DISSERTATION

# EFFECTS OF PROTECTIVE BEHAVIORAL STRATEGIES IN A RANDOMIZED CONTROLLED TRIAL OF THE CANNABIS ECHECKUP TO GO INTERVENTION

Submitted by

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ABSTRACT

EFFECTS OF PROTECTIVE BEHAVIORAL STRATEGIES IN A RANDOMIZED CONTROLLED TRIAL OF THE CANNABIS ECHECKUP TO GO INTERVENTION

College students who use cannabis may underestimate cannabis-related harm and experience negative consequences associated with using cannabis, highlighting the need for harm reduction interventions. Cannabis protective behavioral strategies (PBS) are behaviors for reducing cannabis misuse and related harm. This study is a secondary data analysis of a multisite randomized controlled trial (see Conner et al., 2024 for primary effects). This study examined PBS as a mechanism of behavior change in reducing cannabis use and negative consequences within an adapted version of the online intervention for college students, Cannabis-eCHECKUP TO GO. A total of 779 college students in the US and Canada who expressed interest in reducing or engaging in safer cannabis use were randomly assigned to an experimental or control condition. Participants completed baseline and follow-up assessments and received personalized feedback online. Results showed no significant differences in PBS use frequency between conditions and no evidence that PBS mediated program effects on cannabis use or negative consequences. However, greater PBS use was associated with reduced cannabis use and fewer negative consequences. Additionally, PBS use increased from baseline to follow-up, regardless of intervention condition. Results suggest that, while the intervention did not significantly change PBS use frequency, PBS is a valuable predictor of cannabis-related harm reduction among college students in the US and Canada. Future research could explore ways to facilitate cannabis PBS use among college students.

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# INTRODUCTION

## Cannabis Use

Cannabis use is prevalent among young adult college students and has increased over the past decade (Health Canada, 2021; Patrick et al., 2023). Among young adults in the United States (US), over half report lifetime use and past-month use increased from 19.5% in 2013 to 25.2% in 2023 (Substance Abuse and Mental Health Services Administration [SAMHSA], 2024). This rise in cannabis use coincides with the increased availability and potency of cannabis products (Arterberry et al., 2019; Cash et al., 2020). Notably, more frequent use and use of high-THC products are associated with greater cannabis-related harm (Cerdá et al., 2020).

Some individuals experience negative consequences from using cannabis. Cannabis use has been linked to impairments in attention, learning, memory, and psychomotor skills, as well as worsened anxiety, depression, and psychosis symptoms (Arria et al., 2015; Augustin & Lovinger, 2022; Hall et al., 2020; Kroon et al., 2021; National Academies of Sciences, Engineering, and Medicine [NASEM], 2017). Risk behaviors, such as driving under the influence, are concerning (Metrik & McCarthy, 2024) and often endorsed by college students (American College Health Association [ACHA], 2023). In 2023, the ACHA reported about 20% of students engaged in moderate-risk cannabis use, highlighting the need for strategies to reduce harm. Additionally, young adults who seek substance use services at emergency departments often report recent cannabis use (SAMHSA, 2024), underscoring the need for cannabis harm reduction strategies across various settings. Reducing cannabis-related harm among young adult college students requires accessible, evidence-based interventions. Further research is needed to

develop and refine cannabis use interventions for college students to support informed decision-making about cannabis use and mitigate cannabis-related harm.

**Treatment Barriers**

Historically, rising substance use rates have corresponded with increased admissions to substance use disorder (SUD) treatment (SAMHSA, 2024). However, rising rates of cannabis use show a different pattern. Despite its growing use, admissions for cannabis use disorder (CUD) have declined (Askari et al., 2021; Mennis et al., 2021). This discrepancy may reflect the rapidly evolving legal and cultural landscape of cannabis, which has outpaced the integration of scientific evidence into policy and practice.

One barrier to cannabis use treatment is the lack of interventions specifically designed for cannabis use. Many cannabis use interventions have been modeled after interventions developed for alcohol or tobacco (e.g., Dimeff, 1999). However, unlike alcohol and tobacco, cannabis is legal for both recreational and medical use in numerous jurisdictions. In Canada, recreational cannabis use is legal for adults ages 18 or 19 years and older (Cannabis Act, 2025). In nearly half of US states, it is legal for adults 21 years and older (NORML and The NORML Foundation, 2025). Medical cannabis legalization predates recreational legalization, beginning in 1996 in the US and 2001 in Canada. Medical cannabis can be prescribed to manage symptoms associated with chronic or debilitating conditions (e.g., cancer, chronic pain, glaucoma, nausea; NASEM, 2017). Given the unique legal and therapeutic context of cannabis use, interventions developed for alcohol and tobacco may not fully address the needs of individuals who use cannabis. Thus, there is a need for interventions designed specifically for cannabis use, which could improve both cannabis use treatment engagement and outcomes.

Additionally, young adults generally view cannabis as low risk (SAMHSA, 2024), which may lead them to underestimate cannabis-related problems and delay or avoid seeking treatment (Gates et al., 2012). Financial constraints, logistical challenges (e.g., lack of transportation), limited treatment options aligned with personal goals, and stigma further deter people from accessing help for substance use and related problems (Gates et al., 2012; Kerridge et al., 2017; NASEM, 2021; van der Pol et al., 2013). Further, traditional abstinence-focused treatment, which prioritizes the complete cessation of use, is not a practical approach given the heterogenous patterns of both substance use and substance use recovery (Kelly et al., 2018; Witkiewitz & Tucker, 2025). These barriers underscore the need for cannabis interventions that support individual goals and accommodate diverse use patterns and recovery pathways.

**Harm Reduction**

Harm reduction for substance use involves practical strategies and a non-judgmental stance to meet people where they are, reduce substance-related harm, and improve quality of life (Des Jarlais, 2017; Marlatt, 1996; Marlatt et al., 2001; Marlatt & Witkiewitz, 2010; National Harm Reduction Coalition, 2024). Harm reduction in the US evolved from grassroots and social justice movements (Des Jarlais, 2017), such as the women's health movement, Black Panther Party's Free Breakfast for Children, and HIV/AIDS crisis and activism (National Harm Reduction Coalition, 2024). Harm reduction initiatives have produced significant public health benefits, including reduced rates of infectious disease transmission, fewer overdoses, and lower mortality rates among people who use substances (Kimmel et al., 2021). In the context of cannabis use, a harm reduction approach can empower individuals to make informed decisions and pursue personalized goals such as accessing support services, reducing the quantity or frequency of use, reducing negative consequences, and improving wellbeing. Harm reduction

strategies can benefit anyone, regardless of specific goals related to cannabis use, and are essential for addressing cannabis-related risks among young adults (Kimmel et al., 2021).

**Protective Behavioral Strategies (PBS)**

Aligned with harm reduction, protective behavioral strategies (PBS) for cannabis are specific behaviors for reducing cannabis misuse and harm (Pedersen et al., 2017). Examples of cannabis PBS include setting limits on frequency or quantity of use, using only with trusted peers, and having a designated driver (Pedersen et al., 2017).

PBS use is a proposed mechanism of behavior change (MOBC) in reducing cannabis misuse and harm. MOBCs refer to the processes through which changes in outcomes (e.g., substance use, consequences) occur (Kazdin, 2007). Understanding these processes is important for advancing prevention science and optimizing intervention efforts. Kazdin (2007) outlined seven criteria for establishing a MOBC based on causal inference. Criteria consist of showing a *strong association* between intervention (i.e., independent variable) and mediator and between mediator and outcome (i.e., dependent variable), with *specificity* that the mediator uniquely accounts for change in the outcome. Mediators refer to intervening variables that explain the relation between independent and dependent variables (Baron & Kenny, 1986; Preacher, 2015). Additionally, establishing a MOBC requires *consistency* of variable relations across different studies, samples, and conditions. Inconsistencies may suggest potential moderators of the relation between variables (Preacher, 2015). An *experimental manipulation* demonstrates intervention-induced effects, and a cause-effect *timeline* shows mediators temporally precede outcomes. *Gradient* indicates a dose-response relation where stronger activation of the mediator corresponds with greater changes in the outcome, though nonlinear relations may complicate

these inferences. Lastly, *plausibility or coherence* requires theory to support the mediator (Kazdin, 2007).

Mediation is an essential part of testing a mechanism (Tryon, 2018). In a mediation model, the indirect effect represents the effect from an independent variable *X* to a dependent variable *Y* through a mediator *M* (Baron & Kenny, 1986; Preacher, 2015). The direct effect represents the effect from *X* to *Y* not explained by *M* (Baron & Kenny, 1986; Preacher, 2015). Mediation can occur regardless of a direct effect (Zhao et al., 2010). Notably, mediation alone does not show how a mechanism causes change. Thus, mechanisms are mediators, but not all mediators qualify as mechanisms.

Research suggests PBS use meets several MOBC criteria for cannabis outcomes. Studies indicate higher frequency of PBS use correlates with lower cannabis use and fewer negative consequences among college students (Bolts et al., 2023; Bravo, Anthenien, et al., 2017; Bravo et al., 2019; Gray et al., 2024; Pearson et al., 2019; Pedersen et al., 2017; Richards et al., 2022), supporting the plausibility and coherence of PBS. Further, evidence suggests both the frequency and perceived helpfulness of PBS interact with and mediate the relations between various risk and protective factors and cannabis outcomes. For example, Bravo et al. (2017) found PBS mediated the effects of sex and cannabis motives on cannabis use frequency and consequences. However, some research reports nonlinear relations, where higher PBS use is observed alongside higher cannabis use (e.g., Richards et al., 2021). This pattern could indicate the use of less effective strategies or suggest that individuals who use cannabis more frequently also tend to use PBS more frequently.

Few studies have directly examined intervention-induced effects and the temporal order between PBS and cannabis outcomes. In one randomized controlled trial (RCT), Prince et al.

(2019) employed an episode-level intervention with young adults who frequently use cannabis. Participants tracked and received feedback on their cannabis use and PBS. Results showed PBS use was negatively associated with cannabis use quantity, even after controlling for intervention effects (Prince et al., 2019), thereby supporting the role of PBS as a potential MOBC in reducing cannabis use.

**eCHECKUP TO GO**

Two RCTs examined PBS within the Cannabis eCHECKUP TO GO program (eCHECKUP; San Diego State University Research Foundation, 2018), a brief online personalized feedback intervention. Cannabis eCHECKUP is part of the suite of eCHECKUP programs (eCHECKUP TO GO, 2024a), grounded in the transtheoretical model of change (Prochaska & DiClemente, 1982) and motivational approaches (SAMHSA, 2019). The transtheoretical model views behavior change as a progression through distinct stages of change (i.e., precontemplation, contemplation, preparation, action, and maintenance; Prochaska & DiClemente, 1982). Motivational approaches, such as motivational enhancement therapy (Miller, 1992) and motivational interviewing (Miller & Rollnick, 2023), provide person-centered support (Rogers, 1951) throughout the change process.

The first eCHECKUP began in 2003. It was developed to reduce alcohol misuse among college students and has demonstrated efficacy (eCHECKUP TO GO, 2024b). Modeled after Alcohol-eCHECKUP, the suite now includes programs for cannabis, nicotine, sexual violence prevention, wellbeing, mental health, and practitioners (eCHECKUP TO GO, 2024a). Millions of students have used eCHECKUP and some universities require students to complete the programs (eCHECKUP TO GO, 2024a).

In Cannabis-eCHECKUP, individuals respond to questions on cannabis use behaviors and normative beliefs. Personalized feedback is immediately provided based on these responses. Individuals can complete the program anonymously and numerous times. Prior research suggests online interventions are promising for reducing cannabis misuse (Côté et al., 2024; Hoch et al., 2016; Tait et al., 2013) and improving access to and engagement with evidence-based care (Budney et al., 2019; Copeland et al., 2017; Hoch et al., 2016; Lees et al., 2021; López-Pelayo et al., 2020; Pantalon & Gotham, 2020; Tait et al., 2013; Tait & Christensen, 2010).

Despite the widespread use of eCHECKUP, few RCTs have examined if and how it changes cannabis use behaviors. Similar to the alcohol literature (e.g., Doumas et al., 2010; Neighbors et al., 2004), findings from RCTs suggest Cannabis-eCHECKUP can reduce college students' normative beliefs about cannabis (i.e., descriptive: perceptions of others' cannabis use; injunctive: perceived approval of using cannabis) to align perceived cannabis use more accurately with actual use (Conner et al., 2024; Elliott et al., 2014; Elliott & Carey, 2012; Fetterling et al., 2021; Palfai et al., 2014). However, findings are mixed for the effects of Cannabis-eCHECKUP on cannabis use and negative cannabis consequences.

Three Cannabis-eCHECKUP studies (Elliott et al., 2014; Elliott & Carey, 2012; Palfai et al., 2014) took place at universities in the northeastern region of the US prior to the widespread legalization of recreational cannabis use. Elliott and Carey (2012) examined program effects among college students who were not using cannabis and found changes in normative beliefs without changes in cannabis initiation rates. Among students who reported past-month cannabis use, Elliott et al. (2014) found reductions in descriptive norms but no significant effects on cannabis use frequency, consequences, CUD symptoms, or injunctive norms. Palfai et al. (2014) found reductions in descriptive norms and cannabis consequences but not cannabis use

frequency. These findings suggest Cannabis-eCHECKUP may change normative beliefs about cannabis use. Further testing is needed to determine if Cannabis-eCHECKUP changes cannabis use and consequences, especially in environments with legalized cannabis use.

Researchers at Colorado State University (CSU) adapted and tested Cannabis-eCHECKUP in legalized recreational cannabis use environments. In collaboration with the creators of eCHECKUP, researchers conducted two RCTs testing an adapted version that included site-specific injunctive norms and PBS (Conner et al., 2024; Riggs et al., 2018). Adapting Cannabis-eCHECKUP to include PBS may be particularly relevant for young adult college students who endorse high cannabis use rates and low levels of perceived harm.

In both RCTs (Conner et al., 2024; Riggs et al., 2018), college student participants completed baseline and 4-6-week follow-up assessments that included standardized Cannabis-eCHECKUP questions plus measures of site-specific injunctive norms and PBS. Participants were randomly assigned to either an *experimental condition* or a *healthy stress management waitlist control condition*. In the experimental condition, participants received personalized feedback on the standardized Cannabis-eCHECKUP plus recommended PBS. Participants assigned to the control condition received stress management information derived from the Mayo Clinic (see Appendix A). Control condition materials were designed to control for expectancy effects and attention without targeting cannabis use specifically.

The first RCT included US college students who used cannabis at least twice per week (Riggs et al., 2018). Personalized feedback included a list of PBS drawn from the Protective Behavioral Strategies for Marijuana scale (PBSM; Pedersen et al., 2017), a questionnaire designed to assess strategies for safer cannabis use. The intervention led to reductions in descriptive norms and the frequency of being high (Prince et al., 2021; Riggs et al., 2018). The

intervention affected norms differently by assigned sex. Participants who self-identified as female reported an increase in the number of days since last cannabis use through decreased injunctive norms, while males reported decreased descriptive norms (Fetterling et al., 2021). Additionally, reductions in the frequency of being high while studying partially explained overall reductions in frequency of being high (Prince et al., 2021). Regarding PBS, female participants assigned to the experimental condition reported higher PBS use at follow-up than male participants assigned to the experimental condition (Riggs et al., 2018). However, the intervention did not significantly impact consequences (Riggs et al., 2018) or PBS use frequency (Fetterling et al., 2021).

The second RCT (Conner et al., 2024) was a multisite cross-national study with college students in the US and Canada who reported recent cannabis use and an interest in reducing or safer use. Personalized feedback was tailored based on PBS frequency, perceived helpfulness of PBS, and the frequency and severity of negative cannabis consequences. See Appendix B for an example of the personalized feedback. The intervention did not yield significant reductions in cannabis use frequency or consequences (Conner et al., 2024). However, Canadian participants in the experimental condition reported greater reductions in descriptive norms compared to those in the control condition (Conner et al., 2024). The present study focuses on the PBS outcomes from Conner et al. (2024).

Overall, only two RCTs (Prince et al., 2019; Riggs et al., 2018) have examined the temporal order between cannabis PBS and cannabis outcomes. One of these RCTs tested an adapted version of Cannabis-eCHECKUP. Findings support the role of PBS as a potential MOBC in reducing cannabis use frequency among young adults (Prince et al., 2019) and the feasibility of adding a PBS component to the widely used Cannabis-eCHECKUP program for

college students in a US state with legalized recreational cannabis use (Riggs et al., 2018). Results from RCTs examining Cannabis-eCHECKUP indicate Cannabis-eCHECKUP may reduce negative cannabis consequences (Palfai et al., 2014) and that an adapted personalized feedback and PBS version of Cannabis-eCHECKUP may reduce cannabis use frequency among college students (Fetterling et al., 2021; Prince et al., 2021; Riggs et al., 2018). Further investigation is needed into both cannabis PBS as an MOBC and the mechanisms through which Cannabis-eCHECKUP may change cannabis behaviors in legal cannabis contexts.

**Current Study**

The current study is a secondary data analysis of the multisite RCT conducted by Conner et al. (2024) with college students in the US and Canada (see Conner et al., 2024 for primary effects). This study examined PBS use as a mechanism of change for reducing cannabis use and negative cannabis consequences. Two hypotheses were tested: 1) Participants randomly assigned to the experimental condition would self-report greater increases in PBS use compared to those assigned to the control condition, and 2) PBS use would mediate intervention effects on cannabis use and consequences. Exploratory analyses examined whether these relations differed across the study sites.

# METHOD

## Procedure

### *Recruitment and Screening*

Participants were recruited between December 2019 and March 2020 via social media advertisements aimed at college students who use cannabis (Conner et al., 2024). Recruitment occurred at Colorado State University (CSU) in Fort Collins, Colorado, US, St. Francis Xavier University (StFx) in Antigonish, Nova Scotia, Canada, and the University of Victoria (UVic) in Victoria, British Columbia, Canada. All sites are located in jurisdictions where recreational cannabis is legal. Advertisements included location-specific tags and described the study as "a study on cannabis use and stress management." Interested individuals completed an online screening survey and provided informed consent via Qualtrics (*Qualtrics*, 2024). To be eligible, participants had to be 18 years old or older, currently enrolled in college, report recent recreational cannabis use, and express interest in reducing or engaging in safer cannabis use.

### *Data Collection*

After providing informed consent, eligible participants were redirected from the screening survey to eCHECKUP and randomly assigned within each site to either the experimental or control condition. As shown in Figure 1, 388 participants were allocated to the experimental condition (CSU $n$ = 186; StFx $n$ = 90; UVic $n$ = 111) and 393 to the control condition (CSU $n$ = 196; StFx $n$ = 78; UVic $n$ = 118). Participants then completed baseline assessments (i.e., standardized Cannabis-eCHECKUP plus measures of cannabis use, consequences, and PBS). Follow-up data were collected on average 37.12 days later ($SD$ = 8.11). Participants completed all assessments online, received eGift Cards as compensation, and had

access to online feedback for three months following data collection. Institutional review boards at each site approved all study procedures.

During data collection at the US site, an error occurred when Qualtrics redirected participants from the screening survey to eCHECKUP using randomly generated ID numbers that prevented matching baseline and follow-up data. This issue affected data for 128 participants who completed baseline surveys before February 1, 2020. To address this, I discontinued the automatic redirection from Qualtrics to eCHECKUP and manually distributed unique URLs via email. Data collection also coincided with the onset of the COVID-19 pandemic and related mandated university closures in March 2020, which may have influenced participant experiences.

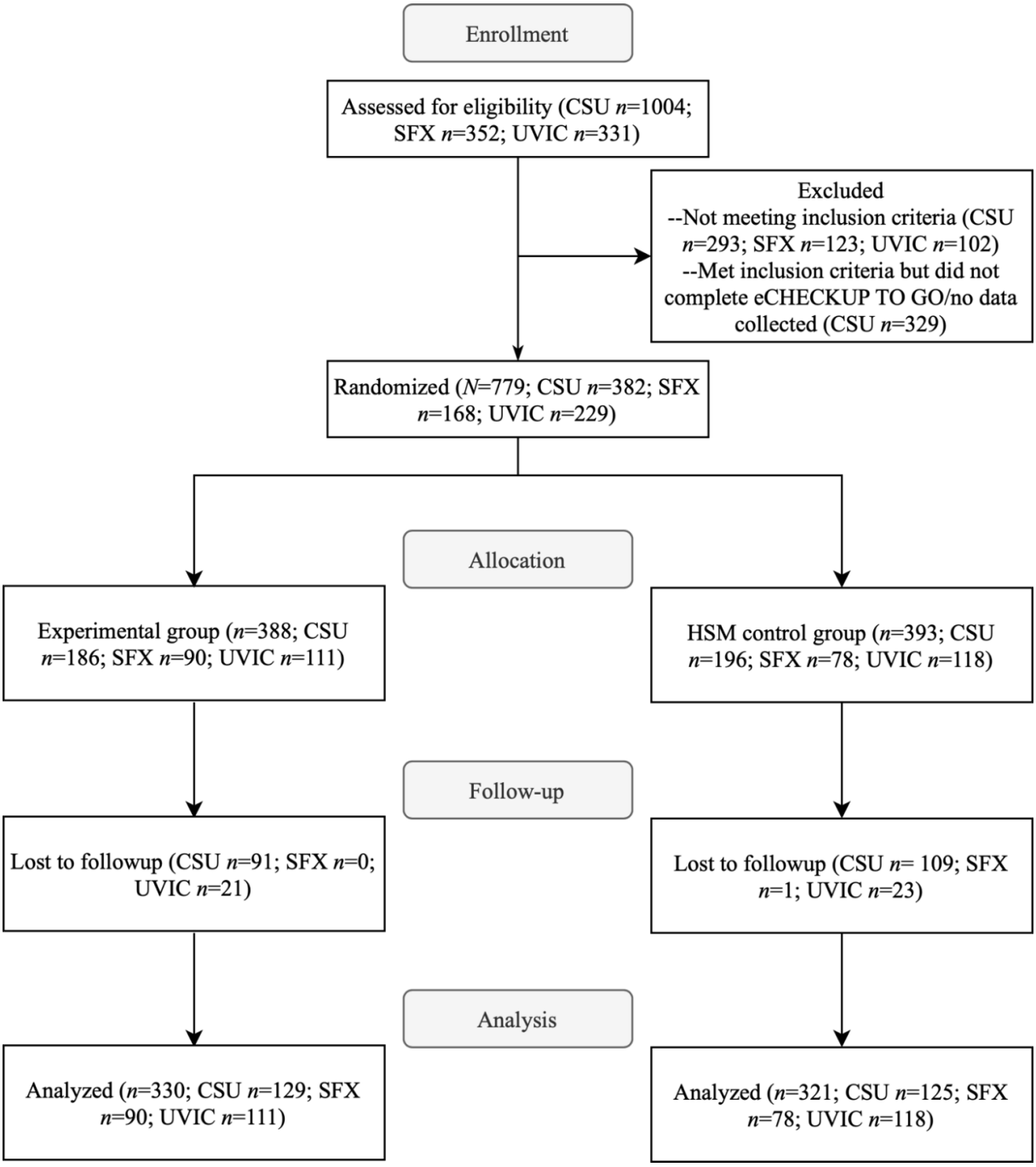


**Figure 1.** CONSORT Flowchart of Participants. Adapted from "Results of a Randomized Controlled Trial of the Cannabis eCHECKUP TO GO Personalized Normative Feedback Intervention on Reducing Cannabis Use, Cannabis Consequences, and Descriptive Norms," by B. T. Conner, K. Thompson, M. A. Prince, O. L. Bolts, A. Contreras, N. R. Riggs, and B. J. Leadbeater, 2024, *Journal of Substance Use and Addiction Treatment*, *159*, 209267 (https://doi.org/10.1016/j.josat.2023.209267). Copyright 2023 by Elsevier.

## Measures

### *Descriptive Characteristics*

Participants responded to fixed demographic questions from the standardized Cannabis-eCHECKUP program (see Appendix C).

### *Cannabis Use*

Cannabis use indicators included two count variables: high-times (i.e., number of times per day under the influence of cannabis) and high-hours (i.e., hours per day under the influence of cannabis). High-times was assessed by dividing each day into four 6-hour time blocks (morning, 6am-12pm; afternoon, 12pm-6pm; evening, 6pm-12am; late-night, 12am-6am). Participants selected the time(s) they were under the influence of cannabis during a typical cannabis-using week within the past month. Times were summed across days for a total high-times score. High-hours were assessed by the number of hours under the influence of cannabis each day during a typical cannabis-using week within the past month. The number of hours reported was summed across days for a total high-hours score. Figure 2 displays these indicators.

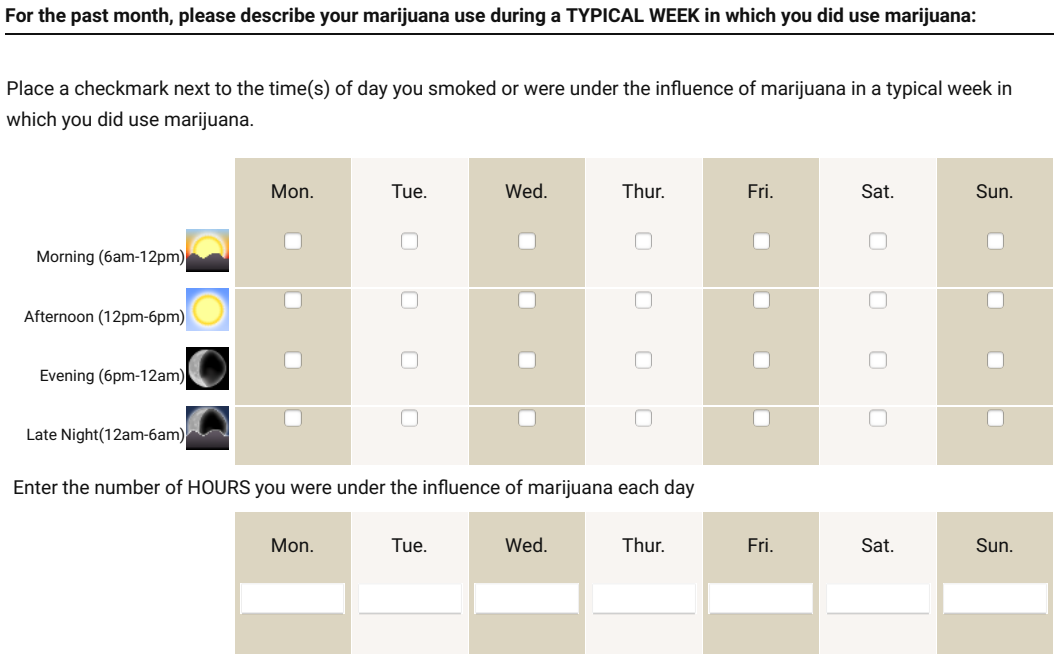


**Figure 2.** Cannabis Use Indicators: High-times and High-hours.

### *Negative Cannabis Consequences*

Negative cannabis consequences were assessed using the 21-item Brief Marijuana Consequences Questionnaire (B-MACQ; Simons et al., 2012). Participants indicated whether they experienced each consequence (0 = *no*, 1 = *yes*) during a typical cannabis-using week. Consistent with the B-MACQ (Simons et al., 2012) scoring, yes/no responses were summed for a total consequence score. I used the total consequence score in my analyses. Participants also rated how negative each consequence they experienced was on a 5-point scale (1 = *minimally negative*, 5 = *extremely negative*), which was used to determine personalized feedback in the intervention but was not included in my analyses. Figure 3 displays an example B-MACQ item with severity rating. See Appendix D for all consequence items.

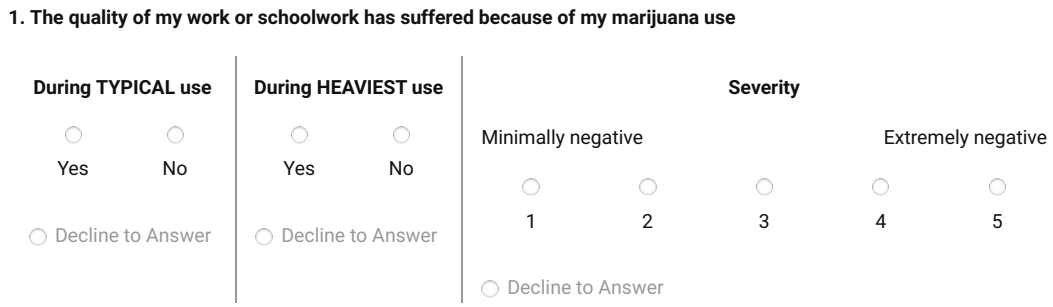


**Figure 3.** Example B-MACQ Item with Severity Rating.

### *Protective Behavioral Strategies*

The 17-item Marijuana Protective Behavioral Strategies scale (PBSM; Pedersen et al., 2017) assessed PBS use. Participants indicated the frequency of engaging in each behavior when using cannabis (0 = *never*, 5 = *always*). Consistent with the PBSM (Pedersen et al., 2017) scoring, frequency scores were averaged for a mean PBS use frequency score. I used the mean PBS use frequency score in my analyses. Participants also indicated the perceived helpfulness of each behavior in moderating cannabis use (0 = *not at all helpful*, 5 = *extremely helpful*), which

was used to determine personalized feedback but was not included in my analyses. Figure 4 displays an example PBSM item with helpfulness rating. See Appendix E for all PBSM items.

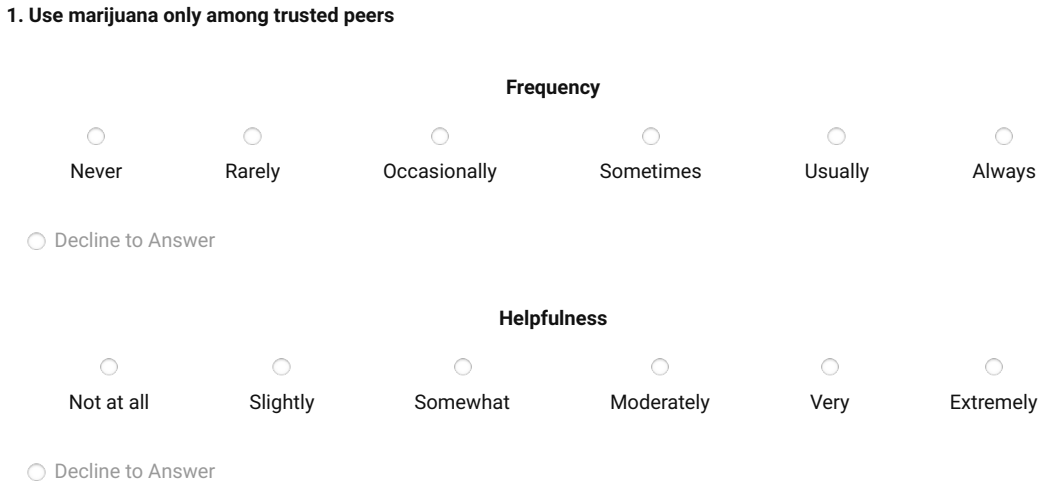


**Figure 4.** Example PBSM Item with Helpfulness Rating.

## Analysis Plan

I conducted analyses using R version 4.4.2 (R Core Team, 2024) and Mplus version 8.10 (Muthén & Muthén, 2017). I used an intent-to-treat approach; all participants who completed baseline assessments were analyzed within their assigned condition, regardless of follow-up completion (Newell, 1992). I examined data for distributional properties and used count models to accommodate the non-normal distributions (Gelman et al., 2020; Hilbe, 2011, 2014, 2017) of cannabis use and consequences. Analyses included a residualized gains approach to control for baseline levels of outcome variables and to predict residualized change (Kline, 2016; Pearl, 2016). Sex was included as a covariate but not interpreted, following recommendations by Hünermund and Louw (2020) to focus on the primary variables of interest.

### *Missing Data*

I used multiple imputation by predictive means matching to handle missing data (Little & Rubin, 2020; Rubin, 1987). This method helps maintain statistical power and preserve relations in the data (Van Buuren, 2018). Multiple imputation performs well for intent-to-treat analyses

(Lang & Little, 2018) and data missing completely at random (MCAR) or missing at random (MAR; Buuren, 2018; Enders, 2023; Hayes & Enders, 2023; Little & Rubin, 2020; Sterne et al., 2009). Data are MCAR when the probability of being missing is the same for all cases, with missing values being unrelated to observed values and unobserved outcomes (Rubin, 1976). Under MAR assumptions, the probability of being missing is the same only within groups defined by the observed data, and missing values may relate to observed data but are unrelated to unobserved outcomes (Rubin, 1976). I determined data were a combination of MCAR and MAR based on missing data patterns and the missingness due to Qualtrics error. The overall percentage of missing data was 10.9%. The range of fraction of missing information of variables with missingness was 0.02 to 0.22. As shown in Figure 4, the percent of missing data in each variable with missing values ranged from 3.47% to 33.50%. As shown in Figure 5, missingness appeared distributed across values rather than clustered in specific values.


**Figure 4.** Percent of Missings in Variables with Missing Values.
*Note.* Variables labeled "1" represent a baseline score and "2" represent a follow-up score.

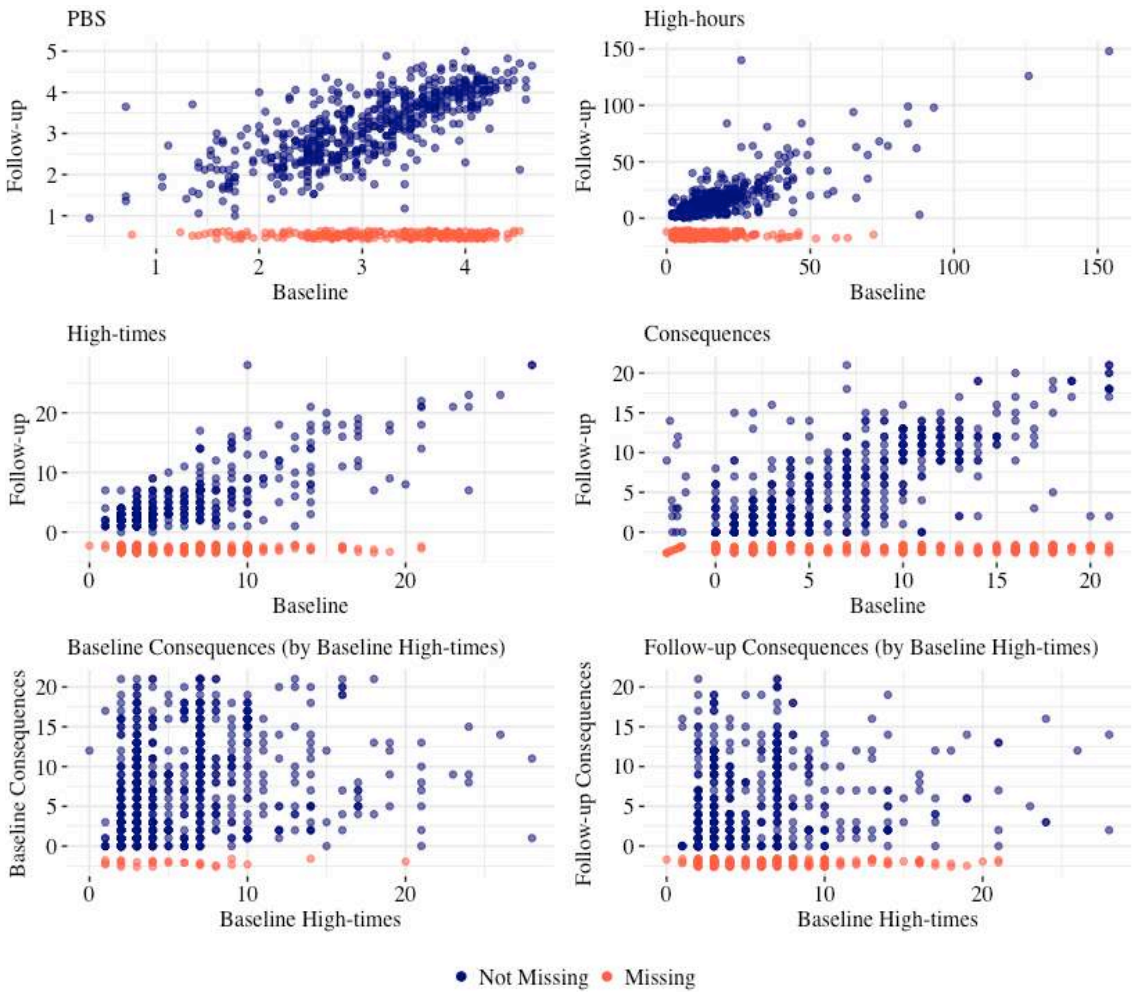


**Figure 5.** Missingness in Follow-up PBS by Baseline PBS, Follow-up High-hours by Baseline High-hours, Follow-up High-times by Baseline High-times, Follow-up Consequences by Baseline Consequences, Baseline Consequences by Baseline High-times, and Follow-up Consequences by Baseline High-times.

The imputation process involved three steps. First, imputing the incomplete data by generating multiple imputations (*m*) to create complete and multiple versions of the data. This step includes replacing missing values with plausible values based on observed data. I generated 20 imputations to ensure high relative efficiency given the highest fraction of missing information was 0.22 (Bodner, 2008; Graham et al., 2007). The second step involves analyzing each imputed dataset, *m,* to estimate the parameters of interest. Third, pooling *m* parameter estimates into one estimate using Rubin's rules (Van Buuren, 2018). Figure 6 displays the distributions of observed versus imputed values.

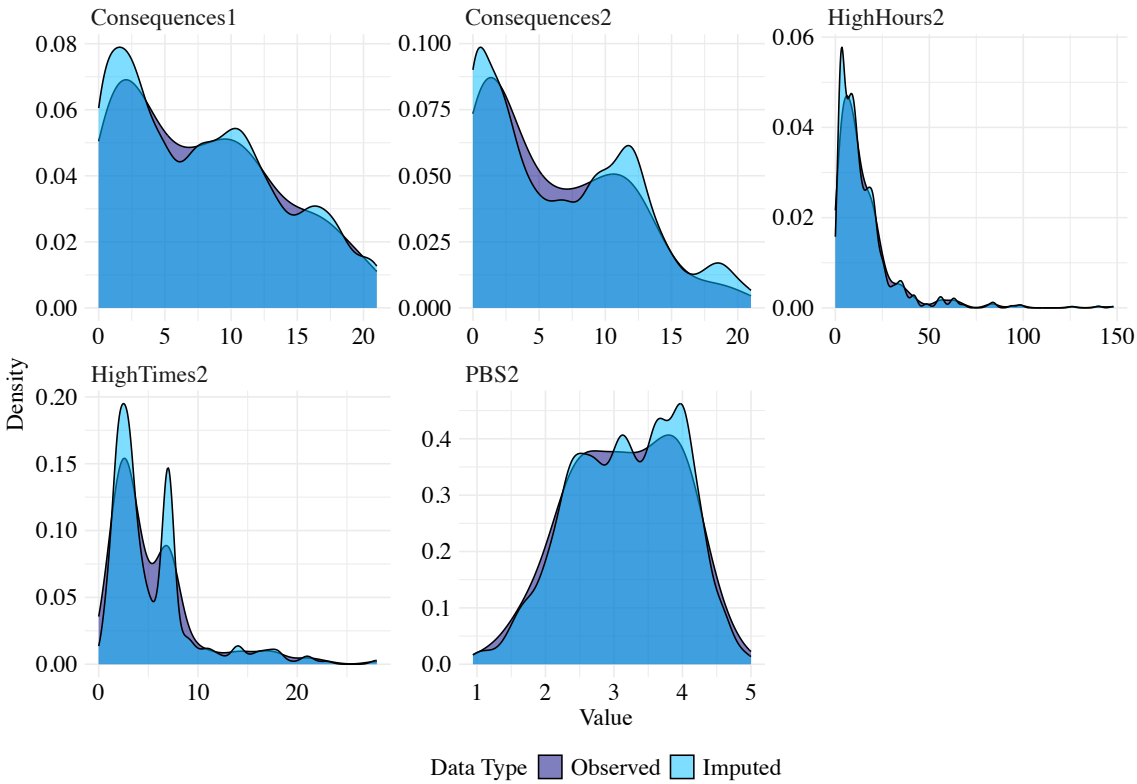


**Figure 6.** Distributions of Observed Versus Imputed Values.
*Note.* Variables labeled "1" represent a baseline score and "2" represent a follow-up score.

### *Hypothesis 1*

For hypothesis 1, I used residualized ordinary least squares regression with maximum likelihood estimation to test whether intervention condition predicted follow-up PBS, controlling for baseline PBS and assigned sex. I evaluated model performance using BIC, RMSEA, and CFI/TLI. Confidence intervals were derived from pooled standard errors across 20 imputed datasets. Figure 7 shows the model for hypothesis 1.


**Figure 7.** Hypothesis 1 Model of Intervention Condition Predicting PBS.

***Hypothesis 2***

I estimated two mediation models to test hypothesis 2. The first tested whether PBS mediated the relation between intervention condition and cannabis use, controlling for baseline PBS, baseline cannabis use, and assigned sex. The second tested whether PBS mediated the relation between intervention condition and negative consequences, controlling for baseline PBS, baseline consequences, follow-up cannabis use, and assigned sex. Model fit indices are not available for count models; thus, I evaluated model fit based on successful convergence and interpretability of parameter estimates. Figure 8 and Figure 9 illustrate these models.

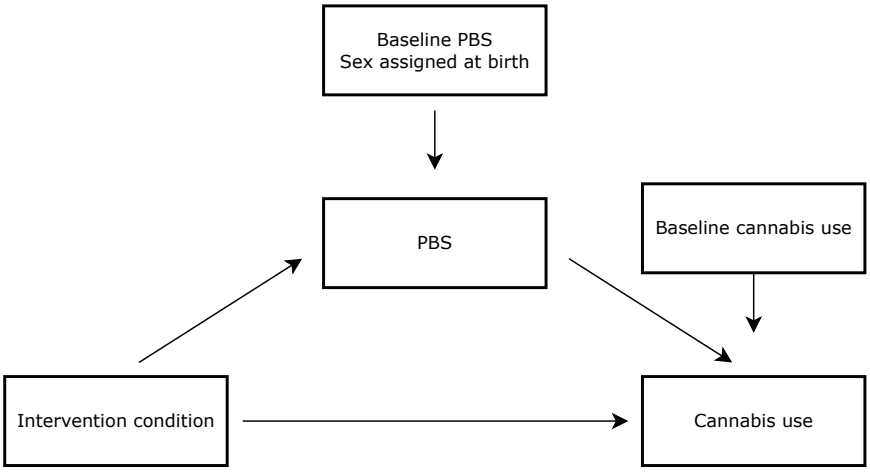


**Figure 8.** Hypothesis 2 Model of Direct and Indirect Effects Of Intervention Condition on Cannabis Use Through Protective Behavioral Strategies.

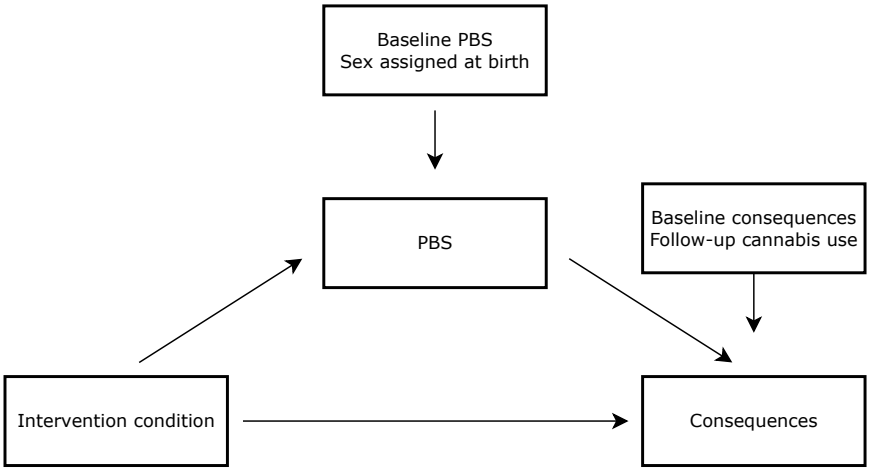


**Figure 9.** Hypothesis 2 Model of Direct and Indirect Effects of Intervention Condition on Negative Cannabis Consequences Through Protective Behavioral Strategies.

In Mplus, I used maximum likelihood estimation with Monte Carlo integration to compute confidence intervals for testing indirect effects. While bootstrapping is widely recommended for mediation analyses (Preacher, 2015; Preacher & Hayes, 2008), it is computationally intensive for imputed data (Pesigan & Cheung, 2023; Schoemann et al., 2025) and not available for analyzing imputed data in Mplus (Muthén & Muthén, 2017). Research indicates Monte Carlo confidence intervals (MCCI) perform comparably to bootstrapping while allowing for computational efficiency (Preacher & Selig, 2012), especially when analyzing imputed datasets (Schoemann et al., 2025). Additionally, multiple imputation pools estimates and standard errors across imputations, which provide accurate parameter estimation for MCCI to test indirect effects (Pesigan & Cheung, 2023; Schoemann et al., 2025).

***Exploratory Aim***

To test whether my hypothesized model paths differed by site (i.e., CSU, StFx, UVic), I conducted three multiple-group analyses (i.e., one for the regression model associated with hypothesis 1, two for the mediation models associated with hypothesis 2). I compared model parameters across groups defined by site. Each analysis included an overall model and group-specific models. In the overall models, I constrained factor loadings to be equal across groups to examine measurement invariance. In the group-specific models, I freely estimated factor loadings across groups to detect potential group differences in model paths. I assessed group differences by specifying model constraints and testing for differences in model paths between the groups that were statistically different from 0 (i.e., CSU versus StFx, CSU versus UVic, StFx versus UVic).

For the hypothesis 1 regression model, I specified the multiple-group analysis using the grouping option in Mplus, as recommended for continuous outcomes (Muthén & Muthén, 2017).

I assessed model fit using BIC, RMSEA, and CFI/TLI. For the hypothesis 2 mediation models, I specified the multiple-group analyses using the classes and knownclass options in conjunction with type=mixture in Mplus, as recommended for count outcomes (Muthén & Muthén, 2017). I evaluated model fit based on successful convergence and the interpretability of parameter estimates.

# RESULTS

## Descriptive Characteristics

Table 1 presents PBS use frequency by intervention condition, assigned sex, and site. Figure 10 illustrates correlations among cannabis variables and sex, prior to imputation. Table 2 presents characteristics of the sample overall, by intervention condition, and by missing data status. The demographic questionnaire did not inquire about race or ethnicity. However, most students at CSU, StFx, and UVic identify as white (Common Data Set, 2020; Morris et al., 2023).

Overall, participants reported a significant increase in PBS from baseline to follow-up ($p < .001$). Both the control ($p < .001$) and experimental ($p = .04$) conditions reported significant increases in PBS. Additionally, participants who self-identified as female reported higher PBS than male participants at both time points, with significant increases for both groups (females: $p < .001$; males: $p = .01$). PBS scores varied across sites; participants at CSU reported higher PBS than participants at StFx and UVic. PBS significantly increased for participants at CSU ($p = .02$) and UVic ($p < .001$) but not at StFx ($p = .21$).

**Table 1**
*PBS Use Frequency Scores*

| | *n* | Baseline PBS *M* (*SD*) | Follow-up PBS *M* (*SD*) |
|---|---|---|---|
| Intervention Condition | | | |
| Control | 392 | 3.09 (0.75) | 3.17 (0.78) |
| Experimental | 287 | 3.10 (0.81) | 3.13 (0.84) |
| Assigned Sex | | | |
| Female | 310 | 3.15 (0.77) | 3.21 (0.81) |
| Male | 469 | 3.06 (0.79) | 3.11 (0.82) |
| Site | | | |
| CSU | 382 | 3.30 (0.73) | 3.42 (0.72) |
| StFx | 168 | 2.79 (0.75) | 2.86 (0.77) |
| UVic | 229 | 2.97 (0.80) | 3.14 (0.85) |

*Note*. PBS = protective behavioral strategies. CSU = Colorado State University in Colorado, United States. StFx = St. Francis Xavier University in Nova Scotia, Canada. UVic = University of Victoria in British Columbia, Canada.

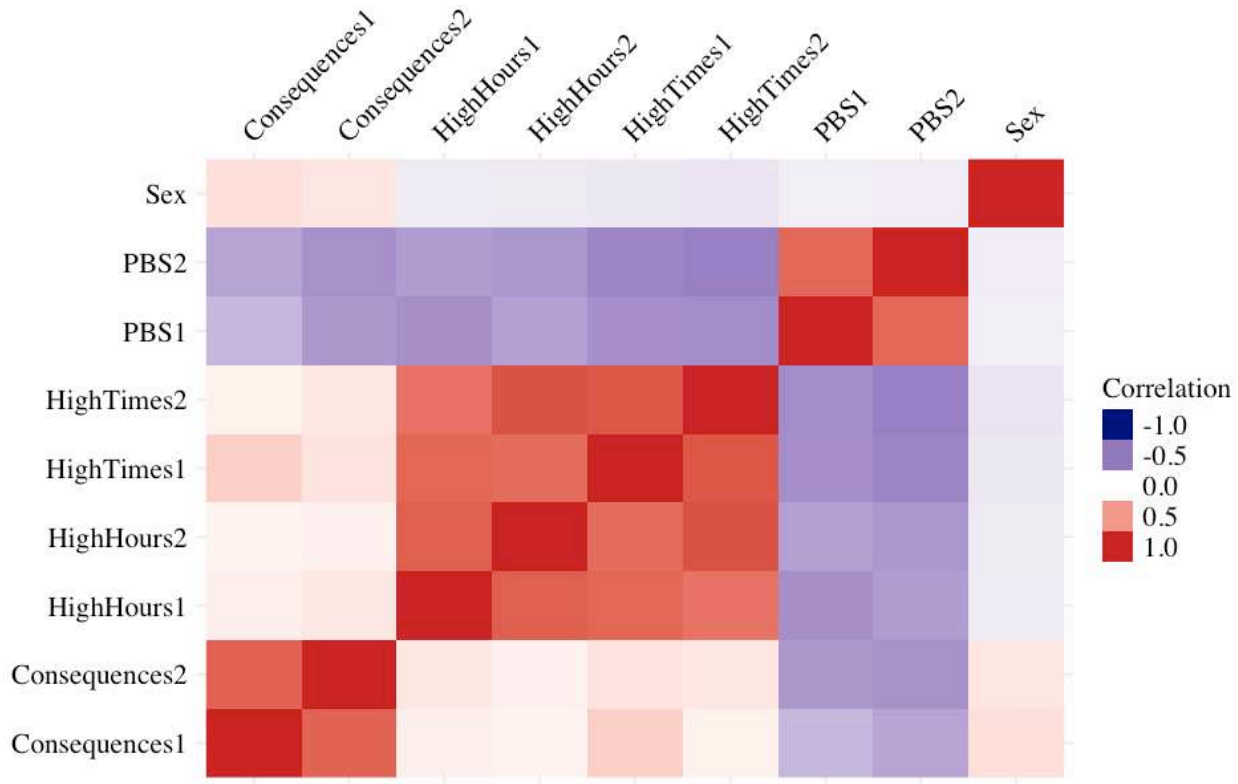


**Figure 10.** Correlation Heatmap of Cannabis Variables and Assigned Sex.
*Note.* Variables labeled "1" represent a baseline score and "2" represent a follow-up score.

**Table 2**

*Descriptive Characteristics of the Sample by Intervention Condition and Missing Data Status*

| Variable | Overall $N = 779$[1] | Intervention Condition | | Missing Data Status | |
|---|---|---|---|---|---|
| | | Control $n = 392$[1] | Experimental $n = 387$[1] | Missing $n = 245$[1] | Not Missing $n = 534$[1] |
| Age | 21.72 (2.83) | 21.55 (2.70) | 21.89 (2.94) | 21.44 (2.34) | 21.85 (3.02) |
| Age first used cannabis | 17.70 (2.08) | 17.62 (2.02) | 17.78 (2.14) | 18.34 (1.72) | 17.41 (2.16) |
| Assigned Sex | | | | | |
| Female | 310 (40%) | 150 (38%) | 160 (41%) | 81 (33%) | 229 (43%) |
| Male | 469 (60%) | 242 (62%) | 227 (59%) | 164 (67%) | 305 (57%) |
| Site | | | | | |
| CSU | 382 (49%) | 196 (50%) | 186 (48%) | 200 (82%) | 182 (34%) |
| StFx | 168 (22%) | 78 (20%) | 90 (23%) | 1 (0.4%) | 167 (31%) |
| UVic | 229 (29%) | 118 (30%) | 111 (29%) | 44 (18%) | 185 (35%) |
| Year in College | | | | | |
| First | 110 (14%) | 53 (14%) | 57 (15%) | 25 (10%) | 85 (16%) |
| Second | 209 (27%) | 105 (27%) | 104 (27%) | 62 (25%) | 147 (28%) |
| Third | 188 (24%) | 98 (25%) | 90 (23%) | 62 (25%) | 126 (24%) |
| Fourth | 210 (27%) | 107 (27%) | 103 (27%) | 63 (26%) | 147 (28%) |
| Graduate student | 60 (7.7%) | 28 (7.2%) | 32 (8.3%) | 33 (13%) | 27 (5.1%) |
| PBS use frequency | | | | | |
| Baseline | 3.10 (0.78) | 3.09 (0.75) | 3.10 (0.81) | 3.23 (0.77) | 3.03 (0.78) |
| Follow-up | 3.15 (0.81) | 3.17 (0.78) | 3.13 (0.84) | — | — |
| Cannabis use | | | | | |
| Baseline high-hours | 16 (15) | 16 (15) | 16 (15) | 13 (11) | 17 (16) |
| Baseline high-times | 6.0 (4.4) | 6.0 (4.4) | 6.1 (4.4) | 6.2 (4.1) | 5.9 (4.5) |
| Follow-up high-hours | 16 (18) | 16 (18) | 16 (18) | — | — |
| Follow-up high-times | 5.4 (4.6) | 5.2 (4.4) | 5.6 (4.8) | — | — |
| Consequences | | | | | |
| Baseline | 7.8 (5.9) | 7.8 (6.0) | 7.8 (5.9) | 10.1 (6.7) | 6.8 (5.2) |
| Follow-up | 6.2 (5.3) | 5.9 (5.1) | 6.4 (5.5) | — | — |

*Note*. [1]*M* (*SD*) or *n* (%). CSU = Colorado State University in Colorado, United States. StFx = St. Francis Xavier University in Nova Scotia, Canada. UVic = University of Victoria in British Columbia, Canada. PBS = protective behavioral strategies.

**Hypothesis 1**

Regression results are presented in Table 3. The effect of the intervention condition on follow-up PBS was small and not significant, suggesting the intervention did not produce significant changes in PBS. However, baseline PBS was a strong and significant predictor of follow-up PBS, indicating participants with higher baseline PBS tended to report higher follow-up PBS. Sex was not a significant predictor of follow-up PBS, suggesting no significant sex differences in PBS change. The model explained 53% of the variance in follow-up PBS ($p < .001$). The model demonstrated adequate fit (BIC = 1315.63, RMSEA = 0.00, CFI/TLI = 1.00) and estimation terminated normally for all imputed datasets. Regression results for imputed and complete-case datasets were consistent.

**Table 3**

*Regression of Intervention Condition Predicting PBS Use*

| | B (*SE*) | 95% CI | β | *p* | $R^2$ |
|---|---|---|---|---|---|
| Intercept | 1.00 (0.13) | [0.75, 1.26] | 1.25 | < .001 | 0.53 |
| Condition | -0.05 (0.05) | [-0.15, 0.05] | -0.03 | 0.33 | |
| Baseline PBS | 0.75 (0.03) | [0.69, 0.81] | 0.72 | < .001 | |
| Assigned Sex | -0.07 (0.05) | [-0.16, 0.03] | -0.04 | 0.15 | |

*Note*. PBS = protective behavioral strategies. B (*SE*) = unstandardized regression coefficient (standard error). CI = confidence interval. B = standardized regression coefficient. $R^2$ = proportion of variance explained in follow-up PBS.

**Hypothesis 2**

Mediation results are presented in Table 4. The direct effect of intervention condition on PBS was not significant, suggesting condition did not significantly predict PBS. However, follow-up PBS significantly predicted follow-up high-times and high-hours, indicating higher levels of PBS were associated with less cannabis use. The direct effects of condition on high-times and high-hours were not significant. Additionally, follow-up PBS was a significant predictor of consequences, indicating greater PBS use was associated with fewer consequences. However, condition did not have a significant direct effect on consequences and neither high-

times nor high-hours significantly predicted consequences. The indirect effect of condition on high-times through PBS was not statistically significant, nor was the indirect effect of condition on high-hours. Similarly, the indirect effect of condition on consequences via PBS was not significant. This suggests PBS did not serve as a significant mediator in the relation between intervention condition and cannabis outcomes.

Model fit statistics indicated an adequate fit. The upper and lower bounds of 95% confidence intervals crossed zero, indicating non-significant indirect effects. The model estimations terminated normally for all imputed datasets.

**Table 4**

*Path Analysis of Intervention Condition Predicting Cannabis Use and Consequences Mediated by PBS*

| | B (*SE*) | 95% CI | *p* |
|---|---|---|---|
| *a* path | | | |
| Condition → PBS | -0.05 (0.05) | [-0.15, 0.05] | 0.33 |
| *b* paths | | | |
| PBS → High-times | -0.17 (0.03) | [-0.22, -0.11] | <.001 |
| PBS → High-hours | -0.17 (0.04) | [-0.25, -0.08] | <.001 |
| PBS → Consequences | -1.24 (0.22) | [-1.67, -0.81] | <.001 |
| Direct effects | | | |
| Condition → High-times | 0.02 (0.04) | [-0.07, 0.10] | 0.69 |
| Condition → High-hours | -0.04 (0.05) | [-0.15, 0.07] | 0.47 |
| Condition → Consequences | 0.14 (0.30) | [-0.46, 0.73] | 0.65 |
| Indirect effects | | | |
| Condition → High-times | 0.01 (0.01) | [-0.01, 0.03] | 0.33 |
| Condition → High-hours | 0.01 (0.01) | [-0.01, 0.03] | 0.34 |
| Condition → Consequences | 0.06 (0.06) | [-0.07, 0.19] | 0.35 |
| Control Variables | | | |
| PBS1 → PBS2 | 0.75 (0.03) | [0.69, 0.81] | <.001 |
| Assigned Sex → PBS2 | -0.07 (0.05) | [-0.16, 0.03] | 0.15 |
| High-times1 → High-times2 | 0.10 (0.01) | [0.08, 0.11] | <.001 |
| High-hours1 → High-hours2 | 0.04 (0.00) | [0.03, 0.05] | <.001 |
| Consequences1 → Consequences2 | 0.68 (0.03) | [0.62, 0.75] | <.001 |
| High-times2 → Consequences2 | 0.05 (0.07) | [-0.09, 0.19] | 0.51 |
| High-hours2 → Consequences2 | -0.02 (0.02) | [-0.05, 0.01] | 0.22 |

*Note*. PBS = protective behavioral strategies. B (*SE*) = unstandardized regression coefficient (standard error). CI = confidence interval. "→" indicates predicting. Variables labeled "1" represent a baseline score and "2" represent a follow-up score.

## Exploratory Aim

### *Multiple-Group Analysis for Hypothesis 1*

Regression results from the multiple-group analysis are presented in Table 5. Across sites, intervention condition did not significantly predict follow-up PBS, while baseline PBS remained a significant predictor of follow-up PBS. Comparisons between CSU and StFx (B = 0.05, *SE* = 0.12, *p* = 0.66), CSU and UVic (B = 0.05, *SE* = 0.10, *p* = 0.61), and StFx and UVic (B = 0.01, *SE* = 0.12, *p* = 0.99) were not significant, indicating no meaningful differences in the effect of intervention condition on PBS across sites. The model demonstrated adequate fit (BIC = 1345.84, RMSEA = 0.00, CFI/TLI = 1.00).

**Table 5**

*Multiple-Group Analysis: Regression of Intervention Condition Predicting PBS*

| | B (*SE*) | 95% CI | β | *p* | $R^2$ |
|---|---|---|---|---|---|
| **CSU** | | | | | |
| Intercept | 1.06 (0.28) | [0.51, 1.61] | 1.38 | < .001 | 0.50 |
| Condition | -0.02 (0.08) | [-0.18, 0.14] | -0.01 | 0.82 | |
| Baseline PBS | 0.74 (0.06) | [0.63, 0.85] | 0.69 | < .001 | |
| Assigned Sex | -0.08 (0.09) | [-0.26, 0.10] | -0.04 | 0.40 | |
| **StFx** | | | | | |
| Intercept | 1.33 (0.23) | [0.89, 1.77] | 1.85 | < .001 | 0.42 |
| Condition | -0.07 (0.09) | [-0.24, 0.10] | -0.05 | 0.41 | |
| Baseline PBS | 0.62 (0.06) | [0.51, 0.73] | 0.64 | < .001 | |
| Assigned Sex | -0.10 (0.09) | [-0.27, 0.07] | -0.07 | 0.24 | |
| **UVic** | | | | | |
| Intercept | 0.83 (0.21) | [0.42, 1.25] | 0.98 | < .001 | 0.59 |
| Condition | -0.07 (0.08) | [-0.22, 0.08] | -0.04 | 0.37 | |
| Baseline PBS | 0.81 (0.05) | [0.72, 0.91] | 0.76 | < .001 | |
| Assigned Sex | -0.05 (0.08) | [-0.21, 0.11] | -0.03 | 0.52 | |

*Note*. PBS = protective behavioral strategies. B (*SE*) = unstandardized regression coefficient (standard error). β = standardized regression coefficient. CI = confidence interval. $R^2$ = proportion of variance explained in follow-up PBS. CSU = Colorado State University in Colorado, United States. StFx = St. Francis Xavier University in Nova Scotia, Canada. UVic = University of Victoria in British Columbia, Canada.

### *Multiple-Group Analysis for Hypothesis 2*

Table 6 presents the mediation results for the multiple-group analysis. The direct effects of intervention condition on PBS, high-times, and high-hours were not significant, with no significant differences across sites. For cannabis consequences, direct effects were not significant among participants at CSU and UVic, but showed a significant positive effect for participants at StFx. Indirect effects were not significant, with no significant differences across sites.

Significant group differences emerged for the associations between PBS and outcomes. For high-times, the effect of PBS was significantly stronger for CSU compared to UVic (B = 0.17, *SE* = 0.07, *p* = .01) but did not significantly differ between CSU and StFx (B = 0.05, *SE* = 0.07, *p* = 0.52) or UVic and StFx (B = -0.12, *SE* = 0.07, *p* = 0.08). For high-hours, the effect of PBS was significantly stronger for CSU compared to StFx (B = 0.20, *SE* = 0.10, *p* = 0.04), CSU compared to UVic (B = 0.39, *SE* = 0.09, *p* < .001), and lower for UVic compared to StFx (B = -0.19, *SE* = 0.09, *p* = .03). The effect of PBS on cannabis consequences did not significantly differ between CSU and UVic (B = -0.62, *SE* = 0.49, *p* = 0.21), CSU and StFx (B = 0.09, *SE* = 0.52, *p* = 0.87), or UVic and StFx (B = 0.71, *SE* = 0.62, *p* = 0.26). Model fit statistics indicated an adequate fit based on successful convergence and interpretability of parameter estimates.

**Table 6**

*Multiple-Group Analysis: Path Analysis of Intervention Condition Predicting Cannabis Use and Consequences Mediated by PBS*

| | CSU | | StFx | | UVic | |
|---|---|---|---|---|---|---|
| | B (*SE*) | 95% CI | B (*SE*) | 95% CI | B (*SE*) | 95% CI |
| *a* path | | | | | | |
| Condition → PBS | -0.02 (0.08) | [-0.18, 0.11] | -0.07 (0.09) | [-0.24, 0.09] | -0.07 (0.08) | [-0.22, 0.08] |
| *b* paths | | | | | | |
| PBS → high-times | -0.09 (0.05) | [-0.18, 0.01] | -0.13 (0.05)* | [-0.23, -0.03] | -0.25 (0.05)*** | [-0.35, -0.16] |
| PBS → high-hours | 0.01 (0.08) | [-0.14, 0.16] | -0.19 (0.06)** | [-0.31, -0.07] | -0.37 (0.06)*** | [-0.50, -0.25] |
| PBS → consequences | -1.42 (0.33)*** | [-2.08, -0.77] | -1.51 (0.41)*** | [-2.32, -0.71] | -0.80 (0.37)* | [-1.53, -0.08] |
| Direct effects | | | | | | |
| Condition → high-times | 0.06 (0.08) | [-0.10, 0.21] | 0.06 (0.07) | [-0.08, 0.19] | -0.06 (0.07) | [-0.20, 0.08] |
| Condition → high-hours | -0.08 (0.09) | [-0.25, 0.10] | 0.04 (0.09) | [-0.14, 0.21] | -0.07 (0.01) | [-0.24, 0.10] |
| Condition → consequences | 0.13 (0.47) | [-0.83, 1.08] | 1.11 (0.55)* | [0.04, 2.19] | -0.66 (0.52) | [-1.67, 0.36] |
| Indirect effects | | | | | | |
| Condition → high-times | 0.00 (0.01) | [-0.01, 0.02] | 0.01 (0.01) | [-0.01, 0.21] | 0.02 (0.02) | [-0.02, 0.06] |
| Condition → high-hours | 0.00 (0.01) | [-0.01, 0.01] | 0.01 (0.02) | [-0.02, 0.05] | 0.03 (0.03) | [-0.03, 0.09] |
| Condition → consequences | 0.03 (0.12) | [-0.20, 0.25] | 0.11 (0.13) | [-0.15, 0.37] | 0.06 (0.07) | [-0.08, 0.19] |
| Control Variables | | | | | | |
| PBS1 → PBS2 | 0.74 (0.06)*** | [0.63, 0.85] | 0.62 (0.06)*** | [0.51, 0.73] | 0.81 (0.05)*** | [0.72, 0.91] |
| Assigned Sex → PBS2 | -0.08 (0.09) | [-0.26, 0.10] | -0.10 (0.09) | [-0.27, 0.07] | -0.05 (0.08) | [-0.21, 0.11] |
| High-times1 → High-times2 | 0.11 (0.01)*** | [0.09, 0.12] | 0.09 (0.01)*** | [0.07, 0.10] | 0.08 (0.01)*** | [0.07, 0.10] |
| High-hours1 → High-hours2 | 0.06 (0.01)*** | [0.05, 0.07] | 0.03 (0.00)*** | [0.02, 0.03] | 0.03 (0.00)*** | [0.02, 0.03] |
| Consequences1 → Consequences2 | 0.65 (0.05)*** | [0.56, 0.74] | 0.73 (0.06)*** | [0.61, 0.85] | 0.61 (0.07)*** | [0.47, 0.75] |
| High-times2 → Consequences2 | 0.08 (0.12) | [0.16, 0.33] | 0.14 (0.12) | [-0.09, 0.37] | -0.01 (0.09) | [-0.20, 0.18] |
| High-hours2 → Consequences2 | -0.03 (0.03) | [-0.09, 0.03] | -0.03 (0.03) | [-0.08, 0.03] | 0.01 (0.02) | [0.04, 0.05] |

*Note*. PBS = protective behavioral strategies. CSU = Colorado State University in Colorado, United States. StFx = St. Francis Xavier University in Nova Scotia, Canada. UVic = University of Victoria in British Columbia, Canada. B (*SE*) = unstandardized regression coefficient (standard error). CI = confidence interval. "→" indicates predicting. Variables labeled "1" represent a baseline score and "2" represent a follow-up score. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

# DISCUSSION

## Overview

This study is the first to examine cannabis protective behavioral strategies (PBS) as a mechanism of behavior change (MOBC) within an adapted version of Cannabis-eCHECKUP, a widely used online intervention (San Diego State University Research Foundation, 2018). Findings revealed no significant differences in PBS use frequency between the experimental and control groups and no evidence that PBS mediated intervention effects on cannabis use or negative cannabis consequences. However, higher PBS use frequency was associated with reduced cannabis use and fewer consequences. Regardless of intervention exposure, participants who frequently used PBS reported less harm associated with cannabis use. Additionally, participants, on average, reported increased PBS use, decreased cannabis use, and fewer cannabis consequences at follow-up. These results suggest that, while the intervention did not significantly change PBS use frequency, PBS is a valuable predictor of cannabis-related harm reduction among college students in the US and Canada.

The finding that the intervention did not significantly change PBS frequency contrasts with alcohol research, which has demonstrated PBS skills training may increase PBS use and reduce alcohol harm (Kenney et al., 2014). However, my findings are somewhat consistent with the previous study that tested an adapted version of Cannabis-eCHECKUP, which also found no significant effects on PBS frequency (Riggs et al., 2018). Consistent with cannabis research, I found higher PBS frequency was associated with less cannabis use and fewer consequences (Pedersen et al., 2017). The current study adds to the small body of literature examining intervention-induced effects and the temporal order between PBS and cannabis outcomes (Prince

et al., 2019; Riggs et al., 2018). Further research is needed to investigate mechanisms underlying cannabis PBS use and its role in behavior change. A better understanding of the mechanisms driving changes in PBS use will clarify how to integrate PBS into behavior change interventions more effectively.

**Interpreting the Findings**

Several factors may help explain why the intervention did not significantly change PBS use. One potential explanation involves how PBS was measured. The standard PBSM (Pedersen et al., 2017) assesses PBS frequency but not the perceived helpfulness, effectiveness, or context-specific use of strategies, which likely contribute to reducing harm. For example, an individual who uses one highly effective PBS will score lower on the PBSM than an individual who uses multiple, less effective strategies. This nuance is not captured in frequency scores. Although cross-sectional studies consistently show correlations between higher PBSM scores and less cannabis use and fewer consequences (Bolts et al., 2023; Bravo, Anthenien, et al., 2017; Bravo et al., 2019; Gray et al., 2024; Pearson et al., 2019; Pedersen et al., 2017; Richards et al., 2022), these correlations may not translate into meaningful behavior change. Quantifying PBS use does not necessarily provide a thorough understanding of how PBS functions in real-world settings or its effect on individual behavior.

In this study, participant ratings of perceived helpfulness of PBS were used to inform personalized feedback. Prior research suggests adults who perceive PBS as more helpful tend to use less cannabis and experience fewer negative consequences (Prince et al., 2019). This aligns with the social cognitive health belief model (Hochbaum, 1958; Rosenstock, 1974), which posits perceiving greater benefit of a behavior predicts engagement in that behavior. One cross-sectional study suggests college students who perceive greater harm-reduction benefit from using

PBS also use PBS more frequently (Bolts et al., 2023). However, causal mechanisms of these relations are unclear.

Theory of planned behavior (Ajzen, 1985, 1991) and theory of reasoned action (Fishbein & Ajzen, 1975) posit that attitudes toward a given behavior, norms, and self-efficacy are central to behavioral intention and engagement. Both the standardized eCHECKUP and adapted version in this study provide personalized normative feedback but do not address self-efficacy. This is a notable limitation since both PBS use and cannabis use require behavior engagement. Future research assessing self-efficacy in using PBS, alongside the perceived helpfulness and benefits of PBS in specific contexts, could provide greater insight into mechanisms underlying PBS use.

Another consideration is the measurement of cannabis use. The current study assessed cannabis use by times and hours per day under the influence, but not quantity, potency, or method of consumption. Refined assessments of cannabis quantity, potency, and method would provide a more nuanced understanding of use patterns, associated consequences, and relations to PBS. Research links high-THC products to increased harm (Arterberry et al., 2019; Cash et al., 2020; Freeman et al., 2021), yet product type and potency were not accounted for in the present study. A thorough assessment of cannabis use could provide valuable data for designing personalized PBS. For example, an individual who uses highly potent cannabis products with 60-90% THC and is not interested in reducing use frequency might benefit from reducing high-THC product usage by alternating with lower-THC products. The ability to design personalized PBS requires a more nuanced assessment of cannabis use itself.

Overall, cannabis use behaviors are complex and shaped by various biological, psychological, sociocultural factors that current measurement tools do not fully capture. Focusing only on quantities, such as how frequently someone uses PBS, risks mistaking

measurement for meaning. It is important to both improve measurement tools and recognize their limitations. The current cannabis literature remains limited in its ability to fully explain how cannabis PBS use translates into meaningful clinical outcomes.

Additionally, data collection for the current study occurred during the onset of the COVID-19 pandemic and mandated university closures, a period of significant disruption in college life (Clabaugh et al., 2021). Campus closures, changes in social environments, and shifts in accessibility to cannabis may have influenced both experimental and control group behaviors. Many students left campus following mandated closures and experienced increased stressors and difficulty coping during this time (Clabaugh et al., 2021). Further, college students often use cannabis in social settings (Beck et al., 2009; Buckner et al., 2012, 2015; Phillips et al., 2018), and multiple PBS items reference in-person social contexts (e.g., use only among trusted peers, avoid using while spending time with family, avoid using before work or school, avoid using in public places). Increased stress, changes in daily routines, and different social environments may have affected cannabis behaviors and PBS engagement in unforeseen ways among participants in this study.

Students assigned to the control condition received stress management information, which may have encouraged lifestyle changes (e.g., managing stress without cannabis) that indirectly increased PBS use (e.g., avoiding cannabis use to cope with emotions) and reduced cannabis use and consequences. Evidence suggests increases in substance-free positive reinforcement are associated with reduced alcohol and tobacco use among college students (MacPherson et al., 2010; Reynolds et al., 2011). Thus, it is possible the stress management information helped students in the control group increase PBS use and reduce cannabis use by promoting ways to manage stress and increase rewards without cannabis.

Another important factor in interpreting these results is the role of individual differences in behavior change. Akin to substance use recovery research that shows some people recover without formal treatment (Kelly et al., 2018; Witkiewitz & Tucker, 2025), some students may use PBS effectively without intervention while others may require more intensive or personalized support. Future intervention studies may consider targeted approaches that accommodate individual differences in biopsychosocial processes and cannabis use patterns. This personalization is important since harm reduction strategies are valuable at any level of motivation (Kimmel et al., 2021). Examining self-efficacy and readiness to change (Miller & Rollnick, 2023; Prochaska et al., 1992; SAMHSA, 2019) could provide insight into potential differences in the effectiveness of PBS interventions across subgroups.

Findings from the current study revealed a significant increase in average PBS frequency from baseline to follow-up for both the experimental and control conditions. However, the effect of intervention condition on follow-up PBS was small and not significant, indicating the adapted Cannabis-eCHECKUP did not significantly influence PBS frequency to a greater degree than the healthy stress management control condition. This pattern is consistent with prior Cannabis-eCHECKUP research (Elliott et al., 2014; Elliott & Carey, 2012; Fetterling et al., 2021; Palfai et al., 2014; Prince et al., 2021; Riggs et al., 2018) and alcohol PBS intervention research (Barnett et al., 2007; Labrie et al., 2010; Larimer et al., 2007; Reid & Carey, 2015) reporting mixed findings. In the current study, it is possible that participants' PBS use frequency was driven more so by biopsychosocial factors (e.g., self-efficacy, use context) than the brief intervention exposure.

Importantly, baseline PBS use emerged as the strongest predictor of follow-up PBS, indicating students who already employed harm reduction strategies were more likely to continue

doing so. Regarding cannabis outcomes, higher PBS frequency at follow-up was associated with less cannabis use and fewer negative consequences. These findings reinforce previous research linking cannabis PBS with harm reduction benefits (Bolts et al., 2023; Bravo, Anthenien, et al., 2017; Bravo, Prince, et al., 2017; Fetterling et al., 2021; Pearson et al., 2017; Peterson et al., 2021; Prince et al., 2019). However, PBS did not mediate the relation between intervention condition and cannabis use, suggesting additional factors may drive intervention efficacy.

**Implications and Future Directions**

Despite null intervention effects, the strong associations between PBS and cannabis outcomes underscore the potential value of targeting PBS in cannabis interventions. Future research could explore barriers to PBS implementation, including perceived effectiveness, motivation, accessibility, and knowledge of when and how to use specific PBS. From a health belief perspective, college students who perceive a greater threat of negative consequences and recognize greater benefits of PBS are more likely to use cannabis PBS (Bolts et al., 2023). However, perceived barriers to PBS use may vary among students who use cannabis. For example, students may experience different challenges depending on their use context (e.g., alone, social settings). Additionally, students new to cannabis use may encounter barriers due to unfamiliarity with PBS in cannabis use contexts (Bolts et al., 2023). Mixed methods research with qualitative interviews could provide insights into these barriers and potential refinements to PBS.

Measurement refinement is also important for understanding the role of PBS in harm reduction. Assessing context-specific PBS use, perceived helpfulness or effectiveness, and actual effectiveness could provide a more comprehensive understanding of how PBS functions in reducing cannabis harm. Evidence shows stronger belief in the helpfulness of PBS is associated

with more strategy use and less cannabis use and consequences (Prince et al., 2019). This association aligns with addiction theory that suggests individuals who perceive themselves as having effective coping skills and self-efficacy are more likely to regulate their substance use effectively (Liese & Beck, 2022; Marlatt et al., 1995). Additionally, tailoring PBS to specific cannabis use contexts and targeted consequences may enhance intervention efficacy. Expanding cannabis use assessments to include factors such as potency, product type, and consumption method could further improve the tailoring of PBS. Given the rise in cannabis availability and potency, understanding these elements is crucial for implementing interventions that align with current cannabis use patterns. Further, longitudinal studies assessing the long-term impact of PBS on cannabis-related outcomes would provide insights into the sustained effects of PBS.

Additionally, cannabis interventions may benefit from incorporating non-substance components, such as stress management and lifestyle modifications, to facilitate harm reduction. Allowing students to set personalized goals, whether related to cannabis use reduction or broader wellbeing, could support intervention engagement and relevance. Research suggests addressing lifestyle modifications (e.g., increasing engagement in substance-free activities) can effectively reduce substance use and associated consequences (Daughters et al., 2018; MacPherson et al., 2010; Reynolds et al., 2011). Pairing lifestyle modifications with PBS may provide students with practical alternatives to support harm reduction. For example, an individual who limits cannabis use to weekends could complement this PBS by increasing engagement in meaningful substance-free activities during the weekdays. Future research could explore how to tailor PBS components to individuals' substance and non-substance use goals to enhance intervention efficacy.

**Limitations**

The current study has several limitations. Selection bias may have influenced results since participants were self-selected college students from CSU, StFx, and UVic who use cannabis. The sample demographics represent students at CSU, StFx, and UVic but may limit generalizability to students elsewhere. Although recruiting students interested in safer cannabis use was a strength, the findings may not generalize to students who are not seeking treatment or who are mandated to treatment. Additionally, this study did not assess heterogeneity in demographic characteristics (e.g., the standardized eCHECKUP questionnaire only offered binary sex options) or multiple facets of cannabis use (e.g., potency, method), which limit the generalizability of results.

Data collection occurred during the onset of the COVID-19 pandemic and corresponding campus closures. This posed another challenge since participants' cannabis behaviors (e.g., social use, accessibility to cannabis) may have changed in ways not expected or captured by the study design. For example, students who typically use cannabis in social settings may have reduced cannabis use due to changes in their environment and access. Further, the stress management information provided to students in the control group may have had a greater effect than anticipated, given managing pandemic-related stress was likely highly relevant. This may have increased the potency of the control condition, making it difficult to identify distinct intervention effects.

Additionally, relying on self-reported quantitative data has the potential for participants underreporting or overreporting cannabis use, consequences, and PBS. Lastly, an error prevented matching baseline and follow-up data for 128 CSU participants. I handled missing data appropriately using multiple imputation (Little & Rubin, 2020; Rubin, 1987), but results could be affected if imputed values differ from observed values.

## Conclusion

The current study contributes to the growing literature on cannabis and harm reduction by examining cannabis PBS as a MOBC among college students in the US and Canada. While PBS did not mediate intervention effects, the significant associations of PBS with reduced cannabis use and consequences highlight PBS as an important harm reduction tool. These findings suggest the value of supporting and optimizing cannabis PBS use for harm reduction. Further, incorporating PBS into this intervention supports the feasibility of adding a PBS component to substance use interventions, including widely disseminated and established programs like Cannabis-eCHECKUP (San Diego State University Research Foundation, 2018). Future research could refine measurement approaches, investigate individual differences in PBS implementation, and explore intervention designs that integrate lifestyle modifications alongside cannabis harm reduction strategies. Ultimately, improving our understanding of cannabis PBS mechanisms and optimizing interventions will strengthen efforts to promote safer cannabis use among college students.

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# APPENDICES

## Appendix A: Control Condition Materials

**Thank You for Completing Your Entry**

Did you know?

- **70.1%** of college students reported experiencing stress within the last school year.
- **30.5%** of college students reported that stress affected their academic performance.
- **30.0%** of college students reported that being overcommitted affected their academic performance.
- **21.0%** of college students reported that being overcommitted had a high or very high effect on their stress levels.

**Students reported the following items as having a high or very high effect on their stress level within the last school year:**

- **36.4%** academic responsibilities
- **24.5%** career-related issues
- **21.0%** being overcommitted
- **18.8%** financial concerns
- **17.5%** personal emotional issues

Stressors are demands from the internal (self) or external (environment) that have the potential to produce stress. Factors or events, either real or imagined, can create a state of stress.

Stressors can generally be divided into two classes:

- Ongoing everyday chronic stressors
- Isolated or major events

Ongoing everyday chronic stressors for college students can be grouped into the following categories:

- School
- Time
- Money
- Relationships

Ongoing everyday chronic stressors for college students can be grouped into the following categories:

- Leaving home
- Balancing changing roles: student, employee, child, significant other

**Symptoms of Stress May Include**

- Difficulty focusing or concentrating
- Increased anxiety
- Frustration
- Moodiness or change in temperament
- General irritability
- Feeling out of control or overwhelmed
- Restlessness or fatigue
- A change in behavior or routines

### What Is Stress and Why Is Everybody Feeling It?

According to the American Psychological Association's (APA) 2010 Stress in America survey, "most Americans are suffering from moderate to high stress, with 44 percent reporting that their stress levels have increased over the past five years." Money, work, and the economy are the top stressors, as close to 50 percent of the respondents say they are worried about job stability.

Everybody has stress—both good stress and bad stress. It's a simple fact of life. The site WebMd describes stress as a "physical, mental, and emotional response to life's changes and demands." Some stress can be motivating, but too much stress can wreak havoc on one's physical, mental, and emotional health. "Stress is experienced in levels. Low levels may not be noticeable at all. Occasional, moderate stress can be positive and challenge people to act in creative and resourceful ways. High levels can be harmful, leading to chronic disease," according to WebMd.

The events that provoke stress are called stressors. The human body responds to stressors by activating the nervous system and specific hormones. TeensHealth.org, which is sponsored by the Nemours Foundation, explains the process: "The hypothalamus signals the adrenal glands to produce more of the hormones adrenaline and cortisol and release them into the bloodstream. These hormones speed up the heart rate, breathing rate, blood pressure, and metabolism."

These natural responses help the body to respond quickly under pressure, but what if you're a person who constantly feels like you are under the gun?

When you're stressed out, your body remains in a heightened state, which can cause damage to the nervous system, wear out your body's reserves, weaken your immune system, elevate your blood pressure, and leave you feeling completely overwhelmed. Therefore, it's important to learn how to step back, breathe, and manage your response to life's stressors.

### Avoid, Alter, Accept, and Adapt

Adults who are experiencing stress overload may have some of the following **symptoms**: anxiety or panic attacks; a feeling of being constantly pressured, hassled, or hurried; stomach problems, headaches, or chest pain; allergic reactions such as eczema or asthma; problems sleeping; substance abuse or eating disorders; or extreme feelings of sadness or depression.

The Mayo Clinic suggests four strategies for getting stress under control in the brochure "Need stress relief? Try the four A's":

**Avoid:** "A lot of needless stress can simply be avoided. Plan ahead, rearrange your surroundings." If it's traffic that stresses you out, leave early for work and try an alternate, less-traveled route. If your co-worker drives you crazy, avoid engaging in conversation with her as much as possible. If you feel like you have too much on your plate, learn how to say no and ask for help.

**Alter:** If there's something that causes you stress, try thinking about the alternatives. If your source of stress is another person, "respectfully ask the other person to change [his] behavior. And be willing to do the same." If your workload is too much to bear, speak with your supervisor to develop a mutually beneficial solution. And if you're getting behind in your work, think about ways to better manage your time and organize your tasks.

**Accept:** Stress can't always be avoided or altered; sometimes you have to accept things as they are. But you don't have to suffer in silence. Reach out. Talk to a friend. Take a coffee break. And if the situation calls for a little forgiveness, you will feel better for letting go of the negative energy and anger.

**Adapt:** The perception that you can't cope is actually one of the greatest stressors. That's why adapting—which often involves changing your standards of expectations—can be most helpful in dealing with stress. Learn to redefine success and perfection and be gentle with yourself. And try looking at the long view. Ask yourself, "Will this matter in a year? In five years?"

### Be Healthy and Wise

**Sleep**:  Experts agree that managing your health will help you to manage your stress. So eat healthy, exercise, and get plenty of sleep. Getting 7-9 hours of sleep each night is crucial in maintaining your body's overall health and wellness.

**Try practicing relaxation techniques**: such as deep breathing and stretching; do yoga; listen to music; take a walk; or work in your garden. Jot down your feelings in a journal. Focus on eliminating the stream of thoughts that cause you to feel stress.

**Delegation**: Whether you're at work or at home, learn to how to say "no" when necessary to keep your life in balance. Also, don't put yourself in a situation where you have to rush to finish. Prioritize, plan ahead, and don't procrastinate.

**Support**:  When you're feeling overwhelmed, break out of your protective cocoon and tap into your support network. Connect with a friend, call a relative, and distract yourself with people you love. And if you need help, ask for it. Seek professional help when needed.

Although it may seem daunting at first, getting out and socializing can help reduce risk factors for stress.

**Listen to your body**: if you like to stay active, then stay active, but be mindful of your boundaries; and if you're bored, then seek out new challenges and stimulate yourself.  Exercise not only releases chemicals that help you to feel happy, but it helps to break down the chemicals that raise your stress levels. A regular exercise schedule can help regulate naturally-occurring hormones.

### What Can Schools Do to Minimize Stress?

Workplace stress can lead to higher rates of illness and absenteeism and lower productivity; therefore, some employers are looking for ways to minimize stress by offering health and wellness services such as fitness classes, relaxation seminars, wellness fairs, and more.

**Emergency Stress Stoppers**

There are many stressful situations — at work, at home, on the road and in public places. We may feel stress because of poor communication, too much work and everyday hassles like standing in line. Emergency stress stoppers help you deal with stress on the spot.

Try these emergency stress stoppers. You may need different stress stoppers for different situations and sometimes it helps to combine them.

- Count to 10 before you speak.
- Take three to five deep breaths.
- Walk away from the stressful situation, and say you'll handle it later.
- Go for a walk.
- Don't be afraid to say "I'm sorry" if you make a mistake.
- Set your watch five to 10 minutes ahead to avoid the stress of being late.
- Break down big problems into smaller parts. For example, answer one letter or phone call per day, instead of dealing with everything at once.
- Drive in the slow lane or avoid busy roads to help you stay calm while driving.
- Smell a rose, hug a loved one or smile at your neighbor.
- Consider meditation or prayer to break the negative cycle.

Keeping a gratitude journal or journaling about life has been shown to help boost optimism and can help to take burdens from your shoulders.

### Laughter and Unplug

**Laugh:  even if you have to force a fake laugh—just start chuckling. You will feel better. "When you start to laugh, it lightens your mental load and actually causes positive physical changes in your body. Laughter fires up and then cools down your stress response and increases your heart rate and blood pressure, producing a good, relaxed feeling," says the Mayo Clinic article "Stress relievers: Top 10 picks to tame stress." Laughter not only releases chemicals that help you to feel happy, but it helps to break down the chemicals that raise your stress levels. A regular exercise schedule can help regulate naturally-occurring hormones.**

College students have an enormous amount of stress in their lives because they struggle with heavy credit loads, jobs, and economic uncertainty. Very few college students know how to handle their stress.

Laughter therapy, which gets people chuckling by watching funny movie clips, YouTube videos, and a stand-up comic.

This has been shown to release chemicals and reduce stress hormones in your brain. Read a good comic or watch a funny movie or video clip.

Remember to laugh every day and do something fun. Spend time outdoors. Move every day and find an activity that you love to do. Discover new hobbies. Be mindful of the moment, focus on your breath—take three deep breaths if you start to feel anxious. Practice compassion for another person. Journal your thoughts and feelings. Play. Make art. Unplug—turn off the TV, computer and the cell phone.  Develop a healthy social life—support systems are critical in handling stress.

11. Play cards or board games with family and friends.

### Make Changes

In order to manage stress, you need to make changes to cope with life's challenges. Create and stick to a schedule. To start, prioritize those things of most importance and then add in stress reducers. Eliminate unnecessary stressors. Finally, make appropriate lifestyle changes for healthier living.

### Positive Self-Talk

Self-talk is one way to deal with stress. We all talk to ourselves; sometimes we talk out loud but usually we keep self-talk in our heads. Self-talk can be positive ("I can do this" or "Things will work out") or negative ("I'll never get well" or "I'm so stupid").

Negative self-talk increases stress. Positive self-talk helps you calm down and control stress. With practice, you can learn to turn negative thoughts into positive ones.

| Negative | Positive |
|---|---|
| "I can't do this." | "I'll do the best I can." |
| "Everything is going wrong." | "I can handle things if I take one step at a time." |
| "I hate it when this happens." | "I know how to deal with this; I've done it before." |

To help you feel better, practice positive self-talk every day — in the car, at your desk, before you go to bed or whenever you notice negative thoughts.

Having trouble getting started? Try positive statements such as these:

- "I've got this."
- "I can get help if I need it."
- "We can work it out."
- "I won't let this problem get me down."
- "Things could be worse."
- "I'm human, and we all make mistakes."
- "Someday I'll laugh about this."
- "I can deal with this situation."

Remember: Positive self-talk helps you relieve stress and deal with the situations that cause you stress.

# Appendix B: Example of Experimental Condition Personalized Feedback

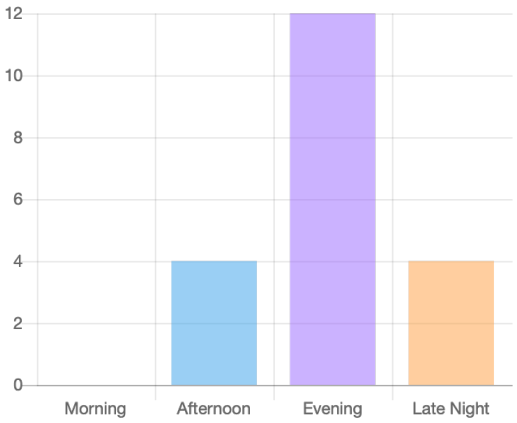
## Your Personal Use Profile

***In a typical month:***

- You use marijuana on **20** days.
- You drink **52** standard alcoholic drinks.
- You don't typically smoke cigarettes.

### When and how often do you use?

The graph to the right shows your *pattern of use* over the past month and what time of the day you were most likely to use.




Counselors working with people who use marijuana ***more than one time*** during the day find they have more social and physical problems than those who only use in the evenings. It is also common to discover that people who use at ***multiple times*** are also more likely to be smoking to avoid problems they feel unable to confront.

### Mixing Marijuana and Alcohol

***You indicated that you drink about 52 alcoholic drinks in a typical month***.

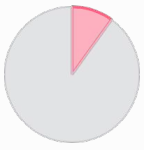
Using marijuana in addition to alcohol can put you at increased risk. The effects of some drugs become exponentially greater when taken together. In addition, the physical tolerance that one drug produces can sometimes affect another drug, which can lead to dependence on multiple substances.

### How do you spend your time?

***In a typical month***:

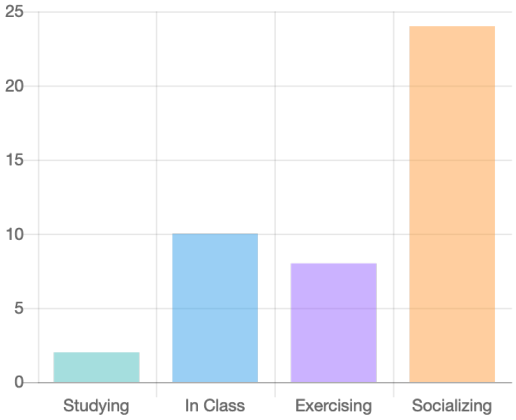
You spend **56 hours** under the influence of marijuana

That's **10%** of your waking hours



The graph to the right shows you what **percent** of your waking hours you spend engaged in the activities listed. In a TYPICAL MONTH, you spend.

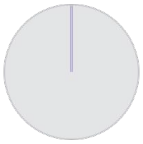
- **2%** of your time **studying**
- **10%** of your time **in class**
- **8%** of your time **exercising**
- **24%** of your time **socializing/partying**



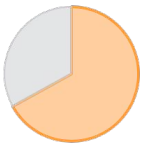

You are under the influence of marijuana **0%** of the time you **study**

You are under the influence of marijuana **0%** of the time you are in **class**

You are under the influence of marijuana **0%** of the time you are **exercising or playing sports**



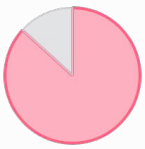
You are under the influence of marijuana **67%** of the time you are **socializing/partying**



## The Cost to You

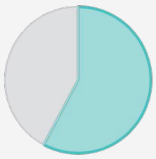
**Per YEAR**

You spend about **$1560 per year** on marijuana, alcohol and/or cigarettes...

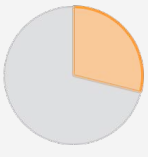


Which means you spend about **86.7%** of your spending money on marijuana, alcohol and/or cigarettes.

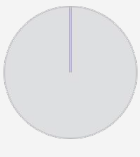
You spend about **$1040** (57.8%) of your spending money on **marijuana**.



You spend about **$520** (28.9%) of your spending money on **alcohol**.



You spend about **$0** (0%) of your spending money on **cigarettes**.



### Spending your money on what you choose

By way of comparison, the amount of money you spend on marijuana, alcohol and/or cigarettes would be enough to stream your music for **156 months**, or...

Pay your cell phone bills for **52 months**, or...

Allow you to pay your rent for **2.6 months**, or...

If you had that money you could buy new books and supplies for a year or a new computer!


## Potential Risks

### Driving Under the Influence

***You reported that:***

- You drove **5 days in the past month** within 5 hours of using marijuana. It is likely that **you were driving while intoxicated**.
- In the past month, **you rode 10 days** with a driver who used marijuana within 5 hours prior to driving. It is likely that **your driver was driving while intoxicated**.

Reliable research examining the effects marijuana have on driving skills suggests that you are significantly more likely to be in a car crash after using marijuana. This research also shows that it **can take as many as 10 hours** for THC blood levels to return to levels safe to drive.

If you use **marijuana as an edible (i.e., eat/ingest it), it may take even longer** for you blood levels to return to levels safe to drive.

- You **sometimes** drink alcohol while also using marijuana.

You also indicated that you often use both alcohol and marijuana during the same occasion. The mixture of marijuana and alcohol in your body substantially increases your risk of being involved in a car crash and other negative consequences.

### Can Marijuana be Addictive?

"Estimates from research suggest that about 9 percent of users become addicted to marijuana. This number increases among those who start young (to about 17 percent) and among daily users (25-50 percent)" (National Institute of Drug Abuse, 2017).

***You said:***

- You began using marijuana at **age 18**
- You use marijuana on **20 days** in a typical month.

**Potential Physical Health Costs**

The physical effects of marijuana depend on many individual factors such as personal health, the time of day that marijuana is used, the problems it causes, and how well a person is able to control his or her use. Research studies reported by the National Institute of Drug Abuse have shown that one of the primary concerns for those who use marijuana is **cardiopulmonary damage**.

- Marijuana causes **damage to lungs** that is similar to that caused by cigarettes. For people who inhale deeply or hold the smoke in their lungs longer, the risk can be greater.
- One study that compared cigarette and marijuana smokers found that marijuana smokers absorbed five times the amount of carbon monoxide, and had five times the tar in their lungs, as compared to cigarette smokers.
- For those who smoke both **marijuana and cigarettes**, the damage can be exponentially greater than that caused by marijuana or cigarettes alone.
- Marijuana use **disrupts sleep** by extending "deep" (stage 4) sleep and depriving you of REM sleep. This leads to several "day after" effects, including: sleepiness, irritability, anxiety and jumpiness.

**Potential Cognitive Costs:**

Marijuana use has been shown to yield cognitive deficits, both short-term and long-term.

- Short term:
  - Decreased attention
  - Decreased concentration
  - Compromised working memory
  - Lower processing and response speed
- Longer term:
  - Difficulty dividing attention
  - Difficulty filtering out unnecessary/unwanted information
  - Verbal memory problems

For those who use marijuana daily, impairments of attention, memory and concentration last for 28 days after stopping. " Research has shown that, in chronic users, marijuana's **adverse impact on learning and memory** can last for days or weeks after the acute effects of the drug wear off. As a result, someone who smokes marijuana every day may be functioning at a suboptimal intellectual level all of the time." (National Institute of Drug Abuse).

**Potential Mental Health Costs**

While the use of marijuana has been shown to be correlated with **anxiety and depression**, "currently, the strongest evidence links marijuana use and schizophrenia and/or related disorders. **High doses of marijuana can produce an acute psychotic reaction**; in addition, use of the drug may trigger the onset or relapse of schizophrenia in vulnerable individuals." (National Institute of Drug Abuse).

Research has demonstrated that, for those who possess certain gene variations, marijuana use is correlated with a higher risk of psychosis.

- Studies show that people with a particular variation of the AKT1 gene are 7 times more likely to develop psychosis with daily use of marijuana.

- People who possess the "Val" variant of the COMT gene are at higher risk of developing schizophrenia-like disorders if they used marijuana during adolescence.

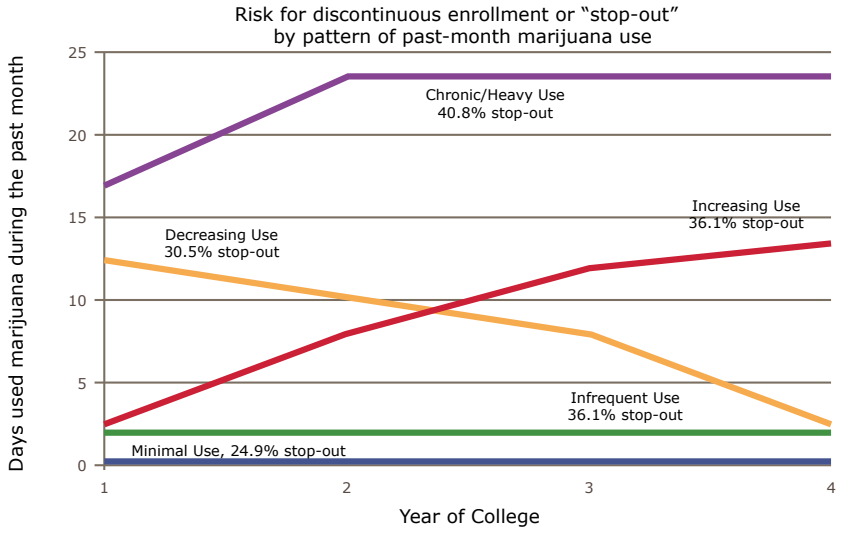
Furthermore, using marijuana may exacerbate already-existing mental health issues and therefore create further challenges to attending and completing college.

**Potential Academic Costs:**

As noted before, using marijuana puts students at risk of losing federal financial aid if caught and convicted of possession.

Research also shows marijuana use "appears to contribute to college students skipping more classes, spending less time studying, earning lower grades, dropping out of college, and being unemployed after college. (p.5, citation below)"

Additionally, marijuana users are at greater risk for taking a semester or more off during the course of college, which can jeopardize graduation.




In the graph above: 40.8% of chronic marijuana users had an interruption in their college attendance (i.e., a "stop-out"). 36.1% of students who increased their marijuana use in college experienced a stop-out. 36.1% of students who used marijuana "infrequently" experienced a stop-out. 30.5% of students who decreased their marijuana use in college experienced a stop-out. 24.9% of students reporting "minimal use" of marijuana experienced a stop-out. Source: Arria AM, Garnier-Dykstra LM, Caldeira KM, Vincent KB, Winick ER, O'Grady KE. Drug use patterns and continuous enrollment in college: Results from a longitudinal study. *J Stud Alcohol Drugs*. 2013;74(1):71-83.
More Info: http://www.cls.umd.edu/docs/AcadOppCosts.pdf

**Can I Trust the Research?**

While the research is clear and unambivalent about some of the specific risks associated with marijuana use (including the increased risk of being involved in a car crash, the potential to develop an addiction and possible cardiopulmonary damage) many studies examining other risks have shown mixed results.

Given that the goal of the Marijuana eCHECKUP TO GO program is to provide you with individual and personalized feedback and not simply to present general statistical information, it is important for you to give thoughtful consideration to any research that suggests a potential harm or risk to you or your family — even when other studies may show mixed results.

Given what you know about yourself, your family, your use and your aspirations, you are in a strong position to personally consider all potential harms associated with marijuana use.

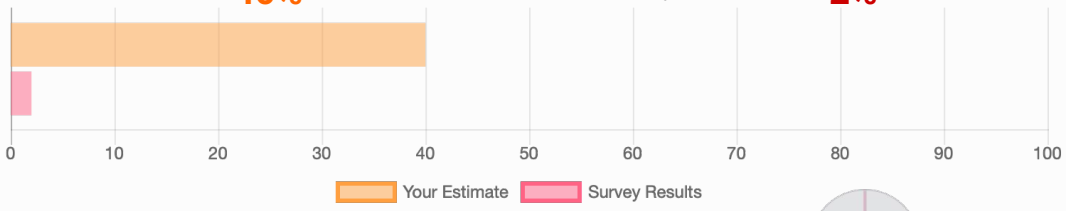
## How Does Your Marijuana Use Compare?

**About 95.4% of United States college students use marijuana *LESS frequently* than you.**

**About 2.1% of United States college students use marijuana *MORE frequently* than you.**

**What percent of United States college students use marijuana *more frequently* than you?**

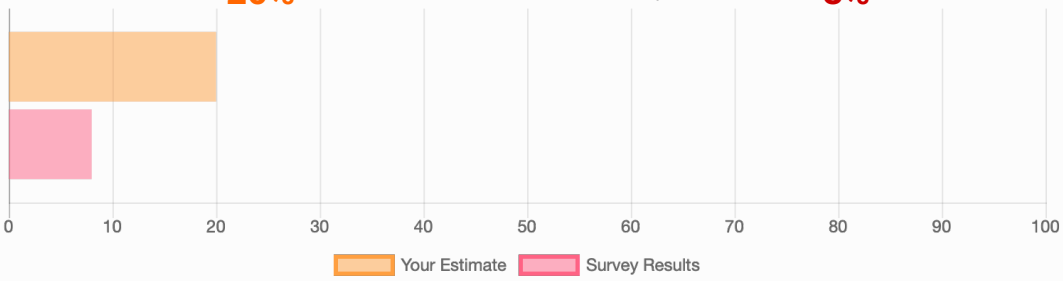
You said: **40%** Survey results indicate: **2%**




*89%* of US college students *who use marijuana* use marijuana *LESS frequently* than you.

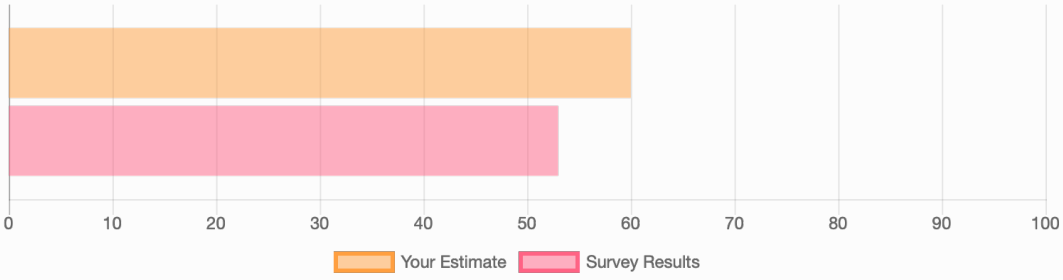
**What percent of Colorado State University students use marijuana AT LEAST ONCE PER DAY?**

You said: **20%** Survey results indicate: **8%**



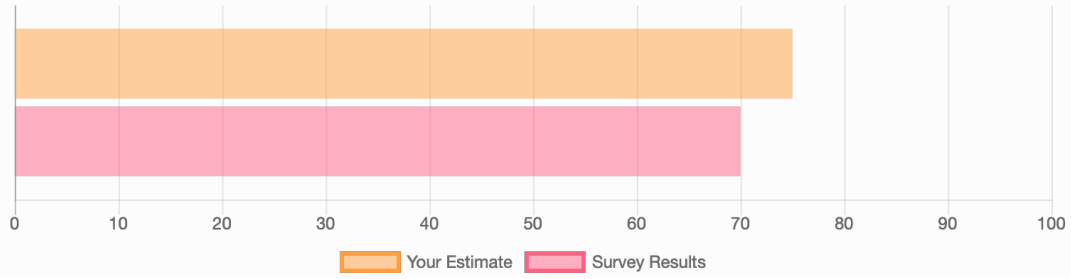

**What percent of Colorado State University students use marijuana AT LEAST ONCE A WEEK?**

You said: **60%** Survey results indicate: **53%**



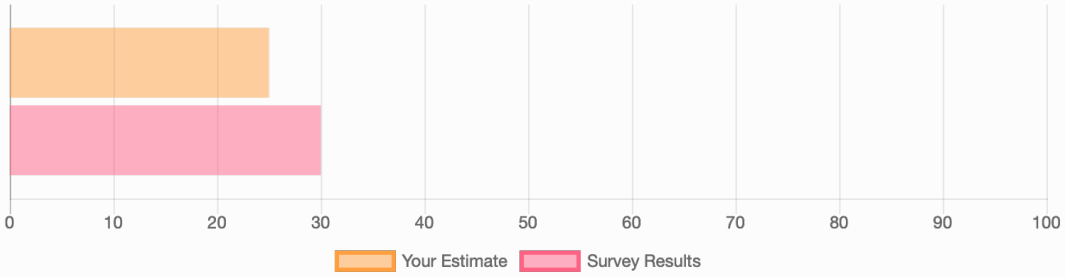

**What percent of Colorado State University students use marijuana AT LEAST ONCE A MONTH?**

You said: **75%** Survey results indicate: **70%**



**What percent of Colorado State University students DO NOT USE marijuana at all IN A TYPICAL MONTH?**

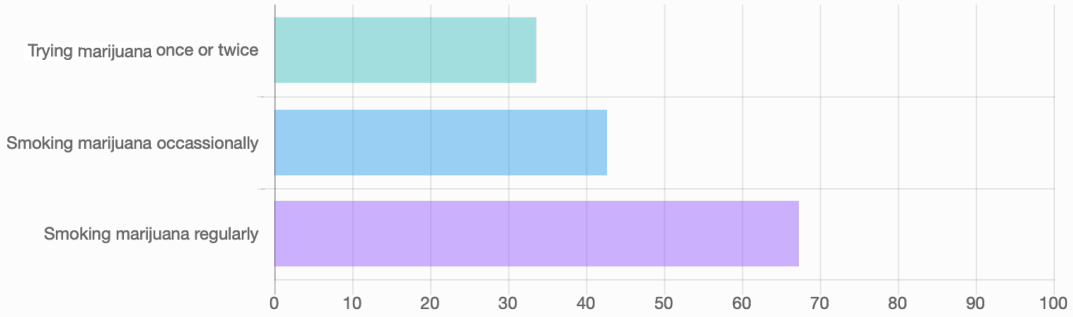
You said: **25%** Survey results indicate: **30%**




**How do your peers feel about marijuana use?**

Amongst Americans in your age group (19-22):

- **33.6%** disapprove of trying marijuana once or twice
- **42.7%** disapprove of smoking marijuana occasionally
- **67.3%** disapprove of smoking marijuana regularly




**Were your Guesses Off?**

You're not alone. Several studies have shown that members of the campus community (including faculty and staff) tend to ***overestimate*** the number of students who use marijuana, drink heavily and use other drugs.

In addition to showing how your marijuana use fits in with national norms, we have also shown how your estimates compared with actual survey responses. The college normative information is based on the anonymous survey responses of 18,702 students from multiple two- and four-year institutions to the 2015 CORE Survey. The survey was conducted by the CORE Institute.

The CSU normative information is based on the responses of CSU students to the 2015-16 National College Health Assessment. Additional data is provided from:

National Academies of Sciences, Engineering, and Medicine. (2017). *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research.* National Academies Press.

Schulenberg, J. E., Johnston, L. D., O'Malley, P. M., Bachman, J. G., Miech, R. A., & Patrick, M. E. (2017). *Monitoring the future national survey results on drug use, 1975–2016: Volume II, college students and adults ages 19–55.* Ann Arbor: Institute for Social Research, The University of Michigan. Retrieved from http://monitoringthefuture.org/pubs.html#monographs

## Brief Marijuana Consequences Questionnaire (B-MACQ) feedback

**You reported perceiving using marijuana regularly as "No risk"**

Below are some known consequences of using marijuana regularly. This list comes from a recent comprehensive review by the National Academies of Sciences, Engineering, and Medicine.

1. Worsening respiratory symptoms (e.g., chronic cough, bronchitis)
2. Dependence on cannabis and other substances
3. Impairments in learning, memory, and attention
4. Increased risk of motor vehicle accidents when driving under the influence
5. Increased risk for developing social anxiety, schizophrenia or other psychoses

We also asked you to personally report which consequences you have experienced and how severe they are. Below are the consequences you reported experiencing most often and as the most severe.

1. **The quality of my work or schoolwork has suffered because of my marijuana use**
2. **I have neglected obligations to family, work, or school because of my marijuana use**
3. **I have received a lower grade on an exam or paper than I ordinarily could have because of marijuana use**

National Academies of Sciences, Engineering, and Medicine. (2017). *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research.* Washington, DC: The National Academies Press. doi:10.17226/24625.

## My Plan

You reported using these strategies most often and reported these strategies as the most helpful in moderating your use of marijuana.

1. **Avoid methods of using marijuana that can make you more intoxicated than you would like (e.g., using large bongs, volcano, 'edibles,' etc.)**
2. **Avoid using marijuana in public places**
3. **Avoid mixing marijuana with other drugs**

We find that people who use these strategies meet their goals of reducing or limiting their marijuana use, and so we encourage you to keep using these. Keep up the good work!

**Change Plan**

My goal is:

- ○ Not change my marijuana use at all
- ○ Reduce my marijuana use and reduce my risk of negative consequences
- ○ Abstain completely from using marijuana
- ○ Decline to answer

My reasons to change are:

1. 

2.

3.

Given everything that you have learned throughout this program, what are your next steps?

## Making a Change?

***On a scale of 1 to 10:***

- You rated the **importance** of making a change in your personal use of marijuana as a: **8**
- You rated your **confidence** in your ability to make any change in your personal use of marijuana as a: **5**


You indicated that it is very important for you to change your marijuana use, and you are fairly confident that you could make a change when you decided to. You responses put you in a category of people who are most likely to see a benefit from making a change. People with moderate levels of confidence can usually make a change if they decide to. For some, the process of making a change may mean avoiding friends or situations that lead to marijuana use. For others, it may mean making the choice to spend money on other things, on time on other activities.

**Your change plan...**

Your goal was to: **Reduce my marijuana use and reduce my risk of negative consequences**

What progress have you made toward this goal?

- ○ None
- ○ A little
- ○ A lot
- ○ I met my goal
- ○ Decline to answer

## Appendix C: Standardized eCHECKUP Demographics Questions

What is your sex?
( ) Male ( ) Female

*Why do we ask about your sex? The eCHECKUP TO GO Program uses participants' sex information to make assumptions about the average amount of water in the body and average metabolic rate and to provide participants with sex-based normative comparisons when available. Unfortunately, normative comparisons and information about water retention and metabolic rate for transgender or transsexual people, intersex people, or for persons in transition are currently unavailable. If you are interested in the social and normative aspects of marijuana use, select the group (males/females) to which you would like to be compared.*

How old are you in years?
[ ]

*Why do we ask about your age? The eCHECKUP TO GO Program uses participants' age to make appropriate age-based normative comparisons (if available) and to modify sections of the feedback to specific age groups when pertinent.*

How much do you weigh? (in lbs. or kgs.)
[ ]

*Why do we ask about your weight? The eCHECKUP TO GO Program uses participants' weight information to calculate Blood Alcohol Content (BAC) estimations and to modify sections of the feedback, when pertinent.*

What is your student status?
( ) [Colorado State University] Student ( ) Other College Student
( ) High School Student ( ) Non-student ( ) Decline to answer

*Why do we ask about your student status? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to your student status, when available.*

What is your year level/class standing?
( ) First year ( ) Second year ( ) Third year
( ) Fourth year ( ) Fifth year or greater ( ) Not Applicable ( ) Decline to answer

*Why do we ask about your year level? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to your class standing, when available.*

Do you live on-campus or in a residence hall?
( ) Yes ( ) No

*Why do we ask if you live on-campus? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to students living on or off campus, when available.*

Do you belong to a fraternity or sorority?
( ) Yes ( ) No

*Why do we ask if you are in a fraternity or sorority? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to students who are members of Greek organizations, when available.*

Do you play on an athletic team?
( ) Yes ( ) No

*Why do we ask if you are an athlete? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to athletes and non-athletes, when available.*

Are you currently taking any prescription medications?
( ) Yes ( ) No

*Why do we ask about medications? The eCHECKUP TO GO Program uses this information to provide you with personalized feedback and information pertinent to athletes and non-athletes, when available.*

**Appendix D: Modified Brief Marijuana Consequences Questionnaire (B-MACQ)**

Below is a list of things that people sometimes experience because of their marijuana use. Please indicate if that item describes something that happened to you during your typical and heaviest marijuana use. Then, indicate how negative each consequence you experienced was for you.

1. The quality of my work or schoolwork has suffered because of my marijuana use.
2. I have driven a car when I was high.
3. I have felt in a fog, sluggish, tired, or dazed the morning after using marijuana.
4. I have been unhappy because of my marijuana use.
5. I have gotten into physical fights because of my marijuana use.
6. I have spent too much time using marijuana.
7. I have felt like I needed a hit of marijuana after I'd gotten up.
8. I have become very rude, obnoxious, or insulting after using marijuana.
9. I have been less physically active because of my marijuana use.
10. I have had trouble sleeping after stopping or cutting down on marijuana use.
11. I have neglected obligations to family, work, or school because of my marijuana use.
12. When using marijuana, I have done impulsive things that I regretted later.
13. I have awakened the day after using marijuana and found I could not remember a part of the evening before.
14. I have been overweight because of my marijuana use.
15. I haven't been as sharp mentally because of my marijuana use.
16. I have received a lower grade on an exam or paper than I ordinarily could have because of marijuana use.
17. I have tried to quit using marijuana because I thought I was using too much.
18. I have felt anxious, irritable, lost my appetite, or had stomach pains after stopping or cutting down on marijuana use.
19. I often have thought about needing to cut down or to stop using marijuana.
20. I have had less energy or felt tired because of my marijuana use.
21. I have lost motivation to do things because of my marijuana use.

***Response Scales***

Did you experience the following consequences during typical use: 0 = *no*, 1 = *yes*
Did you experience the following consequences during heaviest use: 0 = *no*, 1 = *yes*
Severity: 1 = *minimally negative* to 5 = *extremely negative*

***Scoring Protocol***

Create two count variables of consequences experienced during typical and heaviest use by summing the yes/no responses.

***Feedback***

For each item, add yes/no scores for typical and heaviest use responses – resulting in 0 if never experienced it, 1 if experienced during either typical or heavy use, or 2 if experienced during both typical and heavy use. Multiply this number by the severity score for each item. This provides a B-MACQ rank score for each item. Participants receive feedback on the three highest B-MACQ rank scores.

*Feedback Template*

You reported perceiving using marijuana regularly as [pipe in participant response from norms question asking "how much do you think people risk harming themselves (physically or in other ways) if they…"]. Below are some known consequences of using marijuana regularly. This list comes from a recent comprehensive review by the National Academies of Sciences, Engineering, and Medicine.

1. Worsening respiratory symptoms (e.g., chronic cough, bronchitis)
2. Dependence on cannabis and other substances
3. Impairments in learning, memory, and attention
4. Increased risk of motor vehicle accidents when driving under the influence
5. Increased risk for developing social anxiety, schizophrenia, or other psychoses

We also asked you to personally report which consequences you have experienced and how severe they are. Below are the consequences you reported experiencing most often and as the most severe.

1. INSERT TOP THREE RANKED CONSEQUENCES HERE
2.
3.

**Appendix E: Modified Protective Behavioral Strategies for Marijuana Scale (PBSM)**

Please indicate the degree to which you would engage in the behaviors when using marijuana/ cannabis. Then, indicate how helpful each behavior has been in helping you moderate your use.

1. Use marijuana only among trusted peers
2. Avoid use while spending time with family
3. Avoid using marijuana before work or school
4. Avoid using marijuana to cope with emotions such as sadness or depression
5. Limit use to weekends
6. Only purchase marijuana from a trusted source
7. Avoid using marijuana habitually (that is, every day or multiple times a week)
8. Use a little and then wait to see how you feel before using more
9. Avoid mixing marijuana with other drugs
10. Avoid using marijuana in public places
11. Take periodic breaks if it feels like you are using marijuana too frequently
12. Buy less marijuana at a time so you smoke less
13. Have a set amount of "times" you take a hit (e.g., passing on a shared joint if you have already hit that limit)
14. Avoid methods of using marijuana that can make you more intoxicated than you would like (e.g., using large bongs, volcano, edibles, etc.)
15. Only use one time during a day/night
16. Limit the amount of marijuana you smoke in one sitting
17. Avoid using marijuana before engaging in physical activity (i.e., exercise, hiking)

***Response Scales***

Frequency: 0 = *never*, 1 = *rarely*, 2 = *occasionally*, 3 = *sometimes*, 4 = *usually*, 5 = *always*
Helpfulness: 0 = *not at all helpful*, 1 = *slightly helpful*, 2 = *somewhat helpful*, 3 = *moderately helpful*, 4 = *very helpful*, 5 = *extremely helpful*

***Scoring Protocol***

Average the 17 items to create an overall PBS use frequency score.

***Feedback***

Create a PBSM rank score for each item by multiplying the frequency score by the helpfulness score for each item. Participants receive feedback on the three highest PBSM rank scores.

*Feedback Template*

You reported using these strategies most often and reported these strategies as the most helpful in moderating your use of marijuana.

1. INSERT RANKED PBS ITEMS HERE
2.
3.

We find that people who use these strategies meet their goals of reducing or limiting their marijuana use, and so we encourage you to keep using these. Keep up the good work!