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Risk Factors Associated with Driving After Marijuana Use among US College Students During the COVID-19 Pandemic

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Abbreviation list: (alphabetical)
Adjusted odds ratio (AOR)
Alcohol, Smoking and Substance Specific Involvement Test (ASSIST)
Alcohol use disorder (AUD)
American College Health Association-National College Health Assessment III (ACHA-NCHA III)
Confidence intervals (CIs)
Coronavirus disease 2019 (COVID-19)
Driving after marijuana use (DAMU)
Odds ratios (OR)
Suicide Behaviors Questionnaire-Revised (SBQ-R)
Substance use disorder (SUD)
United States (U.S.)

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Abstract

Purpose: To assess the sociodemographic and behavioral risk factors associated with driving after marijuana use among US college students.

Methods: A secondary analysis used the Fall 2020 and Spring 2021 American College Health Association- National College Health Assessment III and the dataset was restricted to college students ≥ 18 years of age who reported recent driving and marijuana use. Associations between risk factors and driving after marijuana use were estimated using multivariable logistic regression.

Results: A total of 29.9% (n=4,947) of the respondents reported driving after marijuana use. Males (adjusted odds ratio [AOR]: 1.64, 95% confidence interval [CI]:1.48-1.82), non-Hispanic Black (AOR: 1.32, 95% CI:1.02-1.71), sexual minorities (AOR:1.19, 95% CI: 1.07-1.31), individuals with an alcohol or substance use disorder (AOR: 1.44, 95% CI:1.08-1.91), anxiety (AOR: 1.20, 95% CI: 1.06-1.36), higher suicidality (AOR: 1.18, 95% CI: 1.07-1.31), and those who also drank and drove (AOR: 3.18, 95% CI: 2.84-3.57) had a higher risk of driving after marijuana use.

Conclusions: Future research should focus on increasing awareness of driving after marijuana use and prevention programs and/or strategies on college campuses regarding driving after marijuana use for these groups to reduce this risky behavior.

Keywords: Driving after marijuana use, college students, COVID-19, injury epidemiology

Implications and Contribution

Driving after marijuana use is an important public health issue among college aged students in the US. A national survey of US college students showed decreasing trend in driving after marijuana use. However, significant effort must be done to increase prevention programs on college campuses regarding driving after marijuana use.

Introduction

Marijuana is the most prevalent non-alcoholic drug identified among drivers involved in motor vehicle collisions(1). The 2018 National Survey on Drug Use and Health found that 12 million (4.7%) United States (U.S.) individuals aged ≥ 16 years reported driving under the influence of marijuana in the past 12 months (1). As of 2021, 36 states have enacted legislation to decriminalize marijuana for medical use. Among those, 18 states, two U.S. territories, and the District of Columbia have decriminalized marijuana for recreational use (2). Additionally, past year marijuana use has increased from 38% in 2015 to 44% in 2020 among college students (3).

Compared to more experienced drivers, marijuana-impaired driving is particularly salient for young, inexperienced drivers who have a higher crash risk (4). Drivers aged 21-25 years of age have the highest prevalence of driving under the influence of marijuana (1, 5), and college students are a population at increased risk of substance-related impaired driving (6, 7). Although driving under the influence of alcohol has decreased in the U.S. among youth over the last few decades, rates of driving after marijuana use (DAMU) have stayed consistent or risen (5). Additionally, many U.S. campuses have programs aimed at reducing alcohol impaired driving and underage drinking, but do not have drugged driving prevention programs (8).

Several studies have reported increased alcohol and drug consumption during the coronavirus disease 2019 (COVID-19) pandemic, including the use of marijuana (9, 10). College

students have suffered heightened stress, decreased social connectedness, and higher anxiety about academic performance and job pressure (11) as a result of the sudden societal changes implemented during the COVID-19 pandemic, such as university closures. These factors may have significantly contributed to increased drug use and increased risk behaviors that are positively associated with increased drug use, including drug-impaired driving (12).

To date, no published studies have investigated DAMU among college students during the COVID-19 pandemic. To fill the gap in the extant literature, this study: 1) describes the prevalence of DAMU among US college students who drive and also report recent marijuana use, and 2) identifies sociodemographic and behavioral risk factors associated with DAMU among these college students during the COVID-19 pandemic. Findings from this study may inform the development of public health or campus prevention programs aimed at reducing DAMU.

Methods

Data Source

The data source used for this cross-sectional study was the Fall 2019-Spring 2021 [1]American College Health Association-National College Health Assessment III (ACHA-NCHA III). The ACHA-NCHA III is a voluntary national survey of college students administered by the ACHA that collects detailed information about students' health habits and behaviors, including substance use, physical and mental health, and personal safety and violence, using sets of validated and reliable instruments (13). These survey years were selected because the survey was redesigned to include DAMU starting in Fall 2019 and included COVID-19 related questions

[1] Fall and Spring semesters are the two intakes for admission purposes among US universities. The Fall semesters usually starts in the late August or early September and ends in late December/early January. The Spring semesters begins in January and ends in early May.

starting in Fall 2020. In total, 13,373 and 96,489 students completed surveys in the Fall 2020 and Spring 2021, respectively. The response rate was 13.9% in Fall 2020 and 12.8% in Spring 2021. The ACHA-NCHA III is currently administered as a web-based survey via sending an email invitation to a random sample of students identified by their institution. College students ≥18 years of age are eligible to participate. As this dataset was de-identified, it did not qualify as human subjects' research by the Institution Review Board at West Virginia University.

Study Population

The sample was restricted to respondents who had both used marijuana within the last 30 days and driven a vehicle in the previous 30 days. Specifically, respondents who selected, '*Within the last 2 weeks*', or, *'More than 2 weeks ago but within the last 30 days,'* about cannabis/marijuana use (*When, if ever, was the last time you used cannabis/marijuana? Please include medical and non-medical use)* and driving history (*When, if ever, was the last time you drove a car or other vehicle?*) were included in the study population. The flow chart of the study population is shown in **Figure 1**.

Variables

Dependent variable

Engaging in DAMU: If respondents reported having both used marijuana and driven a vehicle in the previous 30 days, they were presented with the question, "*Within the last 30 days, did you drive within 6 hours of using cannabis/marijuana?"*. If they answered *'yes'*, they were considered to have engaged in DAMU. Those who answered *'no'* to this question were coded as not having engaged in DAMU. Participants who skipped this question were excluded from the sample.

Independent variables

The independent variables were categorized as demographic characteristics, driving characteristics, substance use behaviors, behavioral health problems, and mental health concerns. The ACHA-NCHA III questions used to classify each variable in these analyses are shown in **Appendix Table 1**. These variables were considered as confounders of DAMU (14-20).

Demographics: Year in school (*Undergraduate, Masters, Doctorate*) was categorized based on the recorded education variable in ACHA-NCHA III. '*Undergraduate*' included participants attending college for undergraduate from 1st year to 5th years or more. '*Masters*' included attending college for master's degrees (i.e., MA, MS, MFA, etc.). '*Doctorate*' included attending college for doctoral degrees (i.e., PhD, EdD, etc.). Sexual orientation was based on answers to the question, "*What term best describes your sexual orientation?*" Those who identified as '*Bisexual*', '*Gay*', '*Lesbian*', '*Pansexual*', '*Queer*', or '*Questioning*' were classified as '*sexual minorities'*. Ethnicity/Race (*Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Other, Multiple races, Hispanic/Latino*) used the recorded race variable. '*Non-Hispanic Other*' included non-Hispanic American Indian or Native Alaskan, non-Hispanic Asian or Asian American, non-Hispanic Middle Eastern/North African or Arab Origin, and non-Hispanic Native Hawaiian or Other Pacific Islander Native. Greek organization member was based on answers to the question, "*Are you a member of a social fraternity or sorority?*" If they answered "*yes*", they were considered as a member of the Greek organization. Those who answered "*no*" to this question was coded as not a member of the Greek organization.

Driving characteristics: The variable indicating previous collisions was based on the answers to the question, "*Within the last 12 months, how many times have you been involved in*

an accident when you drove a car or other vehicle?" If a respondent answered, '*no accidents*,' in this question were identified as '*no*'. Those who answered '*one accident*', '*two accidents*', '*three or more accidents*', were identified as '*yes*'. Driving while drinking was categorized based on participants who answered, "*Within the last 30 days, did you drive after drinking any alcohol at all?*" This question was only available for participants to answer when they drove a car or vehicle in the last 30 days and selected, '*Within the last 2 weeks*' in question, "*When, if ever, was the last time you drank alcohol?*". A continuous variable, days of driving with the past 2 weeks, was based on the answers to the question, "*Within the last 2 weeks, how many days did you drive a car or other vehicle?".*

Hazardous or Harmful Alcohol or Drug Use: The item, "*Over the last two weeks, how many times have you had five or more drinks (males) or four or more drinks (females) containing any kind of alcohol at a sitting?*", was used to assess binge drinking as per the Centers for Disease Control and Prevention's (CDC) definition (21). Those who answered, '*none*', were categorized as '*no*'; those who answered > 1 time were categorized as '*yes*'. The Alcohol, Smoking and Substance Specific Involvement Test (ASSIST) scores (22) was used to measure hazardous or harmful alcohol or drug use and were coded in ACHA-NCHA III. For hazardous or harmful alcohol use, ASSIST scores '*0-10*' indicate '*low risk*', '*11-26*' indicate '*moderate risk*', and '*>=27*' indicates '*high risk*'. For hazardous or harmful marijuana use, ASSIST scores '*0-3*' indicate '*low risk*', '*4-26*' indicates '*moderate risk*', and '*>=27*' indicate '*high risk*'.

Behavioral health problems: Diagnosed alcohol or substance use disorder (AUD/SUD), diagnosed anxiety, and diagnosed depression were categorized based on self-reported chronic conditions variables. Participants were asked whether they were ever diagnosed by a healthcare or mental health professional for these conditions. Those who answered *'yes'* for each variable

were identified as diagnosed with 'alcohol or drug-related abuse or addiction', anxiety, or depression.

Mental health: Suicide risk was assessed in the ACHA-NCHA III using the Suicide Behaviors Questionnaire-Revised (SBQ-R) instrument(23); total scores 3-6 were indicate no suicide risk and scores 7-18 indicate at-risk of suicide. Financial stress due to COVID-19 was defined based on the answers to the question, "*How has your current financial situation been affected by the COVID-19 pandemic?*" Those who answered, '*a lot more stressful*' or '*somewhat more stressful*' were coded as '*more stressful*'; those who answered, '*somewhat less stress*' or '*a lot less stressful*' were coded as '*less stressful*', while those who answered, '*no significant change*' were coded as '*no change*'. Overall stress level due to COVID-19 was identified based on the answers to the question, "*How has your current overall level of stress been impacted by the COVID-19 pandemic?*". Those who identified as '*significantly increased my level of stress*' or '*somewhat increased my level of stress*' were classified as '*increased*'; those who identified as '*somewhat decreased my level of stress*' or '*significantly decreased my level of stress*' were classified as '*decreased*'; those who answered, '*no change in my level of stress*' were classified as '*no change*'.

Statistical analysis

The percentage of respondents who reported DAMU from Fall 2019 to Spring 2021 were plotted using Microsoft Excel. Both descriptive statistics and logistic regression analyses were restricted to Fall 2020 and Spring 2021 as these periods asked about COVID-19 induced stress, which could have been a confounder of DAMU. Descriptive statistics were used to summarize the data and frequencies and percentages of all the independent variables were used to compare the respondents with and without DAMU. All binary variables were analyzed using Chi-Square tests

and all ordinal variables were analyzed using Cochran-Armitage Trend tests with Modified Ridit scoring. Bivariate and multivariable logistic regression analyses were used to determine which independent variables were associated with DAMU using complete case analysis for missing values. A bivariate model was first conducted between each independent variable and the outcome to calculate unadjusted odds ratios (OR) and 95% confidence intervals (CIs). Variable inclusion in the multivariable logistic regression model was based on the bivariate regression model results; if an independent variable was associated with DAMU at alpha ≤ 0.20, it was included in the multivariable model to calculate adjusted odds ratios (AOR) and 95% CIs. Collinearity was assessed using tolerance and variance inflation factor prior to adding the independent variable to the multivariable regression model. Any variable with a tolerance <0.2 or variance inflation factor >5 was considered highly correlated (24). No collinearity was observed. In addition, in order to verify whether selection bias was present, a sensitivity analysis was conducted to estimate the association between covariates and DAMU by adding participants who drove a vehicle but skipped the question about DAMU (**Appendix Table 2)**. Those participants were considered not engaged in DAMU as they did not use marijuana. All analyses were conducted using SAS Version 9.4. Two tailed hypothesis tests were utilized with α=0.05.

Results

Over the four-semester period, the trends of DAMU among US college students changed, and the data suggested a decreasing trend in DAMU (**Appendix Figure 1**). However, the mean days of driving in the past 2 weeks among students who reported DAMU from Spring 2020 to Spring 2021 did not change significantly (**Appendix Figure 2**). Descriptive demographic and driving characteristics of DAMU are summarized in **Table 1**. Overall, 16,531 respondents in the Fall

2020 and Spring 2021 surveys met the inclusion criteria of having both used marijuana and driven within the past 30 days, and 29.9% (n=4,947) reported DAMU. Nearly 31.2% of undergraduates reported DAMU. In respect to gender, 36.2% of males reported DAMU, while only 27.2% of females reported DAMU. Although the majority of respondents were Non-Hispanic White (71.7%), Non-Hispanic Black were more likely to report DAMU compared with non-Hispanic Whites (37.7% vs. 30.9%). Over half of respondents who reported drinking while driving also reported DAMU, but only 25.5% of those who did not drink while driving reported DAMU. Descriptive statistics on substance use behaviors, behavioral health problems, and mental health characteristics of DAMU are summarized in **Table 2**. DAMU was reported by 43.2% of respondents that had high alcohol risk and 72.1% of respondents with high marijuana risk. Over 50% of respondents who were ever diagnosed with alcohol or drug-related abuse reported DAMU. Respondents with a positive screen for suicide were more likely to report DAMU compared with those who had a negative screen for suicide (35.8% vs. 26.3%). Most respondents experienced increased financial or overall stress during the pandemic, with 66.8% of respondents who answered the DAMU question reported increased financial stress due to COVID-19 and 92.2% of those reported increased overall stress due to COVID-19.

The AORs and 95% CIs from the final multivariable logistic regression are shown in **Table 3**. In the multivariable model, the odds of DAMU were higher among respondents who were undergraduates (AOR: 1.68; 95% CI: 1.42-1.98) and master students (AOR: 1.47; 95% CI: 1.21-1.79) compared to doctoral students, males (AOR: 1.64; 95% CI: 1.48-1.82) compared to females, non-Hispanic Black (AOR: 1.32; 95% CI: 1.02-1.71) compared to non-Hispanic Whites, and sexual minorities (AOR: 1.19, 95% CI: 1.07-1.31). Additionally, the odds of DAMU were higher among students who reported having a diagnosed AUD/SUD (AOR: 1.44, 95% CI:

1.08-1.91) or anxiety (AOR: 1.20, 95% CI: 1.06-1.36), and those that were a positive screen for suicidality (AOR: 1.18, 95% CI: 1.07-1.31). Compared to respondents with low marijuana risk, the odds of DAMU were nearly 7 times higher among those who had moderate marijuana risk and 36 times higher among those who had high marijuana risk. There was a significant association between DAMU and some risky driving behaviors, including drinking while driving (AOR: 3.18, 95% CI: 2.84-3.57) and being involved in a collision within the previous 2 weeks (AOR: 1.20, 95% CI: 1.03-1.40). For every one-day increase in driving, there were 7% higher odds of DAMU. However, there were no significant associations between financial stress or overall stress due to COVID-19 and DAMU.

A sensitivity analysis was used to investigate the association between eligible covariates and DAMU among respondents who drove a vehicle but skipped or did not see the DAMU question (due to skip patterns in the questionnaire) (**Appendix Table 2)**. After adjusting for covariates, the results were similar. However, binge drinking had a significant association with DAMU (AOR: 1.19, 95% CI:1.09-1.31). Additionally, belonging to a Greek organization was not associated with DAMU (AOR: 0.96, 95% CI:0.84-1.09) after adjusting for all covariates in the final multivariable model.

Discussion

This study sought to identify sociodemographic and behavioral risk factors associated with DAMU among US college students during the COVID-19 pandemic. This study found that DAMU was associated with being an undergraduate student, male, non-Hispanic Black, sexual minority, and with some mental health (i.e., anxiety, suicide), or substance use issues (i.e., AUD/SUD, marijuana use dependence). Risky driving behaviors, such as drinking and driving and being involved in a previous collision, were associated with DAMU as well.

Although the number of respondents changed each semester, the percentage of students who reported DAMU steadily declined after Spring 2020 when the COVID-19 response began in the US. This finding can be partly explained by public health measures implemented to reduce the spread of COVID-19. Many colleges and universities limited social interactions by changing from in-person classes to online formats. States also implemented social distancing and stay-at-home orders. Due to this reason, students also might have lived with their parents and could not access marijuana under their parents' supervision. Therefore, students were not driving or may have had reduced access to marijuana. However, they likely began to socialize and their access to marijuana increased when restrictions were eased, which may have led to them DAMU(25).

In addition to the observed trends, this study found that males had a higher risk of DAMU compared to females, a finding consistent with previous studies(15, 19, 20). This finding can likely be explained by the differences in risk perception between the sexes. Previous studies have shown that male adolescents are less risk adverse compared to females (26), and males may be more likely to engage in a variety of high-risk behaviors (27). The present study also showed that sexual minorities have a higher risk of DAMU compared to heterosexuals; previous studies identified that sexual minorities are more likely to drive under the influence of illicit drugs (28).

The present study also found a strong association between driving after drinking and DAMU, which is consistent with previous studies (14, 15, 17, 20, 29). The data analyzed in this study did not assess DAMU with alcohol simultaneously. Although the present study showed that 54.1% of respondents who reported DAMU were also involved in driving after drinking, this potentially indicates that these substances were used concomitantly. Among the risk factors identified in the analysis, marijuana use dependence was identified as the strongest predictor of DAMU, which is consistent with other studies (14, 20, 28). Also, anxiety was associated with

DAMU which can be partly explained by those students who may use marijuana as "self-medication" to deal with symptoms of anxiety (30). The current study does not indicate that financial and overall stress due to the COVID-19 were associated with DAMU. This finding is likely because the majority of respondents experienced increased financial or overall stress during the pandemic.

While this study found several sociodemographic and behavioral risk factors associated with DAMU among college students, it is not without limitations. First, the NCHA-NCHA III does not contain items about the perceived beliefs and dangerousness of DAMU and the age of first marijuana use; previous studies have found that social norms (16, 20) and the age of first marijuana use (29) were associated with DAMU. Second, the data used in this study were self-reported by the students and thus subject to limitations of recall bias and reporting bias. Therefore, it is unknown whether respondents who reported DAMU were more likely to skip the question. Third, another limitation is the timing of when both driving and marijuana use occurred; that is, the dependent variable only applies to recent DAMU, and it may not reflect DAMU more than 30 days ago. Additionally, the primary outcome was driving within six hours of using marijuana. However, it is difficult to identify the true duration of marijuana's impact on driving with limited knowledge of dose and quantity used; it is not clear if these drivers were actually considered impaired, although it is supported by a report that THC may persist in blood from a single administration for more than 6 hours (31). The effects might vary more between individuals than they do with alcohol because of tolerance, differences in administration route (smoking versus oral ingestion), and varying Δ9-tetrahydrocannabinol (THC) absorption rates(32). Next, the causal relationships could not be determined due to the cross-sectional nature of the data. Lasty, a list of institutions that participated in the ACHA-NCHA III each semester

could not be obtained. It is possible that not all institutions participated each year or even each semester and not all colleges and universities are members of the NCHA, which may limit generalizability. Additionally, female respondents were over-represented (i.e., 70% of respondents who reported recent driving and marijuana use were females). Also, sample size may not be as representative of all US college students with an average 13% response rate each semester.

The number of motor vehicle crash fatalities in the U.S. increased 7.2% from 2019 to 2020 despite decreases in driving in 2020 due to stay-at-home orders enacted during the COVID-19 pandemic (33). Marijuana is one of the most common substances detected in fatal motor vehicle crashes, particularly among young drivers. The main psychoactive component of marijuana, active Delta-9-tetrahydrocannabinol (THC), had a significantly higher prevalence among seriously or fatally injured road users involved in motor vehicle collisions who presented at five US high-flow level 1 trauma centers and medical examiners during the pandemic compared to pre-COVID-19, and it was more prevalent among those road users during the COVID-19 pandemic compared to alcohol (34). Although research has shown that marijuana use impairs driving performance, including cognition, attention, reaction time, and vigilance (35), the effects of marijuana on driving performance are not predictable due to different individual characteristics (i.e., tolerance, frequent vs. occasional users) (36, 37) and marijuana itself (i.e., dosage, administration route) (37). Additionally, in contrast to alcohol, which is more easily excreted from the body and has known limits for impairment, we have yet to determine a gold-standard for driving impairment following marijuana use and is still detectable in body fluids long after impairment has stopped (31, 38). Assessment of DAMU might only be established with collection and testing of a biological sample and trained drug recognition experts to help

identify drug impairment (39). From a public health perspective, it is probable that concerns regarding DAMU will become more common as states enact recreational and medical marijuana laws (2, 40, 41). It is critical that drivers, as well as young drivers, are made aware of these concerns.

Significant effort must be done to increase prevention programs on campus to focus on DAMU. Additionally, extra efforts to improve education and knowledge of the negative consequences of DAMU on public health, transportation, as well as the general public, particularly younger generations, who have frequent misconceptions and inconsistent beliefs associated with DAMU, are also necessary (36). Compared to alcohol, it may be difficult for young adults to quantify marijuana-related impairment as there are no clear dosing guidelines and potency of marijuana can vary (36). Additionally, young adults might be confused about the laws governing driving under the influence of marijuana given the uncertain legal limit for marijuana, the significant diversity of policies among states, and the lack of reliable and valid tests for detecting marijuana-related driving impairment (36). Future research should be conducted to increase awareness among younger generations and identify effective strategies for changing attitudes against DAMU among drug-using peer networks. Lastly, increased enforcement of existing laws regarding DAMU may be warranted in college communities. In addition, prevention efforts on campuses should aim at reducing DAMU among either the entire campus or high-risk groups such as those who have mental health or existing substance use issues. Student health or mental health clinics may be a viable option for implementing such interventions.

DAMU is an important public health issue especially among college aged students. This study found that approximately 30% of respondents to a national survey of US college students

reported recent DAMU during the COVID-19 pandemic. Various risk factors associated with DAMU were identified as well in this study, such as college students who are male, non-Hispanic Black, sexual minorities, had alcohol or substance use disorder, anxiety, higher suicidality, and involved in drinking and driving. While various interventions exist for drinking and driving (8), very few interventions target DAMU on college campuses. Therefore, future research should focus on increasing awareness among those college-aged students who are considered most likely to engage in DAMU, and those groups can be the intervention targets. Prevention efforts and/or strategies, including laws or policies regarding drinking and driving, DAMU and driving, mental health and substance use interventions, to reduce this potentially life-threatening behavior on college campuses.

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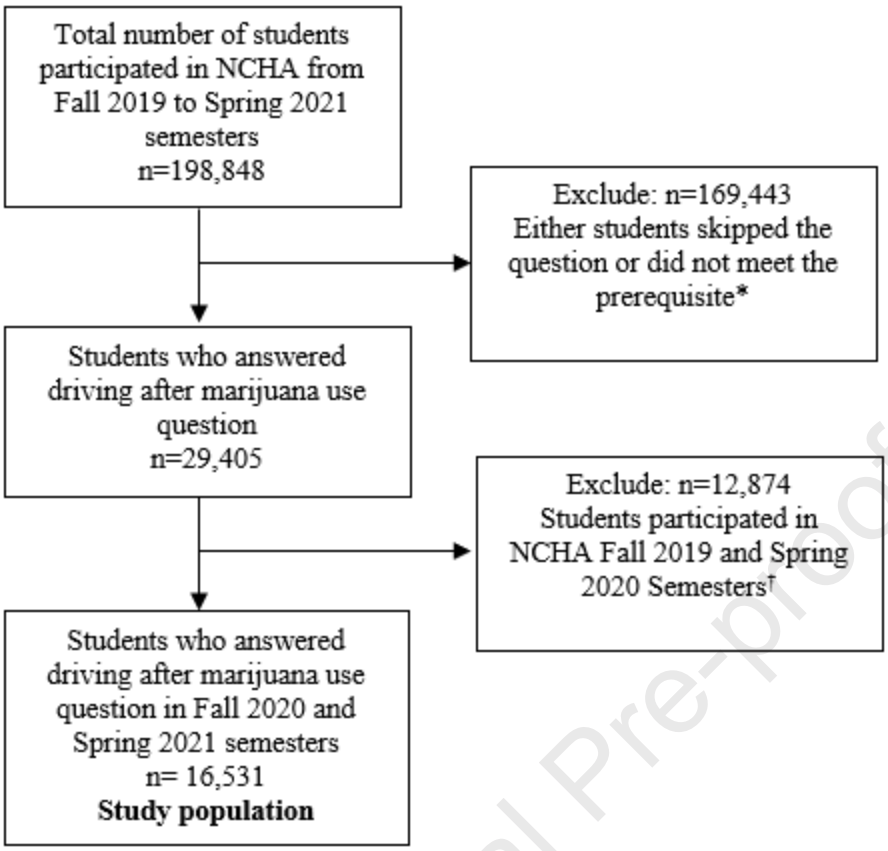

Figure 1: Flow chart of study population

*The driving after marijuana use question was available for participants to answer if they drove in the last 30 days and used cannabis within the last 30 days

†During the Spring 2020 semester, schools that began data collection after March 16, 2020, were not included in the reference group due to the COVID-19 pandemic

Table 1. Demographic and Driving Characteristics of DAMU on Both Fall 2020 and Spring 2021 Semesters (N=16531) *

Variables	Total	DAMU		P-value†
		Yes	No	
	16531 (100%)	4947 (29.9%)	11584 (70.1%)	
Demographic Characteristics				
School year				**<.0001**
Undergraduates	12349 (74.8%)	3857 (31.2%)	8492 (68.8%)	
Masters	2285 (13.9%)	647 (28.3%)	1638 (71.7%)	
Doctoral	1601 (9.7%)	360 (22.5%)	1241 (77.5%)	
Others	265 (1.6%)	74 (27.9%)	191 (72.1%)	
Missing	31	9	22	
Gender				**<.0001**
Male	4940 (29.9%)	1789 (36.2%)	3151 (63.8%)	
Female	11556 (70.0%)	3147 (27.2%)	8409 (72.8%)	
Others	2 (0%)	0 (0%)	2 (100%)	
Missing	33	11	22	
Sexual identity				**<.0001**
Straight/heterosexual	10719 (65.1%)	3060 (28.6%)	7659 (71.5%)	
Sexual minorities§	5753 (34.9%)	1871 (32.5%)	3882 (67.5%)	
Missing	59	16	43	
Enrollment Status				**0.0928**
Full-time	14825 (90.1%)	4407 (29.7%)	10418 (70.3%)	
Part-time	1553 (9.4%)	493 (31.8%)	1060 (68.3%)	
Other	81 (0.5%)	26 (32.1%)	55 (67.9%)	
Missing	72	21	51	
Ethnicity/Race				**<.0001**
Non-Hispanic White	11708 (71.7%)	3616 (30.9%)	8092 (69.1%)	
Non-Hispanic Black	632 (3.9%)	238 (37.7%)	394 (62.3%)	
Non-Hispanic Other	1631 (10.0%)	376 (23.1%)	1255 (77.0%)	
Multiple races	421 (2.6%)	122 (29.0%)	299 (71.0%)	
Hispanic/Latino	1941 (11.9%)	530 (27.3%)	1411 (72.7%)	
Missing	198	65	133	
Greek Organization Member				0.7332
Yes	1783 (10.8%)	527 (29.6%)	1256 (70.4%)	
No	14712 (89.2%)	4406 (30.0%)	10306 (70.1%)	
Missing	36	14	22	
Cumulative grade average				**<.0001**
A	9131 (56.4%)	2424 (26.6%)	6707 (73.5%)	
B	5860 (36.2%)	1975 (33.7%)	3885 (66.3%)	
C or less	1187 (7.3%)	448 (37.7%)	739 (62.3%)	
Missing	353	100	253	
Driving Characteristics				
Previous Collisions				**<.0001**
Yes	1431 (8.7%)	530 (37.0%)	901 (63.0%)	
No	15081 (91.3%)	4411(29.3%)	10670 (70.8%)	
Missing¶	19	6	13	
Driving after drinking				**<.0001**
Yes	2373 (14.4%)	1283 (54.1%)	1090 (45.9%)	
No	12342 (74.7%)	3149 (25.5%)	9194 (74.5%)	
Missing	1815 (11.0%)	515 (28.4%)	1300 (71.6%)	
	Mean Sd	Mean Sd	Mean Sd	**<.0001**
Days of driving within the past 2 weeks	8.57 4.42	9.62 4.04	8.10 4.50	

* Descriptive analysis used to compare DAMU vs. not DAMU counts and row percentages. The "total" column used column percentages. Percentages may not equal to 100% because of rounding. Sample size for each independent variable varies based on the missingness.

† P-value for Chi-square test statistics was used for binary variables and Cochran-Armitage trend test for ordinal variables. Variables with p-value <0.2 in bold are selected for multivariable analysis.

§ Includes asexual, bisexual, gay, lesbian, pansexual, queer, and questioning

¶ The missing value might include participants who drove a car longer 2 weeks because the previous collision variable only captured participants who drove a car within 2 weeks.

Table 2. Substance Use Behaviors, Behavioral Health Problems, and Mental Health Characteristics of DAMU on Both Fall 2020 and Spring 2021 Semesters (N=16531) *

Variables	Total	DAMU		p-value†
		Yes	No	
	16531 (100%)	4947 (29.9%)	11584 (70.1%)	
Hazardous/harmful alcohol or drug use				
Alcohol risk§				**<.0001**
Low	11106 (67.2%)	3114 (28.0%)	7992 (72.0%)	
Moderate	3746 (22.7%)	1338 (35.7%)	2408 (64.3%)	
High	389 (2.4%)	168 (43.2%)	221 (56.8%)	
Missing	1290 (7.8%)	327 (25.4%)	963 (74.7%)	
Marijuana risk¶				**<.0001**
Low	2920 (17.7%)	206 (7.1%)	2714 (93.0%)	
Moderate	11421 (69.1%)	3896 (34.1%)	7525 (65.9%)	
High	1687 (4.2%)	495 (72.1%)	192 (28.0%)	
Missing	1503 (9.1%)	350 (23.3%)	1153 (76.7%)	
Binge drinking**				**<.0001**
Yes	7298 (44.2%)	2354 (32.3%)	4944 (67.7%)	
No	5776 (34.9%)	1556 (26.9%)	4220 (73.1%)	
Missing	3457 (20.9%)	1037 (30.0%)	2420 (70.0%)	
Behavioral health problems				
Diagnosed AUD/SUD				**<.0001**
Yes	409 (2.5%)	212 (51.8%)	197 (48.2%)	
No	16000 (97.5%)	4699 (29.4%)	11301 (70.6%)	
Missing	122	36	86	
Diagnosed anxiety				**<.0001**
Yes	6825 (41.6%)	2316 (33.9%)	4509 (66.1%)	
No	9596 (58.4%)	2600 (27.1%)	6996 (72.9%)	
Missing	110	31	79	
Diagnosed depression				**<.0001**
Yes	5956 (36.3%)	2088 (35.1%)	3868 (64.9%)	
No	10453 (63.7%)	2825 (27.0%)	7628 (73.0%)	
Missing	122	34	88	
Mental health				
Suicide risk††				**<.0001**
Positive screening	6302 (38.3%)	2255 (35.8%)	4047 (64.2%)	
Negative screening	10151 (61.7%)	2667 (26.3%)	7484 (73.7%)	
Missing	78	25	53	
Financial stress due to COVID-19				**0.0199**
More stressful	11038 (66.8%)	3414 (30.9%)	7624 (69.1%)	
No change	4516 (27.3%)	1211 (26.8%)	3305 (73.2%)	
Less stressful	968 (5.9%)	319 (33.0%)	649 (67.1%)	
Missing	9	3	6	
Overall stress due to COVID-19				**0.0061**
Increased	15223 (92.2%)	4520 (30.0%)	10703 (70.3%)	
No change	876 (5.3%)	270 (30.8%)	606 (69.2%)	
Decreased	419 (2.5%)	152 (36.3%)	267 (63.7%)	
Missing	13	5	8	

Abbreviation: COVID-19=coronavirus 2019; AUD= alcohol use disorder; SUD= substance use disorder

* Descriptive statistics used to compare DAMU vs. not DAMU counts and row percentages. The "total" column used column percentages. Percentages may not equal to 100% because of rounding. Sample size for each independent variable varies based on the missingness.

† P-value for Chi-square test statistics was used for binary variables and Cochran-Armitage trend test for ordinal variables. Variables with p-value <0.2 in bold are selected for multivariable analysis.
§ Score with 0-10 for low risk, 11-26 for moderate risk, and >=27 for high risk for alcohol based on Alcohol, Smoking and Substance Specific Involvement Test (ASSIST)
¶ Score with 0-3 for low risk, 4-26 for moderate risk, and >=27 for high risk for marijuana based on ASSIST
** Participants can only answer this question when they drank alcohol within the last 2 weeks. According to the CDC's definition, binge drinking is considered as 5 or more drinks for male or 4 or more drinks for females containing any kind of alcohol at a sitting.
†† Cut-off point of =>7 for at-risk of suicide based on the Suicide Behavior Questionnaire-Revised (SBQ-R)

Table 3. Sociodemographic and behavioral risk factors associated with driving after marijuana use among US college students*

Variables	Bivariate model OR (95% CI)	Multivariable model† AOR (95% CI) (n=10,810)
School year		
Undergraduates	**1.57 (1.38, 1.77)**	**1.68 (1.42, 1.98)**
Masters	**1.36 (1.17, 1.58)**	**1.47 (1.21, 1.79)**
Doctoral	ref	ref
Others	1.34 (1.00, 1.79)	**1.73 (1.18, 2.54)**
Gender		
Male	**1.52 (1.41, 1.63)**	**1.64 (1.48, 1.82)**
Female	ref	ref
Sexual identity		
Straight/Heterosexual	ref	ref
Sexual minorities §	**1.21 (1.13, 1.29)**	**1.19 (1.07, 1.31)**
Enrollment status		
Full-time	ref	--
Part-time	1.10 (0.98, 1.23)	--
Others	1.12 (0.70, 1.78)	--
Ethnicity/race		
Non-Hispanic White	ref	ref
Non-Hispanic Black	**1.35 (1.15, 1.60)**	**1.32 (1.02, 1.71)**
Non-Hispanic Other	**0.67 (0.59, 0.76)**	**0.73 (0.61, 0.87)**
Multiple races	0.91 (0.74, 1.13)	0.95 (0.71, 1.29)
Hispanic/Latino	**0.84 (0.76, 0.94)**	0.93 (0.80, 1.07)
Greek organization member		
Yes	0.98 (0.88, 1.09)	--
No	ref	--
Cumulative grade average		
A	ref	ref
B	**1.41 (1.31, 1.51)**	**1.23 (1.12, 1.36)**
C or less	**1.68 (1.48, 1.90)**	1.09 (0.91, 1.31)
Previous Collisions <= 2 weeks		
Yes	**1.42 (1.27, 1.59)**	**1.20 (1.03, 1.40)**
No ¶	ref	ref
Driving after drinking		
Yes	**3.44 (3.14, 3.76)**	**3.18 (2.84, 3.57)**
No	ref	ref
Alcohol risk**		
Low	ref	ref
Moderate	**1.43 (1.32, 1.54)**	0.92 (0.83, 1.01)
High	**1.95 (1.59, 2.40)**	**0.65 (0.49, 0.85)**
Marijuana risk††		
Low	ref	ref
Moderate	**6.82 (5.89, 7.90)**	**7.61 (6.34, 9.13)**
High	**33.97 (27.29, 42.27)**	**36.8 (27.66, 48.94)**
Binge drinking§§		
Yes	**1.29 (1.20, 1.39)**	1.10 (1.00, 1.21)
No	ref	ref
Diagnosed AUD/SUD		
Yes	**2.59 (2.12, 3.15)**	**1.44 (1.08, 1.91)**
No	ref	ref
Diagnosed anxiety		
Yes	**1.38 (1.29, 1.48)**	**1.20 (1.06, 1.36)**

Variables	Bivariate model OR (95% CI)	Multivariable model† AOR (95% CI) (n=10,810)
No	ref	ref
Diagnosed depression		
Yes	**1.46 (1.36, 1.56)**	1.05 (0.93, 1.20)
No	ref	ref
Suicide risk¶¶		
Positive	**1.56 (1.46, 1.67)**	**1.18 (1.07, 1.31)**
Negative	ref	ref
Financial stress due to COVID-19		
More stressful	**1.22 (1.13, 1.32)**	1.05 (0.94, 1.17)
No change	ref	ref
Less stressful	**1.34 (1.16, 1.56)**	1.16 (0.95, 1.42)
Overall stress due to COVID-19		
Increased	0.95 (0.82, 1.10)	0.97 (0.79, 1.20)
No change	ref	ref
Decreased	1.28 (1.00, 1.63)	1.34 (0.95, 1.90)
Days of driving within the past 2 weeks	**1.08 (1.08, 1.09)**	**1.07 (1.06, 1.08)**

Abbreviations: OR=unadjusted odds ratio; AOR=adjusted odds ratio; COVID-19=coronavirus 2019; AUD= alcohol use disorder; SUD= substance use disorder

*Significant ORs (95% CIs) are bold as they have a p-value <0.05 and OR does not include 1.

†The final multivariable model was adjusted for all eligible variables. The sample size of multivariable logistic regression is (n=10810) after using complete case analysis for missingness.

§ Includes asexual, bisexual, gay, lesbian, pansexual, queer, and questioning

¶ The missing value might include participants who drove a car longer 2 weeks because the previous collision variable only captured participants who drove a car within 2 weeks.

** Scores were 0-10 for low risk, 11-26 for moderate risk, and >=27 for high risk of alcohol risk based on ASSIST

†† Scores were 0-3 for low risk, 4-26 for moderate risk, and >=27 for high risk of marijuana risk based on ASSIST

§§ According to the CDC's definition, binge drinking is considered as 5 or more drinks for male or 4 or more drinks for females containing any kind of alcohol at a sitting.

¶¶ Cut-off point of =>7 for at-risk of suicide based on the SBQ-R