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Cannabis use and behavioral and health outcomes among people with HIV

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Abstract

Background: Cannabis use is more prevalent among people with HIV (PWH) than in the general population and has been increasingly accepted in the US. However, findings about its potential benefits or risks have been mixed. This study examined the relative contribution of cannabis use on health behaviors and health outcomes in the context of a co-occurring cumulative burden comprised of substance use, depression, and poverty.

Methods: Participants (N = 241) were recruited from the community, and were assessed on a number of demographic, behavioral, and physiological domains. Exclusive cannabis use was defined as the use of cannabis alone without other the use of other drugs.

Results: Exclusive cannabis use was only associated with decreased antiretroviral therapy (ART) uptake (b = -1.26, SE = 0.53, p = .018), as well as decreased total exercise (b = -0.66, SE = 0.29, p = .021). In contrast, a variety of other factors including age, education, and the cumulative burden factor were associated with health behaviors.

Conclusion: Findings suggest the deleterious consequences of cannabis among PWH are limited to decreased ART use and exercise, which suggest the need for prevention interventions targeting of memory and motivation.

Keywords: HIV, Cannabis, Anti-Retroviral Therapy, Health Behaviors, Life Burdens

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Introduction

Effective HIV-related treatment and prevention has significantly increased life expectancy among people living with HIV. While antiretroviral therapy (ART) is the key to optimizing health outcomes, adverse side effects may also accompany treatment. Commonly observed side effects include gastrointestinal problems, such as nausea and vomiting, as well as central nervous system complaints, such as headaches and insomnia. Additionally, flu-like symptoms associated with HIV infection may occur. The pervasiveness of these symptoms and side effects are major barriers to achieving optimal behavioral and health outcomes among PWH [1-7].

Patients in the general population seeking relief for a variety of symptoms increasingly use cannabis. Cannabis has been found to relieve muscle pain, nerve pain, paresthesia, nausea, depression, anxiety, stress, and to stimulate appetite [8-11]. Cannabis usage is more prevalent among PWH than in the general population (23-26% compared with 13%), and in 2013, cannabis was the most commonly used drug in this population [12-14]. Approximately 10-35% of PWH use or have used cannabis recently, 26% report non-daily recurrent use, and 8% report daily use. The rationale for cannabis usage has been attributed to alleviation of ART-related side effects, side effects due to HIV infection, and recreational purposes [15,16] however, empirical support for these potential positive effects are still lacking.

While many patients may experience benefits from cannabis usage, patients may also experience negative effects. One concern is that cannabis use has been found to be related to future opiate use and opiate use disorder and may act as a gateway to these more serious substances. While this risk has been identified among the general population, there are also specific risk factors which may be particularly salient to PWH. Cannabis use among PWH has been associated with memory impairment though others have reported decreased risk for neurocognitive

impairment, reduced ART adherence and decreased attendance at scheduled clinic appointments [17-21]. Given the prevalence of cannabis usage among PWH, the potential impact of cannabis use on treatment uptake should be considered and evaluated in the clinical setting. Therefore, findings about potential benefits or risks have been mixed, and studies examining the effect of cannabis use on multiple outcomes are needed to clarify associations between cannabis use and behavioral and health outcomes among PWH [23,24].

Despite the uncertainty, socioeconomic burden, in combination with cannabis use, may prevent PWH from achieving optimal health, namely, maintaining a healthy diet, engaging in moderate exercise and avoiding tobacco smoking [25-27]. Among PWH, cannabis use has been associated with lower levels of exercise and physical activity (e.g., inability to complete a 400-meter walk). Cannabis use among PWH has also been associated with higher kilocalorie intake, higher protein intake, and less frequent meals per day. However, studies have also reported that PWH who use cannabis to have a lower body mass index (BMI), further contributing to uncertainty regarding the association between cannabis use and health outcomes among PWH [28].

Since legal access to cannabis has expanded across the US, cannabis' use as a medical intervention has substantially grown [29]. However, the cost of cannabis use in comparison with the potential benefit may complicate clinical decision-making. To date, for example, research on cannabis use among PWH has not considered the effect of cannabis use on behavioral, i.e., ART use, exercise, nutrition, and tobacco use, and health outcomes, i.e., blood pressure, BMI, and carotid artery plaques. Therefore, this study examined the association between cannabis use and behavioral and health outcomes among PWH. It was hypothesized that cannabis use would be associated with poor health behaviors and poor health outcomes among PWH after controlling for the cumulative burdens of drug abuse, depressive symptoms, and low socioeconomic status, all of which are prevalent among PWH.

Methods

Participants

The parent study was approved by the University of Miami Miller School of Medicine Institutional Review Board (IRB number 20130988). All participants in the study gave their written informed consent prior to participation and completion of study-related assessments. Study data comes from a broader project examining cardiovascular disease and risk factors [30]. General study recruitment lasted from December 2014 through June 2018, and was carried out in South Florida, USA. Participants were recruited from a community sample in the Miami-Dade area by fliers and word of mouth. To be included in the study, participants had to be between 18 to 50 years old. At the time of assessment, participants were not on ART and were later changed to allow for inclusion of individuals who had started using ART in the past 6 months and were verified via medical records. Exclusion criteria included having a history of diabetes mellitus, hyperlipidemia, hypertension, receiving statins, vascular events (e.g., myocardial infarctions, transient ischemic attacks, angioplasty or bypass surgery), or hepatitis C. As the parent study was examining the development of arterial plaque as a main outcome, these preexisting conditions were excluded to remove their potential confounding effects.

Measures

Demographic Information: Demographic information was collected, and included age, HIV status, gender, race/ethnicity, education, living arrangements, marital status, employment status, and income.

Depression: In order to measure depressive symptomatology the Center for Epidemiological Studies Depression Scale (CES-D) was used [31]. The CES-D has been found to possess a favorable factor structure [32] and serve as a valid and reliable measure of depressive symptomatology [33]. The 20-item measure is scored on a 4 point Liker t-type scale (0 = rarely or none of the time (less than 1 day), 3 = Most or all of the time (5-7 days)), and displayed excellent internal consistency in this study (α = .906).

Physical Assessment: At study entry, participants weight and height were measured to calculate body mass index (BMI), as well as participants' blood pressure was measured. Mean arterial pressure (MAP), the average pressure in an artery during a full cardiac cycle, was calculated as (Systolic Pressure + (2 * Diastolic Pressure)) / 3. MAP has been found to be a better predictor of CVD than systolic or diastolic blood pressure alone [34].

Cannabis/Drug Use: To measure drug use, this study used the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV), non-patient version (SCID-IV-NP), which is a semi-structured, widely used measure. The SCID has been found to have to adequate reliability [35]. The presence of drug use was based on the screening items of the SCID. Using responses to the SCID, exclusive cannabis users were defined as those endorsing the use of cannabis and not endorsing the use of stimulants, opiates, cocaine, hallucinogens, or other drugs. Exclusive cannabis users could, however, use alcohol. Exclusive cannabis users were used to ensure that associations reflected true associations with cannabis use, rather than associations with the use of multiple drugs.

Carotid Atherosclerosis: In order to scan for the presence of carotid artery plaque, a high-resolution B-mode carotid ultrasound machine was used by a sonographer who was blind to the participants' HIV status, cocaine use, and other diseases. The ultrasonography machine was calibrated at the beginning of the study. Four hundred ultra sonographic readings were taken at 1-centimeter segment of the distal common carotid artery near and far wall, 1-centimeter of bifurcation, and 1-centimeter proximal internal carotid artery near and far wall. Afterwards, an automated edge tracking system, M'Ath (Intelligence in Medical Technologies, Inc., Paris, France) was used to process these images. M'Ath uses an intensity gradient detection algorithm to identify the number of plaques present, if any. A cardiovascular disease risk reduction standard of care intervention, targeting various health behaviors such as smoking, diet, and exercise was given to participants with detectable plaque.

Health Behaviors

ART use: Current ART use was assessed using a single item which asked participants, "Are you currently taking ART?"

Physical activity: Physical activity was measured using The International Physical Activity Questionnaire [36], a brief measure that assesses the number of minutes and days during the past week an individual walks, does moderate activity, does vigorous activity, and remains sitting. These two numbers were multiplied to calculate the average number of minutes spent weekly performing these various activities, and then summed to calculate the total number of minutes exercised. This measure has been found to be reliable and valid for assessing physical activity [37].

Overall nutrition: Participant's nutritional behavior as measured using the Rapid Eating Assessment for Participants (REAP) is a 31-item measure that was developed to assess engagement in healthy nutrition behaviors and activity [38]. It is scored on a 3-point Likert-like scale with responses ranging from 1 = Usually/ Often to 3 = Rarely/Never. Blank items, which were skipped due to rarely or never eating a certain category of food, were scored as 3 following scoring procedures used in another study [39]. This scale has been found to be a valid measurement of healthy eating. This measure demonstrated adequate internal consistency in this study with an overall $\alpha = .792$.

Cigarette smoking: Cigarette smoking was assessed using a single item which asked participants, "Do you smoke cigarettes?" Participants were also asked to provide the approximate number of cigarettes smoked every day. This question asked, "How many cigarettes do you smoke per day?" If participants indicated smoking more than 0 cigarettes per day or indicated being current smokers, their current smoking status was coded as "Yes."

Analytic Plan

Descriptive statistics (means, medians, standard deviations, and proportions) were used to describe the sociodemographic and cumulative burden status of participants. A total cumulative burden score was created as the sum of score of the four cumulative burdens present, which included having income lower than $1000 per month, endorsing alcohol abuse (based on the SCID), endorsing other drug use for stimulants, opioids, cocaine, hallucinogens, or other drugs (based on the SCID), and having clinically significant elevations in depressive symptomatology (CES-D). This total cumulative burden score along with a variable indicating cannabis use only were then used to predict key study variables in the form of health outcomes (MAP, BMI, and arterial plaque) and health behaviors (ART use, physical exercise, nutrition, and smoking) controlling for education years and age. The cannabis use only group was treated as the reference group, and reported beta coefficients indicate the mean difference for a non-exclusive or exclusive cannabis user. A z-score of 4 was used as a cutoff to remove outliers for the dependent variables of MAP, BMI, and exercise. Independent variables were also checked for potential multicollinearity by examining their variance inflation factors (VIFs).

Statistical analyses were conducted using SPSS version 24 and 25, R version 3.6 (with the "psych" package), and multiple regressions were fit using maximum-likelihood estimation with robust standard errors, various link functions (identity, log, and logit) and distributions (Gaussian, binomial, negative binomial). For continuous responses a Gaussian family with the identity link was used (ordinary regression), for binary responses a logit link with a binomial family was used (logistic regression), and for count responses a log link and negative binomial family was used to better model any over dispersion which might be present [40]. All presented coefficients were unstandardized.

Results

Sociodemographic Characteristics of Participants

A total of N = 210 HIV infected individuals were included in this study at baseline. As summarized in **Table 1**, participants were an average of 37.78 years old (SD = 10.12). Most participants (60%; n = 126) were female, and 72.4% (n = 152) identified as African American. Participants completed an average of 11.27 years of school (SD = 2), and the majority reported not being employed

Table 1. Demographic Characteristics of Participants

Variable	M (Median; SD) / n (%)
Age (Years)	37.78 (40; 10.12)
Gender	
Male	80 (38.1%)
Female	126 (60%)
Transgender	4 (1.9%)
Ethnicity	
Caucasian	17 (8.1%)
African American	152 (72.4%)
Haitian	6 (2.9%)
Hispanic/Latino Caucasian	29 (13.8%)
Hispanic/Latino Black	4 (1.9%)
Other	2 (1%)
Education (Years)	11.27 (12; 2)
Employment Status	
Working Full Time	16 (7.6%)
Working Part Time	20 (9.5%)
Not Working	172 (81.9%)
Volunteering	1 (0.5%)
Monthly Income	
$0 - $500	82 (39.5%)
$500 - $1000	108 (51.4%)
$1000 - $5000	19 (9%)
Living Arrangements	
Own House/Apartment	114 (54.3%)
Someone Else's House	60 (28.6%)
Squatting/Street	4 (1.9%)
Treatment Facility or Halfway House	18 (8.6%)
Homeless Shelter	14 (6.7%)
Marital Status	
Single	145 (69%)
Married	26 (12.4%)
Divorced	6 (2.9%)
Separated	5 (2.4%)
Widowed	5 (2.4%)
Partner	23 (11%)

*Note. N = 210. Continuous variables reported as M (SD), and categorical variables reported as number (%) falling into group. 1 response missing for employment status.

(81.9%; n = 172). A majority of participants (91%; n = 191) reported earning $1000 or less per month. Most participants reported living in their own home or apartment (54.3%; n = 114) and being single (69%; n = 145). The majority of the sample reported currently taking ART (74.8%; n = 157). The average CES-D score of 18.55 indicated high levels of depression (Median = 17; SD = 12.78). **Table 2** provides descriptive statistics for key study outcome variables.

Cumulative Burdens

For cumulative burdens, 91% (n = 191) participants had reported earning less than $1000 per month, 8.1% (n = 17) alcohol abuse (assessed using the SCID), 52.4% (n = 110) other drug use excluding cannabis, and 51.4% (n = 108) had clinically significant depressive symptoms with scores on the CES-D greater than or equal to 16. In order to examine interrelationships between the cumulative burdens, tetrachoric correlations were computed between each of the cumulative burdens [41]. **Table 3** provides the tetrachoric correlation matrix of the cumulative burdens. The strongest relationship appears to be between depression and taking other drugs (rtc = 0.58), while a negative relationship was observed between alcohol abuse and socioeconomic status (rtc = -0.23). A total of 8 participants (3.8%) had no cumulative burdens, 63 (30%) had 1, 60 (28.6%) had 2, 67 (31.9%) had 3, and 9 (4.3%) had 4 (3 were missing). Regressing participant ID onto the independent variables, all variance inflation factors were below 1.2 which indicated a lack of excessive multicollinearity.

Table 2. Descriptive Statistics of Study Outcome Variables

Variable	M (Median; SD) / n (%)
Mean Arterial Blood Pressure	92.26 (90.67; 12.43)
Body Mass Index	29.51 (28.4; 9.6)
Presence of Arterial Plaque	56 (26.9%)
Currently Taking ART (Yes)	157 (78.4%)
Total Minutes of Exercise (Weekly)	439.26 (210; 621.80)
Overall Nutrition	54.48 (53; 8.96)
Smoking Cigarettes	118 (56.2%)

*Note. N = 210. Continuous variables reported as M(Median; SD), and categorical variables reported as number (%) falling into group. 1 response missing for exercise. 7 missing responses for currently taking ART.

Prevalence of Cannabis and Other Drug Use

Participants (n = 93, 44.3%) endorsed currently using cannabis; 12 (5.7%) endorsed using stimulants, 10 (4.8%) opioids, 109 (51.9%) cocaine, 5 (2.4%) hallucinogens, and 1 (0.5%) some other drug(s). A cumulative burden factor was created by combining the presence of any drug use excepting cannabis, which included 110 participants (52.4%). A subset of participants was created, using individuals who endorsed using cannabis and no other drugs. Participants using cannabis and no other drugs were designated as the cannabis only group which included 25 (11.9%) individuals with 3 missing observations. Of these 25 exclusive cannabis users, 21 endorsed using alcohol and 3 indicated alcohol abuse.

Associations between Cannabis Use and Health Outcomes

Mean arterial blood pressure (MAP): A generalized linear model with an identity link and Gaussian family was fit to analyze potential relationships between key study variables and MAP. The overall model was found to be significant $\chi 2$ (4) = 19.77, p = .001.

Table 3. Tetrachoric Correlation Matrix of Cumulative Burdens

Model/Variable	b	SE	95% CI	χ2	P
Mean Arterial Blood Pressure					
Intercept	86.27	6.16	[74.19 98.35]	196.02	< .001
Cannabis Use Only (No Use)	-0.44	2.65	[-5.65 4.76]	0.03	0.867
Cumulative Burden	-0.78	0.78	[-2.31 0.75]	1	0.319
Years of Education	-0.5	0.45	[-1.39 0.38]	1.24	0.266
Age	0.36	0.08	[0.19 0.52]	18.63	< .001
Scale	127.16	12.53	[104.83 154.25]	--	--
Body Mass Index					
Intercept	35.23	4.13	[27.13 43.33]	72.62	< .001
Cannabis Use Only (No Use)	0.001	2.23	[-4.38 4.38]	0	1
Cumulative Burden	-1.91	0.53	[-2.95 -0.87]	13.01	< .001
Years of Education	-0.74	0.29	[-1.32 -0.16]	6.36	0.012
Age	0.16	0.06	[0.05 0.27]	7.61	0.006
Scale	57.04	5.62	[47.02 69.19]	--	--
Detectable Plaque					
Intercept	-5.39	1.37	[-8.07 -2.7]	15.43	< .001
Cannabis Use Only (No Use)	-0.11	0.79	[-1.66 1.44]	0.02	0.886
Cumulative Burden	0.1	0.19	[-0.27 0.48]	0.3	0.586
Years of Education	-0.11	0.08	[-0.26 0.04]	1.98	0.159
Age	0.13	0.02	[0.09 0.18]	34.28	< .001

*Note. Total sample for analyses after removing outliers and missing observations n = 206. Detectable plaque model used a binomial family with a logit link with plaque as the response. For cannabis use, exclusive cannabis use served as the reference group with the coefficient in the table reflecting the indicator of the no use group.

Within the model, only age (χ2 (1) = 18.63, p < .001) was found to predict MAP (b = 0.36, SE = 0.08, p < .001). It was found that on average, after controlling for all other variables in the model, as age increased, blood pressure tended to increase. **Table 4** displays the model in more detail.

Body mass index (BMI): A generalized linear model with an identity link and Gaussian family was fit to analyze potential relationships between key study variables and BMI. The overall model was found to be significant χ2 (4) = 21.33, p < .001. Within the model, the cumulative burden factor (χ2 (1) = 13, p < .001), education (χ2 (1) = 6.36, p = .012), and age (χ2 (1) = 7.61, p = .006) were related to BMI. It was found that on average, after controlling for all other variables in the model, as age increased, BMI tended to increase (b = 0.16, SE = 0.06, p = .006). On average, after controlling for other variables in the model, as number of burdens (b = -1.9, SE = 0.53, p < .001) or education (b = -0.74, SE = 0.29, p = .012) increased, BMI tended in decrease. **Table 4** displays the model in more detail.

Arterial plaque: A generalized linear model with a logit link and binomial family (logistic regression) was fit to analyze potential relationships between key study variables and presence of arterial plaque (treated as the response). The overall model was found to be significant χ2 (4) = 46.13, p < .001. Within the model, only age predicted plaque (χ2 (1) = 34.28, p < .001). Examining the exponentiated coefficient for age (b = 0.13, SE = 0.02, p < .001) revealed that each one-year increase in age was associated with a 14.4% increase in the odds of having arterial plaque after controlling for all other variables in the model. **Table 4** displays the model in more detail.

Associations between Cannabis Use and Health Behaviors

Currently taking ART: A generalized linear model with a logit link and binomial family (logistic regression) was fit to analyze potential relationships between key study variables and endorsement of currently taking ART (treated as the response). The overall model was found to be significant χ2(4) = 15.3, p = .004. Within the model, the cumulative burden factor (χ2 (1) = 7.87, p = .005), exclusive cannabis use (χ2 (1) = 5.63, p = .018), and age (χ2 (1) = 4.41, p = .036) were found to predict current ART. Examining the exponentiated coefficient for age (b = 0.04, SE = 0.02, p = .036), each one-year increase in age was associated with a 3.9% increase in the odds of using of ART, controlling for all other variables in the model. Similarly, for each additional cumulative burden, the odds of current ART usage decreased on average by 44% (b = -0.58, SE = 0.21, p = .005), controlling for all other variables in the model. Finally, compared to the exclusive cannabis users as the reference group, it was found that individuals who did not exclusively use cannabis were 3.54 times more likely (b = 1.26, SE = 0.53, p =.018) to be currently taking ART medication, controlling for all other variables in the model. **Table 5** displays the model in more detail.

Minutes of exercise per week: A generalized linear model with a log link and negative binomial family was fit to analyze potential relationships between key study variables and exercise. The overall model was found to be significant χ2 (4) = 18.85, p = .001. Within the model, cannabis use (χ2 (1) = 5.31, p = .021), cumulative burden (χ2 (1) = 7.90, p = .005) and years of education (χ2 (1) = 16.44, p < .001) were related to exercise. On average,

Table 4. Associations between Cannabis Use and Health Outcomes

Model/Variable	b	SE	95% CI	χ2	p
Mean Arterial Blood Pressure					
Intercept	86.27	6.16	[74.19 98.35]	196.02	< .001
Cannabis Use Only (No Use)	-0.44	2.65	[-5.65 4.76]	0.03	0.867
Cumulative Burden	-0.78	0.78	[-2.31 0.75]	1	0.319
Years of Education	-0.5	0.45	[-1.39 0.38]	1.24	0.266
Age	0.36	0.08	[0.19 0.52]	18.63	< .001
Scale	127.16	12.53	[104.83 154.25]	--	--
Body Mass Index					
Intercept	35.23	4.13	[27.13 43.33]	72.62	< .001
Cannabis Use Only (No Use)	0.001	2.23	[-4.38 4.38]	0	1
Cumulative Burden	-1.91	0.53	[-2.95 -0.87]	13.01	< .001
Years of Education	-0.74	0.29	[-1.32 -0.16]	6.36	0.012
Age	0.16	0.06	[0.05 0.27]	7.61	0.006
Scale	57.04	5.62	[47.02 69.19]	--	--
Detectable Plaque					
Intercept	-5.39	1.37	[-8.07 -2.7]	15.43	< .001
Cannabis Use Only (No Use)	-0.11	0.79	[-1.66 1.44]	0.02	0.886
Cumulative Burden	0.1	0.19	[-0.27 0.48]	0.3	0.586
Years of Education	-0.11	0.08	[-0.26 0.04]	1.98	0.159
Age	0.13	0.02	[0.09 0.18]	34.28	< .001

*Note. Total sample for analyses after removing outliers and missing observations n = 206. Detectable plaque model used a binomial family with a logit link with plaque as the response. For cannabis use, exclusive cannabis use served as the reference group with the coefficient in the table reflecting the indicator of the no use group.

Table 5. Associations between Cannabis Use and Health Behaviors

Model/Variable	B	SE	95% CI	χ2	p
ART Use					
Intercept	0.97	1.35	[-1.67 3.6]	0.51	0.473
Cannabis Use Only (No Use)	1.26	0.53	[0.22 2.31]	5.63	0.018
Cumulative Burden	-0.58	0.21	[-0.98 -0.17]	7.87	0.005
Years of Education	-0.09	0.1	[-0.28 0.1]	0.85	0.358
Age	0.04	0.02	[0.003 0.07]	4.41	0.036
Total Exercise					
Intercept	4.29	0.68	[2.97 5.61]	40.3	< .001
Cannabis Use Only (No Use)	-0.66	0.29	[-1.22 -0.10]	5.31	0.021
Cumulative Burden	0.28	0.1	[0.09 0.48]	7.9	0.005
Years of Education	0.19	0.05	[0.10 0.29]	16.44	< .001
Age	-0.01	0.01	[-0.03 0.004]	2.25	0.134
Negative Binomial	1.93	0.18	[1.6 2.3]	N/A	N/A
Overall Nutrition					
Intercept	47.4	4.16	[39.24 55.56]	129.58	< .001
Cannabis Use Only (No Use)	0.3	2.01	[-3.65 4.25]	0.02	0.88
Cumulative Burden	-1.07	0.6	[-2.25 0.1]	3.2	0.074
Years of Education	1.06	0.29	[0.49 1.63]	13.38	< .001
Age	-0.08	0.06	[-0.2 0.04]	1.78	0.182
Scale	73.76	7.25	[60.84 89.44]	N/A	N/A
Cigarette Smoking					
Intercept	-0.96	1.13	[-3.19 1.26]	0.72	0.395
Cannabis Use Only (No Use)	-0.31	0.45	[-1.19 0.58]	0.45	0.501
Cumulative Burden	0.53	0.17	[0.2 0.87]	10	0.002
Years of Education	-0.05	0.08	[-0.22 0.11]	0.44	0.507
Age	0.03	0.02	[-0.002 0.06]	3.37	0.067

*Note. Total sample for analyses after removing outliers and missing observations for ART use n = 202, total minutes of exercise (weekly) n = 206, overall nutrition and cigarette smoking n = 207. Cigarette smoking and ART use models used a binomial family with a log it link, with smoking and ART use as the respective responses. Overall nutrition model used a Gaussian family and identity link. Exercise used negative binomial families with log links. For cannabis use, exclusive cannabis use served as the reference group with the coefficient in the table reflecting the indicator of the no use group.

controlling for all other variables in the model, cannabis use was associated with fewer minutes of exercise (b = -0.66, SE = 0.10, p = .021). In addition, on average, controlling for all other variables in the model, as cumulative burdens increased (b = 0.28, SE = 0.10, p = .005) so did minutes of exercise. On average, controlling for all other variables in the model, as education increased (b = 0.19, SE = 0.05, p < .001) so did minutes of exercise. **Table 5** shows the model in more detail.

Overall nutrition: A generalized linear model with an identity link and Gaussian family was fit to analyze potential relationships between key study variables and nutrition, as measured by the REAP. The overall model was found to be significant χ2 (4) = 19.05, p = .001. Within the model, only education (χ2 (1) = 13.38, p < .001) was found to predict nutrition. It was found that on average, controlling for all other variables in the model, increasing education (b = 1.06, SE = 0.29, p < .001) was associated with endorsing more healthy eating behaviors. **Table 5** displays the model in more detail.

Cigarette smoking: A generalized linear model with a logit link and binomial family was fit to analyze potential relationships between key study variables and endorsement of smoking cigarettes (treated as the response). The overall model was found to be significant χ2 (4) = 18.84, p = .001. Within the model only the cumulative burden factor (χ2 (1) = 9.95, p = .002) was found to predict cigarette smoking. Examining the exponentiated coefficient for cumulative burden (b = 0.53, SE = 0.17, p = .002), it was found that for every additional burden the odds of smoking cigarettes increased on average by 70.6%, controlling for all other variables in the model. **Table 5** displays the model in more detail.

Discussion

This study examined the association of current cannabis use with health behaviors and health outcomes among PWH, as well as the influence of a co-occurring cumulative burdens of substance use, depression, and poverty. More than half of participants endorsed cocaine use, many engaging in other drug use, including cannabis, opiates, and hallucinogens, and more than half of participants had clinically significant symptoms of depression. Exclusive cannabis use was found to be associated only with lower levels of ART use, after controlling for other factors, with their non-exclusive counterparts being almost four times more likely to use ART. Exclusive cannabis use was also associated with less exercise. Health behaviors were primarily positively influenced by education (e.g., nutrition, walking, exercise) and the cumulative burden factor (e.g., walking, smoking, ART usage). The cumulative

burden factor was associated with cigarette smoking, such that each one-point increase in the cumulative burden factor was associated with a 70.6% increase in the odds of smoking. Higher levels of cumulative burden factor were also found to be related to lower utilization of ART, with each additional cumulative burden being associated with a 44% decrease in the average likelihood of using ART.

This study found health outcomes were associated with a traditional risk factor, age, and with the cumulative burden factor and education; cannabis use was related to reduced ART use and exercise. Findings from this study suggest that cumulative burdens may prevent PWH from maintaining a healthy diet and avoiding tobacco smoking. Cannabis in this context was primary found to be associated with less exercise, but not diet, in contrast to previous research on diet, BMI and tobacco use. In previous research, cannabis use was not found to influence athletic performance in healthy adults [42,43]. Therefore, unique factors to this sample or PWH may have influenced this finding. Though the potential bidirectional association between exercise and cannabis use has been extensively studied in the general population and health adults, the association between exercise and cannabis use among PWH has not been previously studied. Future studies should continue to examine this association. Additionally, in this sample, cumulative burdens, such as low income, contributed to more exercise. It is unclear why cumulative burdens were related to increased exercise; however, individuals with greater socioeconomic limitations may have had less access to private or subsidized transportation.

Limitations

Results suggest that there was limited impact of cannabis use among PWH on health behaviors and associated outcomes, but that cumulative burdens had a significant impact. However, these results must be interpreted within several limitations, e.g., the use of self-report rather than biological testing to confirm drug use, lack of assessment of quantity, delivery system, and duration of cannabis use, and the impact of recall bias on the reporting of exercise, diet, and tobacco use. Future studies should assess these missing elements, as well as examine longitudinal data in order to draw more firm conclusions about the impact of cannabis on PWH. Another limitation was the relatively small number of individuals who exclusively used cannabis. Participants in this sample were predominantly low-income and almost half endorsed cannabis use; of these, a tenth were cannabis-only users. Other limitations include the generalizability of the sample given the exclusion criteria of the parent study for certain underlying health conditions, and not excluding alcohol use or abuse from the cannabis only group. This limited the complexity of the linear regressions, as potential covariates were not included in order to retain as much statistical power as possible for the regressions.

Conclusion

Study findings suggest limited deleterious consequences associated with exclusive cannabis use among PWH, with the one area of risk being ART usage. While previous studies have not found associations between cannabis and HIV medication adherence and management, it is possible that some individuals may use cannabis as a replacement of ART rather than a supplement to assuage potential medication side effects. It is also possible that exclusive cannabis use may be inhibiting the use of ART in some other fashion, such as through memory problems; however, both of these are speculatory given the current study did not directly address the mechanisms by which cannabis usage may affect ART uptake. Care should be taken to help patients understand that cannabis use may represent an adjunct to ART, not a replacement.

Physicians who prescribe cannabis for PWH should be very mindful of ensuring that ART usage is not disrupted by the introduction or usage of cannabis in an HIV medication regimen. A more in-depth examination of the patient within the psychosocial context may significantly contribute to a more nuanced approach to medical marijuana prescription. Clinicians should also be aware of individual variability within the domains of duration, delivery systems, and quantity of cannabis use. As legal access to cannabis increases and medical marijuana has the potential to become a useful adjunct to traditional treatment options, a broader lens should be applied in developing a comprehensive and integrative treatment plan.

Declarations and Compliance with Ethical Standards

Ethical approval

All procedures performed in studies involving human participants were approved by and in accordance with the ethical standards of the University of Miami Miller School of Medicine Institutional Review Board (Study Reference #20130988) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Conflicts of Interest and Sources of Funding

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Data Availability

The datasets generated and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Contributions

All authors contributed to this project. Mr. Abbamonte was

involved in conducting the statistical analyses and writing the methods and results section, as well as putting together the manuscript. Mr. Kapadia worked on the introduction. Dr.'s Weiss, Jones, Kumar, and Jayaweera were instrumental in designing the study, as well as providing feedback on the manuscript and shaping the discussion of the results.

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