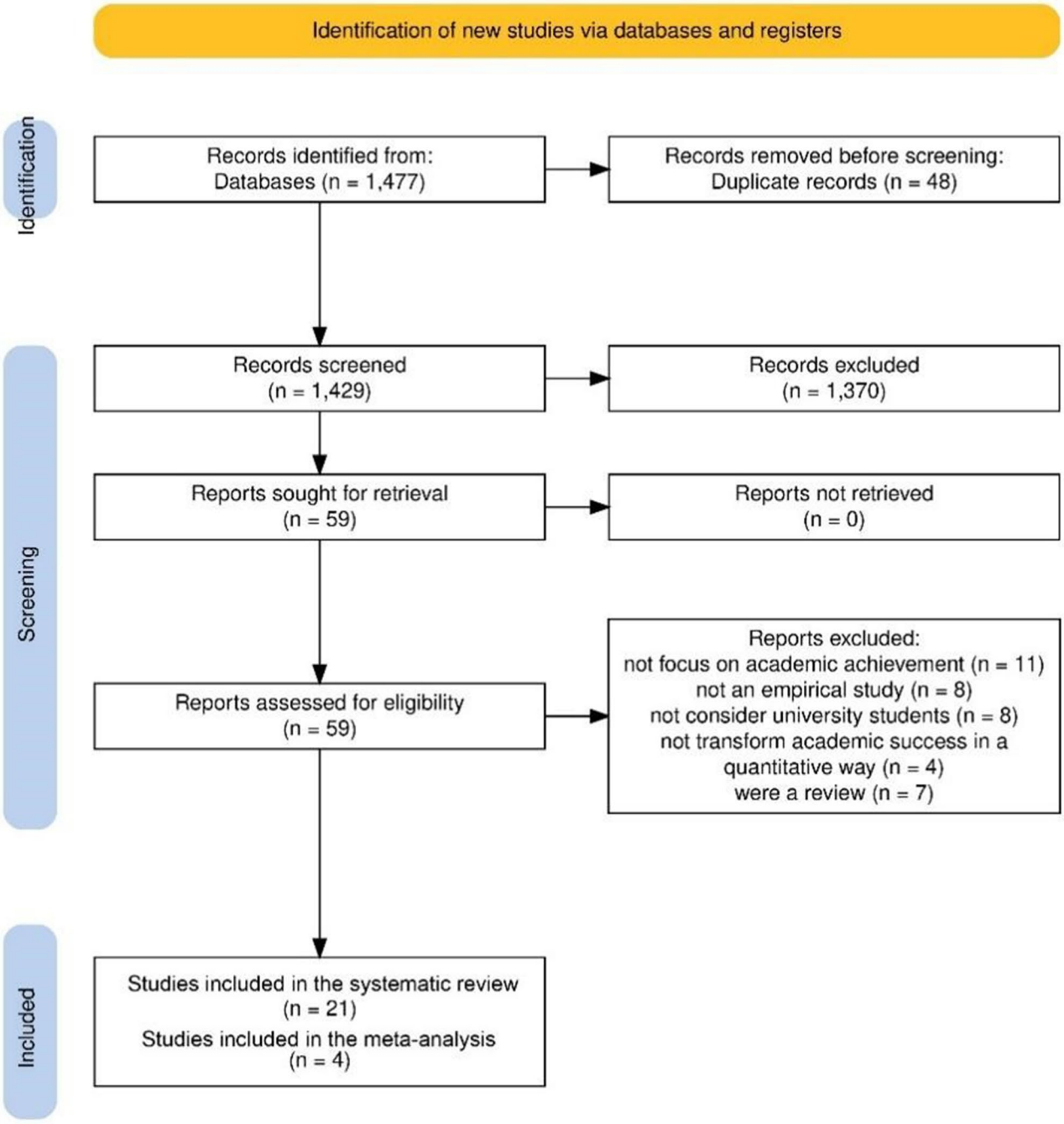


Fig. 1 Flowchart of preferred reporting items for systematic reviews and meta-analyses (PRISMA) study selection. Create using PRISMA Flow Diagram Tool [45]

Academic achievement was assessed with self-reported data [16, 34–36, 46, 47, 50–52, 54–62] or by administrative database [48, 49, 53]. Meda et al. [49] and Paramo et al. [53] use the GPA, while Liguori and Lonbaken [48] use the first–second year retention.

For self-reported data, An et al. [16], Mekonen et al. [57], and Piazza-Gardner et al. [52] used the GPA with a range from 1 to 4 points; Akua and Samek with a range from 1 to 5; Olorunleke et al. [58] used the grade; Petkeviciene et al. [62] with a range from 1 to 3 (from below to above average); de Souza et al. [59], Hernandez-Serrano et al. [36], and Paramo et al. [53] with a range from 0 to 10 points; Ong et al. [34] with a range from 0 to 7 points; and Mercado et al. [50] with a range from 1.4 to 3.5 points. Lukacs et al. [61] use an ordinal scale (poor, medium, good) like De la Cruz & Cebrino Cruz [54] (excellent, very good, good, discrete, bad, very bad). Arria et al. [47] evaluate the ability of the student to have or not

a specific planning about academic duties. El Ansari et al. [35] evaluated the perception of the students about the importance of their performance, including performance rate; in El Ansari et al. [55] considered the importance of achieving a good grade, and comparative evaluation of their performance in relation to peers. Liguori and Lonbaken [48] evaluate the first–second year student retention, Tembo et al. [56] evaluate being late for class, missing classes, the inability to concentrate in class and inability to complete assignments with the Academic Role Expectation and Alcohol Scale (AREAS) [75] and finally Nasui et al. [60] evaluated skipping a class, missing class and receiving a lower grade after drinking.

Risk of bias within studies

Study designs were cross-sectional [34, 53, 56, 57, 59–62]. Petkeviciene et al., [62] used data from 3 surveys on 2000, 2010, and 2017. Longitudinal [16, 46, 47, 49, 51, 52], descriptive [36, 48, 54, 55, 58], or retrospective [50].

The methodological quality of the studies increased from 2/16 to 10/16 points, and they can be considered from low to medium quality. The studies with higher quality reached 10/16 points [46, 56, 60, 62]. These studies had clear aims, a random sample, a discrete sample [60], and a good sample size [56], and they clearly described [56] the inclusion criteria and subjective self-reported data [56, 60]. The study with lower quality reached 2/16 points [58] because there was a convenience sample, no description of the characteristics of the sample, and no clear definition of outcome measurement. All studies had clear aims, but in general, the sample selection methodology was never probabilistic, except for Mekonen et al. [57]. Arria et al. [47], Hernandez-Serrano et al. [36], Liguori and Lonbaken [48], Meda et al. [49], Mekonen et al. [57], Mercado et al. [50], Nasui et al. [60], Piazza-Gardner et al. [52], de Souza et al. [59], and Tembo et al. [56] had clear inclusion criteria specified for the sample, but many of these studies use self-reported measurement (Additional file 3).

Summary statistics for meta-analysis

Legal and illegal use of substances and academic achievement

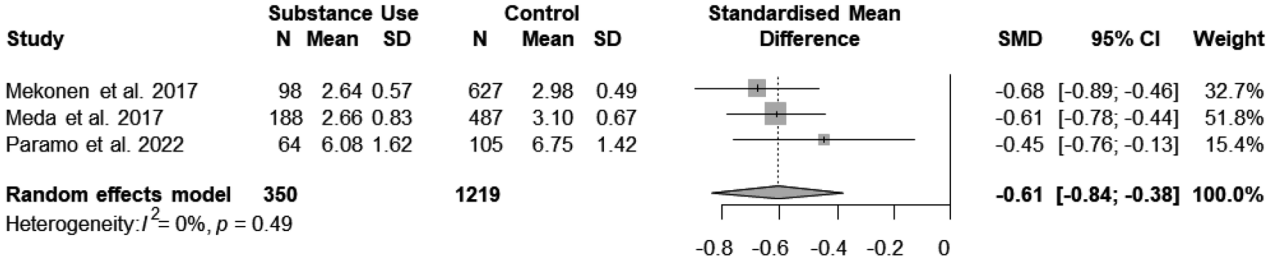
We identified eleven studies [34, 36, 46, 47, 49, 53, 57–59, 61, 62] that assessed academic achievement in relation to substance consumption; however, only three studies [49, 53, 57] reported data for a meta-analysis. Considering these studies, we had 1,219 subjects in the control group and 350 substances consumers. The finding reveals a negative and significant correlation of substance consumption on academic achievement. The strength of association can be considered of medium level (SMD = -0.61; 95% CI -0.84 to -0.38; $p = 0.008$). The heterogeneity among included studies was non-significant ($tau^2 < 0.01$ $I^2 = 0\%$, $p = 0.49$) (Fig. 2).

Alcohol consumption and academic achievement

All studies included in the systematic review reported data on alcohol consumption and academic achievement; however, four studies [16, 49, 53, 57] were useful for assessing the meta-analysis. Considering these studies, we had 2,479 subjects in the control group and 7,134 alcohol consumers. The finding reveals that alcohol consumption is negatively associated with positive academic achievement, but the association is weak as the pooled SMD (– 0.24) was not significant (95% CI – 0.51 to 0.04; $p = 0.073$). The statistical heterogeneity between the studies was high ($tau^2 = 0.02$; $I^2 = 82\%$; $p < 0.01$), but this heterogeneity was not qualitative because no study declared that students with alcohol consumption had better performance compared to students in the control group, except for the differences in the effect size estimated by each study (Fig. 3).

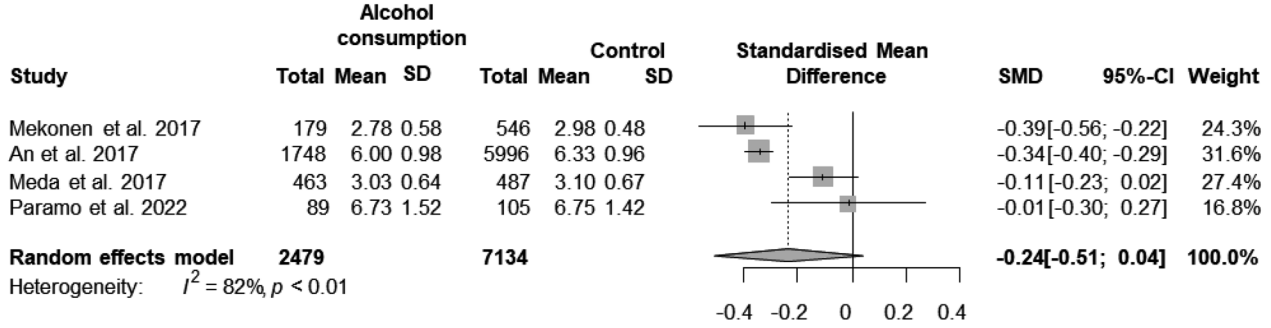
Publication bias assessment

Funnel plots (Figs. 4 and 5) do not show evidence of asymmetry; however, this is difficult to decide due to the few numbers of studies in both meta-analyses. The egger and regression-based tests for funnel plot asymmetry could not be used since there were less than 10 studies.



Legend. SD, standard deviation; I^2, heterogeneity of the studies; SMD, standardised mean difference

Fig. 2 Forest plot of meta-analysis on the consumption of legal and illegal substances and academic achievement



Legend. SD, Standard Deviation; I^2, heterogeneity of the studies; SMD, standardised mean difference

Fig. 3 Funnel plot for consumption of legal and illegal substances and academic achievement meta-analysis

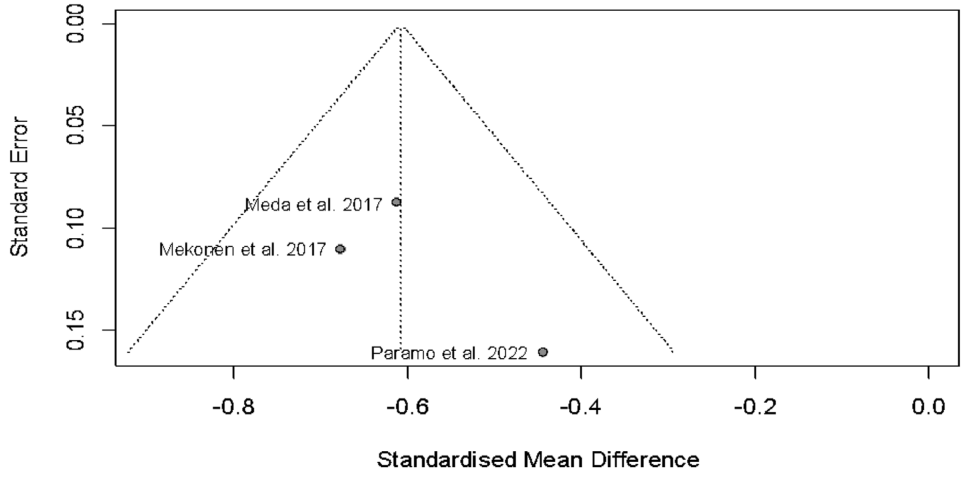


Fig. 4 Forest plot of the meta-analysis on alcohol consumption and academic achievement

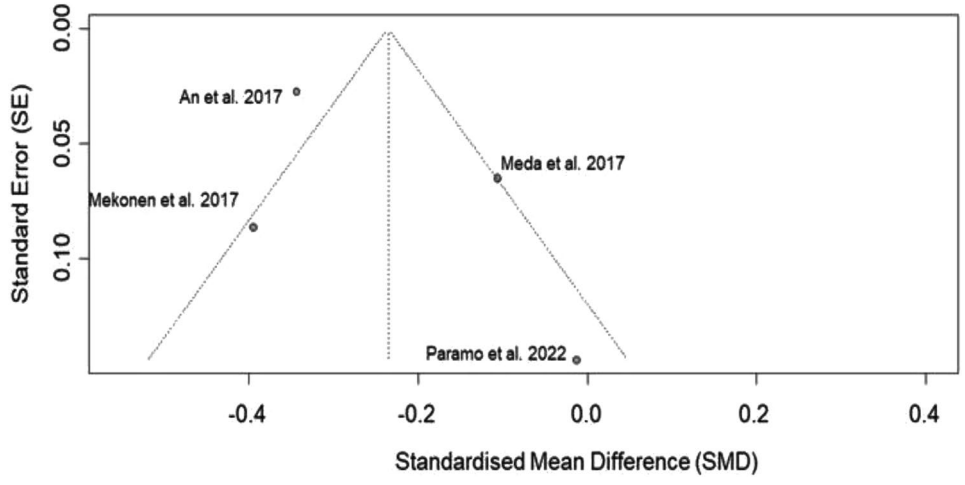


Fig. 5 Funnel plot for alcohol consumption and academic achievement meta-analysis

Sensitivity analysis

As a form of sensitivity analysis, we considered Odds Ratios between substance use and high academic achievement. Definition of usage and achievement were considered as provided by the Authors, as different social and education systems may attribute different considerations of what constitutes a "high achievement".

The included papers were mostly focused on alcohol, and their results suggest that alcohol consumption is linked with poor academic performance. On the other

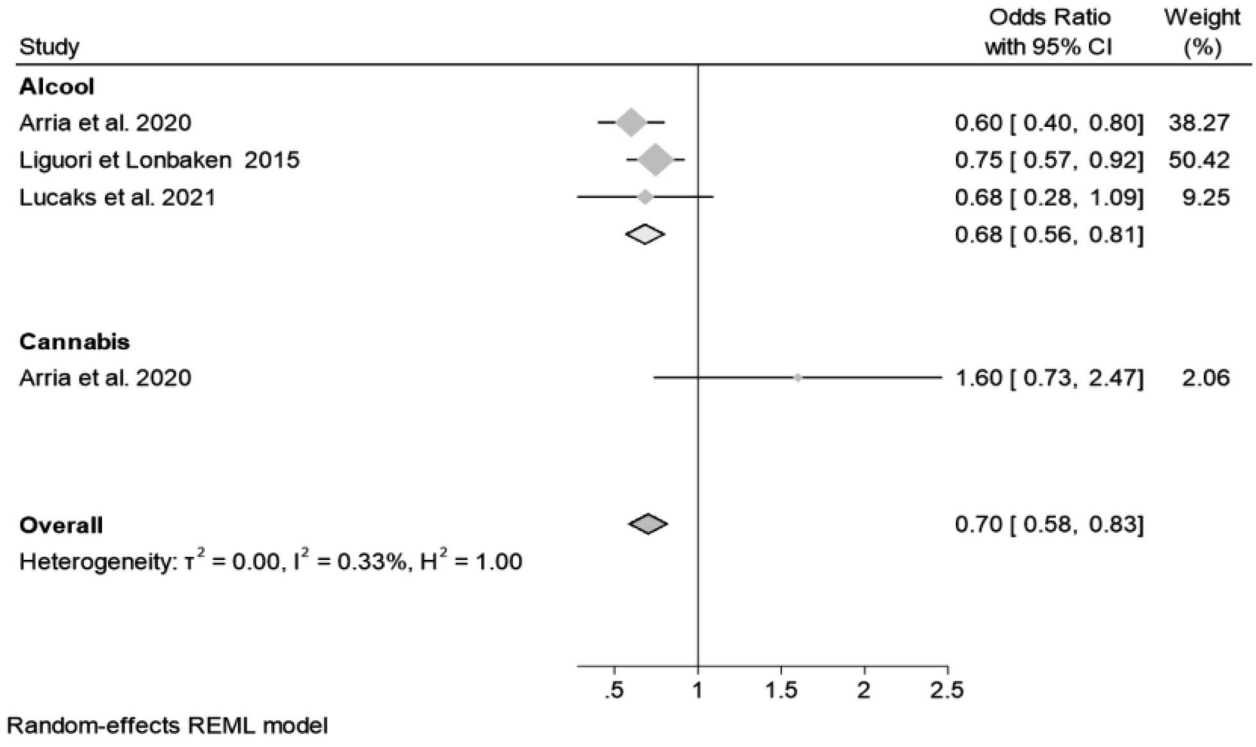


Fig. 6 Funnel plot for consumption of substances and Odds Ratios of High academic performance

hand, the Cannabis subgroup analysis was inconclusive, as only one study arm was available. Overall, substance use seems to be linked to poorer academic performance, as already hinted in the main analysis (Fig. 6).

Discussion

This systematic review provides quantitative evidence on the relationship between legal and illegal use of substances among university students and academic achievement. Three studies [49, 53, 57] reported data for a meta-analysis that included 1,219 subjects in the control group and 350 substances consumers. The finding reveals a negative and significant association between substance consumption and academic achievement, that can be considered of the medium level strength. Furthermore, four studies [16, 49, 53, 57] that considered 2,479 subjects in the control group and 7,134 alcohol consumers suggest that alcohol consumption has a small role in academic achievement. The studies useful for meta-analysis are four only and considered, by the Edwards Score, from low to moderate quality; however, collectively include a substantial number of students, which enhances the overall statistical power of the meta-analysis. A larger sample size allows for more reliable and generalizable conclusions. The heterogeneity among the studies is high for the subgroup (alcohol and academic achievement); however, this heterogeneity is not qualitative because no study declared that students with alcohol consumption had better performance compared to students in the control group, except for the differences in the effect size estimated by each study.

Previous studies reported mixed results [34–36], and this is the first meta-analysis that provides evidence on the role of legal and illegal substances use on academic achievement among university students.

The prevalence of substance use was high in the studies by Mekonen et al. [57], Meda et al. [49], and Paramo et al. [53], in which 28.6%, 57.2%, and 59.3%, respectively, of the students are substance users. Therefore, substance use in university students is a public health priority [4, 23] due to negative consequences on health [2, 4], decision making, attention and memory [13, 76], and, in turn, academic achievement by increasing academic procrastination [18], as well as due to effects on the work market that cause financial loss [77].

Universities should consider prevention and intervention programmes for substance use. Licciardone [78] found that these programmes are unlikely to be successful, but motivational interventions could be effective in reducing students' substance use. In fact, Licciardone [78] found that although student awareness of prevention programs increased during the study period, there was also an increase in parties, drug use, and arrests related to driving under the influence of alcohol or other substances. Larimer et al. [79] found that many preventive and treatment programmes were effective for college

drinking but also for drug prevention. Some behavioral strategies for substance use reduction have already proved somewhat effective. Courses and programmes with direct patient engagement are already well known and diffused for tobacco and cannabinoid usage, and their framework could easily be expanded to also include alcohol and other substances [80]. Recently, digital interventions (such as telemedicine or tele-health services) have also seen a large diffusion and acceptance among patients and healthcare providers, and could also be implemented as strategies to reduce substance use among young people [81–84].

We believe that future research should focus on the effectiveness of preventive and treatment interventions to reduce substance use among university students. However, universities should anonymously monitor substance use among students over time to try to understand the extent of the phenomenon.

Study limitations

This meta-analysis has several limitations that should be acknowledged. While the findings indicate a significant negative association between substance use and alcohol consumption with academic achievement, the strength of the conclusions is constrained by the limited number of eligible studies and their low-moderate quality in the risk of bias assessment. Specifically, only a few studies met the inclusion criteria for the meta-analysis, and among them, just two were longitudinal with a follow-up period of two years [16, 49]. Additionally, there was inconsistency in the measurement of academic achievement across studies. For instance, Paramo et al. [53] used a GPA scale ranging from 1 to 10, whereas An et al. [16] and Mekonen et al. [57] used a 1 to 4 scale. Meda et al. [49] did not report the specific scoring method for academic achievement, further complicating the comparability of outcomes.

Furthermore, the statistical heterogeneity of the studies was not significant about substance use in general and academic achievement, but it was high in the studies that analysed the role of alcohol on academic achievement.

Due to these limitations, the current statistical evidence is insufficient to clarify a strong association between substance or alcohol use and poor academic performance. On the other hand, several primary studies suggest a role, not in terms of association, but attributing drug and alcohol consumption a causal role in shaping academic trajectories, in both direct and indirect ways (for example, lowering rates of class attendance) [85]. Future research should employ more rigorous longitudinal or experimental designs, with larger sample sizes and standardized measures of academic achievement, to better assess this relationship and improve the reliability of findings.

Conclusions

This is the first quantitative synthesis on substance use and academic achievement. This systematic review provides quantitative evidence on the relationship between legal and illegal use of substances among university students and academic achievement. Specifically, we found a significant medium association of substance use in general and a small impact of alcohol consumption on academic achievement. Although this study has some methodological limitations, it offers a preliminary point estimate that may be useful as a reference for researchers during the planning stages of future primary studies, particularly for sample size estimation. This estimate should be interpreted with caution, but it may help inform early design considerations while highlighting the need for further, more robust investigations.

These findings could be also useful for universities and help us to present other hypotheses about the interventions that could prevent or reduce substance use among university students. Universities should be involved in increasing student awareness about the damage from substance use, monitoring the substance use of students, and promoting preventive and treatment intervention programmes. Future research should focus on the efficacy of these programmes in higher education. To strengthen the evidence base, future research should employ robust longitudinal or experimental designs with standardized measures of academic achievement, larger and more diverse samples, and clearer reporting practices. This would provide more reliable insights into the long-term effects of substance use on student outcomes and inform more effective policy and intervention strategies within university settings.

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

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Author contributions

G.B., F.I., F.S., R.M., I.S., A.V., M.M.: Designed the study and conceived the data, extracted data, performed the analysis, interpretation of data, drafted the manuscript and approved it. A.P., S.U., M.C., E.V., and R.A assisted in designing the study and data, interpretation, prepared figures, searched and screened the studies, and critically reviewed the manuscript. All authors read and approved final manuscript.

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Data availability
Available from the corresponding author on reasonable request.

Declarations

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Competing interests
The authors declare no competing interests.

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