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Change in marijuana use and its associated factors among persons living with HIV (PLWH) during the COVID-19 pandemic: Findings from a prospective cohort

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ABSTRACT
Background: Emerging literature shows increased drug use during the COVID-19 pandemic. However, limited research has examined the change in marijuana use among persons living with HIV (PLWH). This study aimed to investigate how marijuana use changed in a cohort of PLWH during the first year of the pandemic and identify factors associated with the change.

Method: 222 PLWH (mean age = 50.2 ± 11.2, 50.9 % female, 14.5 % Hispanic, 64.7 % Black, 15.8 % White, 5 % other, 80.2 % persons using marijuana [at least weekly use], 19.8 % persons not using marijuana) completed a baseline survey on demographics and behavioral/health characteristics between 2018 and 2020 and a brief phone survey between May and October 2020 that assessed changes in marijuana use and overall/mental health, and perceived risks/benefits of marijuana use during the COVID-19 pandemic.

Results: During the pandemic, 64/222 (28.8 %) of the whole sample reported increased marijuana use, 36 (16.2 %) reported decreased use, and 122 (55 %) reported no change. Multinomial logistic regression results indicated that: Compared to those reporting no change, increased marijuana use during the pandemic was associated with more frequent marijuana use and PTSD symptoms at baseline, worsened mental health during the pandemic, and not perceiving marijuana use as a risk factor for COVID-19 infection. More frequent marijuana use at baseline was the only factor significantly associated with decreased marijuana use during the pandemic.

Conclusion: The COVID-19 pandemic has resulted in changes in marijuana use among a considerable proportion (45 %) of PLWH. Future research is needed to understand the temporality of the increases in marijuana use with worsening mental health.

1. Background

The unprecedented COVID-19 pandemic and its profound socio-economic impacts have led to widespread emotional distress in the general public, resulting in increased mental health morbidities such as anxiety and depression (Mazza et al., 2020; McKay and Asmundson, 2020; Pfefferbaum and North, 2020; Qiu et al., 2020). A range of theoretical models (e.g., self-medication, negative reinforcement model) posit that elevation in negative emotions as a result of disasters like the pandemic, such as stress, anxiety, and fear, will increase substance use (Baker et al., 2004; Bravo et al., 1990; Khantzian, 1997). As people are stressed and isolated during the COVID-19 pandemic, they may initiate or increase substance use to alleviate negative feelings (Volkow, 2020). The mental health consequences of the COVID-19 pandemic leading to more substance use may result in a vicious cycle and thus represents a significant public health concern (McKay and Asmundson, 2020; Ornell et al., 2020). On the other hand, COVID-19 is a disease mainly attacking the respiratory system, so persons who smoke, vape, or use certain drugs may be at greater risk for the infection and its severe consequences (Volkow, 2020). The perceived risk may lead to reduced smoking,

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vaping, or substance use as a means to protect themselves from getting the infection or its severe consequences.

Empirical data on how the COVID-19 pandemic impacts substance use are still emerging. A recent representative survey of adults (N = 5412) in the United States showed that 40.9% reported an adverse mental or behavioral health condition during the pandemic. Particularly, 13.3% of the participants reported starting or increasing substance use to cope with stress or emotions related to the pandemic and its socioeconomic consequences (e.g., unemployment, loneliness). The prevalence of adverse health conditions was disproportionately higher among those who were younger, Hispanic or Black, employed, and reported current treatment for anxiety, depression, or PTSD (Czeisler et al., 2020). Similarly, another online survey study of the general public found that those who initiated substance use during the COVID-19 pandemic had the highest level of COVID-19-related worry and fear (Rogers et al., 2020). These studies provide valuable data on how substance use changes in the general public during the pandemic. However, data from vulnerable populations, such as those living with chronic conditions or compromised immunity like persons living with HIV (PLWH), remain scarce.

PLWH represent an especially vulnerable population during the COVID-19 pandemic, not only due to their compromised immune function but also the high prevalence of pre-existing mental health or substance use problems (Mazza et al., 2020; Pfefferbaum and North, 2020). Marijuana is a commonly used substance among PLWH for both medical and recreational purposes (Mannes et al., 2018; Towe et al., 2018). Rates of marijuana use are significantly higher in PLWH than the general population, with prevalence estimates ranging between 20–60% (D’Souza et al., 2012; Gamarel et al., 2016; Mimiaga et al., 2013; Okafor et al., 2017). Besides, the rates of cannabis use disorder (CUD) are also estimated to be significantly higher in this population (Hartzler et al., 2017). Although it remains inconclusive whether marijuana may lead to decreased morbidity and mortality for PLWH (Lutge et al., 2013), some research has supported potential medicinal benefits of marijuana for PLWH (Abrams et al., 2007; Ellis et al., 2009; Haney et al., 2007). Therefore, a potential driving factor for the high prevalence of marijuana use in PLWH may be the perceived medical benefits of marijuana (Towe et al., 2018). Reports show that marijuana sales have boomed during the COVID-19 pandemic (Forbes.com, 2020), as marijuana dispensers have been deemed an “essential business” in several states (CBS News, 2020). On the other hand, a considerable portion of PLWH also uses marijuana for recreational reasons. People’s access to marijuana (especially recreational) may be impacted by social distancing if they rely on the social network as the main source of marijuana. However, no existing research has investigated the actual changes in marijuana use during the COVID-19 pandemic among PLWH and how factors such as mental health and perceived risks/benefits of marijuana influence changes in marijuana use during the pandemic among this population.

This study aims to: 1) investigate the changes in marijuana use frequency and quantity among PLWH during the first year of the COVID-19 pandemic; 2) examine the associations between changes in marijuana use and mental health (e.g., baseline anxiety/depression, self-reported changes in mental health during the pandemic) as well as perceived risks/benefits of marijuana use during the pandemic in a prospective cohort of PLWH. We hypothesize that: (1) The frequency and quantity of marijuana use will increase in PLWH during the COVID-19 pandemic; and (2) Worse mental health (i.e., anxiety, depression, PTSD) at baseline and during the pandemic (i.e., self-reported worsened mental health), and not perceiving marijuana use as a risk factor for getting COVID-19 infection or developing severe symptoms will be associated with increased marijuana use during the pandemic.

2. Methods

2.1. Participants and study procedures

This study analyzed data collected as part of an ongoing cohort study aiming to investigate the long-term effect of marijuana use on cognition and HIV-related outcomes in PLWH (referred to as the Marijuana Associated Planning and Long-term Effects/MAPLE study hereafter). Briefly, this study has enrolled over 300 PLWH across the state of Florida since 2018. Participants were recruited from local Department of Health clinics, infectious diseases clinics, community healthcare centers that provide HIV care, and via flyers in the community. The sample included both persons using marijuana—defined as those who use marijuana at least monthly and confirmed by positive urine test of Tetrahydrocannabinol (THC) and persons not using marijuana—defined as those who have not used marijuana regularly (more than once a month) in their life, have not used marijuana in the past five years, and confirmed by a negative urine test, with an approximate ratio of 4 persons using marijuana to 1 person not using marijuana. The enrollment is still ongoing, and participants included in this paper were enrolled between October 2018 and March 2020. Each participant completed a baseline survey and neurocognitive tests after they were enrolled, and they were followed by a brief phone survey every 3 months, with a more comprehensive annual follow-up visit every 12 months. During the COVID-19 pandemic (May 2020 – October 2020), the research team conducted a special version of the 3-month phone survey with additional questions regarding changes in overall/mental health, changes in marijuana use, and attitudes and beliefs about marijuana use. In this paper, we analyzed data from those who have completed the COVID-19 phone survey (N = 222). Both persons using marijuana and not using marijuana were included in the analyses.

2.2. Measures

2.2.1. Predictors measured at baseline (pre-COVID)

2.2.1.1. Demographics. At baseline, participants completed questions on their age (in years), sex (male/female), race/ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic other), and education (less than high school, high school diploma or equivalent, more than high school).

2.2.1.2. Marijuana use and cannabis use disorder (CUD). For those who use marijuana at baseline, the timeline followback (TLFB) (Sobell and Sobell, 1992) approach was used to assess their marijuana use, including frequency, quantity, and route of administration in the past 30 days. The computerized Substance Abuse Module 5 (SAM-5) (Cottler, 2000) was used to assess lifetime CUD, which was categorized into four levels: none, mild, moderate, and severe CUD.

2.2.1.3. Anxiety. The 7-item scale for generalized anxiety disorder (GAD-7) was used for measuring generalized anxiety (Spitzer et al., 2006) at baseline. Participants were asked to rate their anxiety symptoms on a four-point scale from 0 “not at all” to 3 “nearly every day” in the past two weeks. A total score was calculated to represent the overall anxiety severity and categorized into four levels: none (0–4), mild (5–9), moderate (10–14), and severe (15–21) anxiety.

2.2.1.4. Depression. The Patient Health Questionnaire (PHQ-8) was used to measure depressive symptoms (Kroenke et al., 2001) at baseline. Participants were asked to rate their depressive symptoms over the past two-weeks on a four-point scale from 0 “not at all” to 3 “nearly every day”. A total score of the eight items was calculated to represent the overall severity of depressive symptoms categorized into four levels: none (0–4), mild (5–9), moderate (10–14), and severe (15–24).
Primary Care PTSD Screen (PC-PTSD) was used to evaluate PTSD in this study (Prins et al., 2003). Participants were asked about symptoms (i.e., re-experiencing a traumatic event, emotional numbing, avoidance, and hyperarousal) experienced in the past month related to a traumatic event that occurred anytime in their lifetime. Each item was scored dichotomously as either 0 (no) or 1 (yes). A cut-off point of 3 was used to determine whether or not the participant had PTSD at baseline.

2.2.1.6. Other illicit drug use. At baseline, participants were classified as positive for “any other illicit drugs” if they answered yes to ever shot up or injected drugs in the past 12 months or ever used any non-injection drugs in the past 12 months.

2.2.2. Predictors measured during the pandemic

2.2.2.1. Change in overall/mental health during the pandemic. Participants answered two questions about the change in their overall and mental health: “When considering your overall [mental] health, how would you say your health has changed since before the coronavirus situation until today?” The response options ranged from “1-much better” to “5-much worse”, with a higher score indicating more worsening overall or mental health.

2.2.2.2. Perceived risks/benefits of marijuana use during the pandemic. Participants answered four questions related to perceived risks/benefits regarding marijuana use during the pandemic. The first question asked how they think marijuana use will change the risk of getting infected by the COVID-19 virus. The second and third questions asked how they think smoking and vaping marijuana, respectively, will change their risk of developing severe COVID-19 symptoms if they get infected. The answering options for these three questions were: decreased risk, increased risk, no change in risk, and don’t know. Finally, one question asked the participants whether they think marijuana will have therapeutic effects in helping with recovery from COVID-19 infection, with answering options including “yes”, “no”, and “not sure”.

2.2.3. Outcome variable

2.2.3.1. Change in marijuana use during the pandemic. Three questions in the phone survey were used to assess changes in frequency and quantity (amount) of marijuana use during the COVID-19 pandemic. First, participants were asked to report the frequency of marijuana use before the pandemic, ranging from “0-did not use marijuana” to “5-everyday”. Then they were asked to report the frequency of marijuana use during the pandemic on the same response scale. Finally, for those who reported using marijuana during the pandemic, they were asked whether the overall amount of their marijuana use has changed during the pandemic, with answering options including “increased amount”, “decreased amount”, “no change”, and “not sure/does not apply”.

2.3. Statistical analysis

Descriptive analysis such as means and standard deviations were used to describe the sample characteristics at baseline, their marijuana use before and after the COVID-19 pandemic, and their perceptions of risks/benefits associated with marijuana use during the pandemic. Chi-square tests were conducted to examine whether persons using or not using marijuana (defined at baseline) were different in their baseline demographics, their health status during the COVID-19 pandemic, and their perceptions of risks/benefits associated with marijuana use during the pandemic. Based on their reports of marijuana use frequency and quantity before and during the COVID-19 pandemic, each participant was categorized into one of the following three groups for further analyses. Participants were categorized into “increased use” if they reported either increased frequency or amount in marijuana use; they were categorized “decreased use” if they reported either decreased frequency or amount; otherwise, they were categorized into “no change”. There were 2 (0.9 %) cases where participants reported decreased frequency and increased amount, and 2 (0.9 %) cases where participants reported increased frequency but decreased amount. Based on our definition (i.e., either increase in amount or frequency), they were all categorized as increased use. All other participants’ reports on changes in frequency and quantity were in the same direction. Chi-square test was used to examine the association between each potential influential factor (i.e., baseline demographics and health status, change in overall/mental health during the COVID-19 pandemic, and perceived risks/benefits of marijuana use during the pandemic) and change in marijuana use (i.e., increase, decrease, or no change). Finally, multivariate analysis was conducted using a multinomial logistic regression including all significant factors (p < .05) at the univariate level (i.e., chi-square test) to examine which factors are associated with increased or decreased marijuana use during the pandemic, with the “no change” group as the reference.

3. Results

3.1. Sample characteristics

A total of 222 adults living with HIV (Mean age = 50.2, SD = 11.2, 50.9 % female) were included in this analysis. The interval between the baseline assessment and the COVID-19 phone survey was 11.3 months (SD = 4.6). The sample was diverse in race/ethnicity (14.5 % Hispanic, 64.7 % Black, 15.8 % White, 5 % other). The majority (72.1 %) had high school or more education. At baseline, 178 (80.2 %) were persons using marijuana, and 44 (19.8 %) were not. Among those using marijuana, the majority (73 %) indicated medical use was the more or equally important motive of their marijuana use than recreational use. Among those using marijuana, the majority (86.1 %) reported smoking as the only route of administration, and 13.3 % reported smoking in combination with vaping or other routes. Also, 42 % had cannabis use disorder (CUD) at baseline based on SAM score. In the whole sample, 54.9 % had mild to severe anxiety, 64 % had mild to severe depression, 30.4 % had symptoms of PTSD, and 33.9 % reported other illicit drug use other than marijuana. Chi-square test showed that persons using marijuana at baseline were more likely to be male, have a higher level of anxiety, have PTSD, and more likely to use other illicit drugs than those not using marijuana (p’s < .05). There was a marginal difference (p = .051) for depression, where persons using marijuana at baseline reported a higher level of depression than those not using marijuana. Table 1 provides detailed information on these characteristics by marijuana use status reported at baseline.

3.2. Change in overall/mental health during the pandemic

Table 2 presents the details on changes in overall/mental health and perceived risks/benefits of marijuana use during the pandemic. For the change in overall/mental health, due to the small number of participants reporting “much better” or “much worse”, we collapsed the 5-point answering options into three (i.e., better, no significant change, and worse). While the majority reported no significant change, a small group reported better health-12.2 % reported better overall health and 7.7 % reported better mental health, while another group reported worse health-10.8 % reported worse overall health, and 30.2 % reported worse mental health.

3.3. Perceived risks/benefits of marijuana use during the pandemic

When asked about risks associated with marijuana use during the...
Among the 222 participants, 7(3.1%) reported marijuana use before the pandemic but no marijuana use during the pandemic (i.e., quit marijuana use) in the phone survey, whereas 2(0.9%) reported not
using marijuana before the pandemic but having used it during the pandemic (i.e., initiated marijuana use). While the majority did not change their use status, 64(28.8 %) reported increased frequency or amount of their marijuana use, and 36(16.2 %) reported decreased frequency or amount of use. Table 3 presents the demographic and baseline characteristics by groups based on their change in marijuana use during the pandemic. Chi-square test detected significant group differences: Participants were more likely to increase marijuana use during the COVID-19 pandemic if they reported having a higher level of depression and having PTSD symptoms at baseline (p < .05). We also examined whether marijuana use motive was associated with changes in marijuana use among those using marijuana at baseline (n = 178), and there was no significant association (data not shown).

Table 4 presents changes in overall/mental health during the pandemic and perceived risk/benefits of marijuana use by groups based on the change in marijuana use. Chi-square tests showed that participants were more likely to increase marijuana use during the COVID-19 pandemic if they reported worsened overall or mental health, perceived that marijuana use would not increase their risk for COVID-19 infection or severe symptoms (p < .05).

### Table 3

| Characteristics               | Increased use (n = 64) | No change (n = 122) | Decreased use (n = 36) |
|-------------------------------|-----------------------|---------------------|------------------------|
| Age (Mean(SD))                | 49.2(11.1)            | 50.8(11.2)          | 49.6(11.8)             |
| Race/ethnicity                |                       |                     |                        |
| Hispanic                      | 8(12.7 %)             | 15(12.3 %)          | 9(25.0 %)              |
| Non-Hispanic White            | 20(31.3 %)            | 31(26.5 %)          | 7(20.0 %)              |
| Non-Hispanic Black            | 42(66.7 %)            | 78(63.9 %)          | 23(63.9 %)             |
| Non-Hispanic Other            | 3(4.8 %)              | 7(5.7 %)            | 1(2.8 %)               |
| Education                     |                       |                     |                        |
| Less than high school         | 17(40.6 %)            | 33(27.1 %)          | 12(33.3 %)             |
| High school diploma or equivalent | 19(20.3 %)            | 43(35.2 %)          | 14(38.9 %)             |
| More than high school         | 28(39.1 %)            | 46(37.7 %)          | 10(27.8 %)             |
| Cannabis use disorder         |                       |                     |                        |
| None                          | 34(55.7 %)            | 47(59.5 %)          | 21(58.3 %)             |
| Mild                          | 10(16.4 %)            | 15(19.0 %)          | 2(5.6 %)               |
| Moderate                      | 6(9.8 %)              | 6(7.6 %)            | 5(13.9 %)              |
| Severe                        | 11(18.0 %)            | 11(13.9 %)          | 8(22.2 %)              |
| Anxiety                       |                       |                     |                        |
| None                          | 21(33.9 %)            | 60(51.3 %)          | 16(45.7 %)             |
| Mild                          | 20(32.3 %)            | 31(26.5 %)          | 7(20.0 %)              |
| Moderate                      | 13(21.0 %)            | 14(12.0 %)          | 5(14.3 %)              |
| Severe                        | 8(12.9 %)             | 12(12.3 %)          | 7(20.0 %)              |
| Depression                    |                       |                     |                        |
| None                          | 19(29.7 %)            | 43(42.0 %)          | 10(28.6 %)             |
| Mild                          | 17(26.6 %)            | 38(33.9 %)          | 18(51.4 %)             |
| Moderate                      | 14(21.9 %)            | 15(13.4 %)          | 5(14.3 %)              |
| Severe                        | 14(21.9 %)            | 12(10.7 %)          | 5(14.3 %)              |
| PTSD                          |                       |                     |                        |
| Yes                           | 28(45.2 %)            | 29(24.4 %)          | 9(25.0 %)              |
| No                            | 34(54.8 %)            | 90(75.6 %)          | 27(75.0 %)             |
| Other illicit drug use         |                       |                     |                        |
| Yes                           | 26(40.6 %)            | 33(27.3 %)          | 16(44.4 %)             |
| No                            | 38(59.4 %)            | 88(72.7 %)          | 44(55.6 %)             |

Note: There were missing data for some questions (<2%), so the total in the table does not always add up to 222. Change in marijuana use was determined by two variables: change in marijuana use frequency and change in marijuana use amount. Participants were categorized into “increased use” if they reported either increased frequency or amount. They were categorized into “decreased use” if they reported either decreased frequency or amount. Otherwise, they were categorized into “no change.”

### Table 4

| Associations between changes in overall/mental health changes, perceived risks/benefits, and changes in marijuana use during the COVID-19 pandemic in PLWH (N = 222). | Increased use (n = 64) | No change (n = 122) | Decreased use (n = 36) |
|--------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------|------------------------|
| Change in overall health * | Better               | 8(12.5 %)            | 9(7.4 %)            | 10(27.8 %)             |
|                             | No significant change | 42(65.6 %)           | 107(87.7 %)         | 22(61.1 %)             |
|                             | Worse                | 14(21.9 %)           | 6(4.9 %)            | 4(11.1 %)              |
| Change in mental health *   | Better               | 7(10.9 %)            | 5(4.1 %)            | 5(13.9 %)              |
|                             | No significant change | 27(42.2 %)           | 91(74.6 %)          | 20(55.6 %)             |
|                             | Worse                | 36(56.9 %)           | 26(21.3 %)          | 11(30.6 %)             |
| Marijuana use and risk of COVID-19 infection * | Increased risk | 3(4.7 %)            | 36(29.5 %)          | 11(30.6 %)             |
|                             | No change in risk    | 23(35.9 %)           | 33(27.0 %)          | 11(30.6 %)             |
|                             | Decreased risk       | 7(10.9 %)            | 5(4.1 %)            | 6(16.7 %)              |
|                             | Don’t know           | 31(48.4 %)           | 48(39.3 %)          | 8(22.2 %)              |
| Smoking marijuana and risk of severe COVID-19 symptoms | Increased risk | 9(14.1 %)          | 45(36.9 %)          | 16(44.4 %)             |
|                             | No change in risk    | 27(42.2 %)           | 40(32.8 %)          | 8(22.2 %)              |
|                             | Decreased risk       | 6(9.4 %)             | 5(4.1 %)            | 0(0%)                  |
|                             | Don’t know           | 22(34.4 %)           | 32(26.2 %)          | 12(33.3 %)             |
| Vaping marijuana and risk of severe COVID-19 symptoms | Increased risk | 18(28.1 %)          | 47(38.0 %)          | 13(36.1 %)             |
|                             | No change in risk    | 18(28.1 %)           | 26(20.9 %)          | 7(19.4 %)              |
|                             | Decreased risk       | 4(6.3 %)             | 5(4.1 %)            | 0(0%)                  |
|                             | Don’t know           | 24(37.5 %)           | 44(38.0 %)          | 16(44.4 %)             |
| Marijuana helps people recover from COVID-19 | No | 8(12.5 %)          | 31(25.4 %)          | 9(25.0 %)              |
|                             | Yes                  | 42(65.6 %)           | 59(48.4 %)          | 16(44.4 %)             |
|                             | Not sure             | 14(21.9 %)           | 32(26.2 %)          | 11(30.6 %)             |

Note: There were missing data for some questions (<2%), so the total in the table does not always add up to 222. Increased use was determined by two variables: change in marijuana use frequency and change in marijuana use amount. Participants were categorized into “increased use” if they reported either increased frequency or amount. Otherwise, they were categorized into “no change or decreased use”.

* Significant group differences were detected by chi-square test.

### 3.5. Change in marijuana use during the pandemic and its associating factors: Multivariate analysis

Table 5 presents the multivariate analysis result using a multinomial logistic regression model, including all the significant predictors at the univariate level to predict participants who increased or decreased marijuana use during the COVID-19 pandemic, using those who reported no change in marijuana use as the reference group. Given the small numbers of certain response categories (e.g., “decreased risk”) for the questions on perceived risks of marijuana use, we collapsed responses into binary for this analysis (i.e., coded as “1” if they answered “increased risk” and “0” for all other options). Results indicated that participants were more likely to increase marijuana use during the pandemic if they used marijuana more frequently (odds ratio/OR = 1.476, p < .01) or had PTSD symptoms (OR = 2.287, p < .05) at baseline, if they reported that their mental health worsened during the pandemic (OR = 1.929, p < .05), and if they did not perceive that marijuana use would increase the risk of COVID-19 infection (OR = 0.194, p < .05). Using marijuana more frequently (OR = 1.342, p < .05) at baseline was the only factor significantly associated with decreased marijuana use during the pandemic.
study reported change in marijuana use among PLWH, research conducted in the general population and special subgroups (e.g., sexual minority group) has shown mixed findings, including increased (Bartel et al., 2020), decreased (Starks et al., 2020), or no change in marijuana use (Hochstatter et al., 2020) during the pandemic. Our finding is similar to a survey study that examined substance use, including marijuana use, among medical cannabis users during the pandemic, in which 35 % of participants increased marijuana use while 25 % decreased use (Boehnke et al., 2020). This finding suggests that the impact of the COVID-19 pandemic on the change of substance use may vary from person to person, and it is important to examine the contributing factors associated with the change.

It should be noted that most PLWH in this study did not change their marijuana use status (i.e., quit or newly initiated use): Seven out of the 222 participants (3.1 %) reported marijuana use before the pandemic but no use during the pandemic (i.e., quit marijuana use), whereas 2(0.9 %) reported not using marijuana before the pandemic but having used during the pandemic (i.e., initiated marijuana use). This is lower than the finding from the national survey that showed 13 % of the population in the United States initiated substance use during the pandemic (Czeisler et al., 2020). A possible explanation may be that our participants were primarily middle-aged, who had relatively established habits in marijuana use (either regularly used it or not use it at all), while those who newly initiated substance use in the national survey study tended to be younger.

Another main finding of this study was about the contributing factors associated with the change in marijuana use among PLWH during the pandemic. More frequent marijuana use was a contributing factor to both increased and decreased marijuana use during the pandemic in PLWH. This is plausible because those who use marijuana more frequently have more room to change (either increase or decrease), whereas those who have a low frequency of marijuana use before the pandemic tend to remain unchanged (very few initiated use as mentioned above).

In line with our hypothesis, worse mental health at baseline and change towards worse during the pandemic were both significantly associated with increased marijuana use during the pandemic. PLWH who had mental health issues (depression, PTSD) at baseline were more likely to report increased marijuana use during the pandemic. This finding is consistent with an online survey study, which found that medical marijuana users with mental health conditions were almost as twice as likely to increase marijuana use during the pandemic compared to those who had no mental health conditions (Vidot et al., 2020). In addition to baseline mental health issues, worsened mental health during the pandemic was also associated with increased marijuana use in PLWH. This finding aligns well with theories and empirical studies that link negative emotions such as fear, anger, and anxiety with increased substance use in disastrous situations like a pandemic (Baker et al., 2004; Bravo et al., 1990; Khantzian, 1997; Rogers et al., 2020).

Risk perception also played a role in changing marijuana use during the pandemic in PLWH. Those who did not perceive marijuana use would increase the risk of COVID-19 infection were more likely to increase marijuana use during the pandemic compared to those who had no mental health conditions (Vidot et al., 2020). In addition to baseline mental health issues, worsened mental health during the pandemic was also associated with increased marijuana use in PLWH. This finding aligns well with theories and empirical studies that link negative emotions such as fear, anger, and anxiety with increased substance use in disastrous situations like a pandemic (Baker et al., 2004; Bravo et al., 1990; Khantzian, 1997; Rogers et al., 2020).

### 4. Discussion

The COVID-19 pandemic has taken over two million lives worldwide in about one year (Johns Hopkins University, 2021), and has affected billions of people’s overall, mental, and social well-being across the globe (World Health Organization, 2020). PLWH represent an especially vulnerable population in the pandemic (Shiau et al., 2020), not only because of their compromised immune system that may increase their risk for infection but also due to common mental health comorbidities (e.g., depression, PTSD, substance use disorders) that may pose them at increased risk for worsening mental health and behavioral problems (e. g., substance use) during the pandemic (Lesko and Bengston, 2021; Uribe et al., 2020). Marijuana is a commonly used substance among PLWH, and many are using it not only for recreational but also for medical reasons (Gamarel et al., 2016; Mennes et al., 2018; Minninga et al., 2013; Okator et al., 2017). However, it is unclear whether marijuana use in PLWH would change during the pandemic and what contributing factors may lead to the change. To the best of our knowledge, this study is the first to investigate the change in marijuana use during the pandemic among a relatively large sample of PLWH and leverage prospectively collected data to identify contributing factors associated with marijuana use change during the pandemic in this population.

In this study, 45 % of the participants reported a change in frequency and/or quantity of their marijuana use during the pandemic. Specifically, 64(28.8 %) out of the 222 PLWH reported either increased frequency or amount of their marijuana use, and 36(16.2 %) reported either decreased their frequency or amount of use. Although no prior study reported change in marijuana use among PLWH, research conducted in the general population and special subgroups (e.g., sexual minority group) has shown mixed findings, including increased (Bartel et al., 2020), decreased (Starks et al., 2020), or no change in marijuana use (Hochstatter et al., 2020) during the pandemic. Our finding is similar to a survey study that examined substance use, including marijuana use, among medical cannabis users during the pandemic, in which 35 % of participants increased marijuana use while 25 % decreased use (Boehnke et al., 2020). This finding suggests that the impact of the COVID-19 pandemic on the change of substance use may vary from person to person, and it is important to examine the contributing factors associated with the change.

It should be noted that most PLWH in this study did not change their marijuana use status (i.e., quit or newly initiated use): Seven out of the 222 participants (3.1 %) reported marijuana use before the pandemic but no use during the pandemic (i.e., quit marijuana use), whereas 2(0.9 %) reported not using marijuana before the pandemic but having used during the pandemic (i.e., initiated marijuana use). This is lower than the finding from the national survey that showed 13 % of the population in the United States initiated substance use during the pandemic (Czeisler et al., 2020). A possible explanation may be that our participants were primarily middle-aged, who had relatively established habits in marijuana use (either regularly used it or not use it at all), while those who newly initiated substance use in the national survey study tended to be younger.

Another main finding of this study was about the contributing factors associated with the change in marijuana use among PLWH during the pandemic. More frequent marijuana use was a contributing factor to both increased and decreased marijuana use during the pandemic in PLWH. This is plausible because those who use marijuana more frequently have more room to change (either increase or decrease), whereas those who have a low frequency of marijuana use before the pandemic tend to remain unchanged (very few initiated use as mentioned above).

In line with our hypothesis, worse mental health at baseline and change towards worse during the pandemic were both significantly associated with increased marijuana use during the pandemic. PLWH who had mental health issues (depression, PTSD) at baseline were more likely to report increased marijuana use during the pandemic. This finding is consistent with an online survey study, which found that medical marijuana users with mental health conditions were almost as twice as likely to increase marijuana use during the pandemic compared to those who had no mental health conditions (Vidot et al., 2020). In addition to baseline mental health issues, worsened mental health during the pandemic was also associated with increased marijuana use in PLWH. This finding aligns well with theories and empirical studies that link negative emotions such as fear, anger, and anxiety with increased substance use in disastrous situations like a pandemic (Baker et al., 2004; Bravo et al., 1990; Khantzian, 1997; Rogers et al., 2020).

Risk perception also played a role in changing marijuana use during the pandemic in PLWH. Those who did not perceive marijuana use would increase the risk of COVID-19 infection were more likely to increase marijuana use during the pandemic compared to those who had no mental health conditions (Vidot et al., 2020). In addition to baseline mental health issues, worsened mental health during the pandemic was also associated with increased marijuana use in PLWH. This finding aligns well with theories and empirical studies that link negative emotions such as fear, anger, and anxiety with increased substance use in disastrous situations like a pandemic (Baker et al., 2004; Bravo et al., 1990; Khantzian, 1997; Rogers et al., 2020).

### Table 5

Multinomial logistic regression model to predict changes in marijuana use during the COVID-19 pandemic in PLWH (N = 222).

| Predictor                                | Odds ratio | 95 % confidence intervals |
|------------------------------------------|------------|---------------------------|
| Marijuana use frequency before the pandemic |            |                           |
| Increased use vs. No change              | 1.476      | [1.175, 1.853]**          |
| Decreased use vs. No change              | 1.342      | [1.074, 1.677]**          |
| Depression                               |            |                           |
| Increased use vs. No change              | 1.096      | [0.761, 1.578]            |
| Decreased use vs. No change              | 0.939      | [0.602, 1.466]            |
| PTSD                                     |            |                           |
| Increased use vs. No change              | 2.287      | [1.059, 4.940]*           |
| Decreased use vs. No change              | 1.054      | [0.399, 2.785]            |
| Change in overall health                 |            |                           |
| Increased use vs. No change              | 1.383      | [0.688, 2.781]            |
| Decreased use vs. No change              | 0.503      | [0.220, 1.149]            |
| Change in mental health                  |            |                           |
| Increased use vs. No change              | 1.929      | [1.030, 3.612]*           |
| Decreased use vs. No change              | 1.290      | [0.627, 2.652]            |
| Marijuana use increases risk of COVID-19 infection |    |                           |
| Increased use vs. No change              | 0.194      | [0.047, 0.797]*           |
| Decreased use vs. No change              | 0.902      | [0.322, 2.524]            |
| Smoking marijuana increases risk of developing severe COVID-19 symptoms |    |                           |
| Increased use vs. No change              | 0.761      | [0.291, 1.987]            |
| Decreased use vs. No change              | 1.823      | [0.701, 4.675]            |

Note: *p < .05, **p < .01. Overall model fit: $\chi^2 = 54.03, df = 14, p = .001$. The reference group in the analysis was those who reported no change in their marijuana use during the COVID-19 pandemic. Marijuana use frequency before the pandemic was considered a continuous variable ranging from 0 “did not use marijuana” to 5 “—everyday”. Depression was considered a continuous variable ranging from 0—“None” to 3—“severe depression”. Change in overall/mental health was also considered a continuous variable ranging from 1—“better”, 2—“no change”, 3—“worse”. PTSD, marijuana use increases the risk of COVID-19 infection, and smoking marijuana increases the risk of severe COVID-19 symptoms were categorical variables (0—“no”, 1—“yes”).
education regarding the potential risks related to marijuana use during the COVID-19 pandemic among PLWH. In our sample, a considerable proportion (30–39 %) of them said they did not know whether marijuana use would increase their risk for COVID-19 infection or developing severe symptoms from the infection. As mentioned previously, the primary route of administration for marijuana use among our sample was smoking and/or vaping, which may increase their susceptibility to the infection as well as worse symptoms due to a vulnerable respiratory system (Borgnoli et al., 2021). Therefore, more education on the risks related to smoking or vaping marijuana and information on safer alternatives to smoking/vaping products (e.g., capsules, tincture) may help reduce COVID-19 incidences and severe symptoms due to marijuana use among this population (Fischer et al., 2017). On the other hand, some research suggests the potential benefits of cannabinoids, especially cannabidiol (CBD), in alleviating COVID-19 infection-induced cytokine storms, given their anti-inflammatory property. However, researchers call for further research before cannabinoids are applied as a treatment for COVID-19 (Anil et al., 2021; Byrareddy and Mohan, 2020). The media coverage, emphasizing such potential benefits could sometimes be misleading, so more evidence-based education is urgently needed to ensure a good understanding of potential risks and benefits associated with marijuana use during the pandemic, especially among more vulnerable populations like PLWH.

5. Limitations and conclusion

Despite the strengths, such as the longitudinal nature of the study and the relatively large sample size, this study had several limitations. First, our data were still based on self-report, thus could be subject to biases. The change of marijuana use was based on retrospective reports during the pandemic, which could be less accurate than comparing marijuana use assessed at a recent pre-pandemic period and during the pandemic. Second, our data could not determine whether worsened mental health during the pandemic led to more marijuana use or vice versa. Future research, including qualitative research, is needed to better address this question. Third, we did not collect data on other substance use in the brief phone survey. Future research could examine whether a change in marijuana use leads to changes in the use of other substances (e.g., alcohol, other illicit drugs) during the pandemic. Finally, some of the baseline characteristics (e.g., depression, cannabis use disorder) may have changed over time given the relatively long duration (i.e., approximately one year) between the two assessment points. Future studies would benefit from additional assessments more recent to the pandemic. Despite the limitations, this study is one of the first to report how marijuana use changed during PLWH during the COVID-19 pandemic and its contributing factors. Our findings highlighted the need for mental health intervention and education about potential risks associated with marijuana use during the pandemic in this population.

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Contributors

YW conceptualized the paper, analyzed the data, wrote the manuscript; GEI contributed to data collection and manuscript preparation; KV contributed to manuscript preparation; NES contributed to manuscript preparation; RLC contributed to manuscript preparation; RS contributed to manuscript preparation; ECP contributed to manuscript preparation; RAC contributed to study design and manuscript preparation; RSL contributed to study design and manuscript preparation.

Declaration of Competing Interest

None to declare.

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