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Assessing Health-Related Outcomes of Medical Cannabis Use among Older Persons: Findings from Colorado and Illinois

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ABSTRACT

Objectives: To assess health-related outcomes associated with medical cannabis use among older patients in Colorado and Illinois enrolled in their home state's medical cannabis program.

Methods: Cross-sectional data from anonymous surveys were collected from 139 persons over the age of 60 using medical cannabis in the past year. We used structural equation modeling (SEM) to confirm the hypothesized four-factor structure that includes health-related quality of life (HRQL), health-care utilization (HCU), symptom effects, and adverse events. We then examined associations between cannabis use and self-reported outcome changes using linear regression.

Results: The four-factor model was the best fitting structure (X2(df) = 81.63 (67), p> X2 = 0.108) relative to reduced structures. We also found that using cannabis 1–4 times per week is associated with 3.30 additional points on the HRQL scale (p < .001), 2.72 additional points on the HCU scale (p < .01), and 1.13 points on pain (p < .001). The frequency of use reported at 5–7 times per week is associated with 4.71 additional HRQL score points (p < .001). No significant associations were observed between the frequency of use and adverse events.

Conclusions: We observed how cannabis use outcomes fall into four independent factors, and those using more frequently reported higher values on HRQL, HCU, and pain measures. However, we are cautious about the generalizability of our findings.

Clinical Implications: Clinicians should consider how older patients using medical cannabis can experience positive and negative outcomes simultaneously or separately and assess these outcomes directly along with considering patient self-reports.

ARTICLE HISTORY

KEYWORDS
Medical cannabis; older persons; self-reported outcomes; proximal/distal; structural equation models (SEM)

Introduction

The use of cannabis for a medical purpose (i.e., medical cannabis) is increasing among persons over the age of 50 (Choi, DiNitto, & Marti, 2015; Han & Palamar, 2018, ; Han et al., 2017b; Substance Abuse & Mental Health Services Administration Center for Behavioral Health Statistics and Quality [SAMHSA], 2015). Researchers have also shown how their medical cannabis use is driven largely by age-associated needs. As persons grow older and become more likely to experience severe pain, sleep disturbances, or condition-specific symptoms like Multiple Sclerosis (MS) spasticity and cancer-associated nausea, they may be more likely to use cannabis for purely therapeutic purposes (Ahmed, van den Elsen, van der Marck, & Rikkert, 2014; Bobitt et al., 2019; Salas-Wright et al., 2017). While researchers continue to explore the pathways leading to cannabis use among older adults (Arora et al., 2019a; Choi et al., 2017; Haug et al., 2017; Minerbi, Häuser, & Fitzcharles, 2019), there arguably is a greater need to know more about the outcomes experienced by older adults who use cannabis primarily for a medical purpose. Patients in Colorado and Illinois were able to enroll in their state's medical cannabis program and access cannabis from licensed dispensaries or cannabis shops once they obtained certification of diagnosis with an eligible condition from a board-certified physician (Colorado Revised Statutes 18-18-406.3, 2018; Illinois Compiled Statute, 2019), providing the opportunity to sample a population of older adults and explore outcomes of medical use. In this study, we used self-reported data provided by 139 persons over age 60 who used medical cannabis in the past year to fit a theoretically driven four-factor structure consisting of 14 discrete outcome measures; we then tested a series of linear regression

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models to identify possible associations between cannabis use and these self-reported outcomes.

The range of cannabis outcomes

A number of researchers have associated cannabis use with a range of adverse, negative outcomes. The National Academies' cited a substantial amount of evidence that supported an association between cannabis use with worsening respiratory symptoms and frequent episodes of chronic bronchitis; the Academies also found some evidence that persons using cannabis are at an increased risk of developing chronic obstructive pulmonary disease (COPD), and these persons may then be more likely to experience acute myocardial infarction or ischemic stroke (National Academies of Sciences, Engineering, and Medicine, 2017). Researchers have also linked increasing cannabis use with attention and memory problems, and older persons who use cannabis are also more likely to present clinically with an alcohol, nicotine, cocaine, and/or prescription drug use disorder (Aryana & Williams, 2007; Blazer & Wu, 2009; Wu & Blazer, 2011). Moreover, both medical cannabis use and higher-frequency of cannabis use are associated with misuse of prescription pain relievers, including opioids (Choi, DiNitto, & Choi, 2020).

Older adults who use cannabis are more likely than their non-using age peers to have problems related to driving, experience an injury, and visit the emergency department (Choi, DiNitto, Marti, & Choi, 2016; Choi, Marti, DiNitto, & Choi, 2018). While the exact mechanisms of injury and other such outcomes are not known, researchers have suggested that cannabis-induced mental status alterations, acute intoxication, and other psychophysiological effects, especially when combined with alcohol and other illicit drugs, may increase users' vulnerability to injury (World Health Organization [WHO], 2016). According to the Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality's Treatment Episode Data (Choi, DiNitto, & Marti, 2017b) on admissions to treatment centers, the proportion of admissions for any substance use problem/disorder among those 50 and over increased from 11.0% in 2006 to 17.9% in 2017. While cannabis was identified as the primary substance in just 3% of all older-adult admissions, researchers determined that cannabis use was common among the majority of older adults seeking treatment for alcohol, tobacco, and other drug problems.

There certainly is reason to be concerned that increasing cannabis use among older persons may contribute to increasing rates of substance misuse or other undesirable outcomes. However, it is important to note how older cannabis users self-report experiencing negative outcomes at relatively low rates (Reynolds et al., 2018). In one study, less than 10% of all older persons who used cannabis in the past year reported emotional or functional problems, and the majority indicated they had low levels of perceived risk and placed no limitations on their own use (Black & Joseph, 2014).

In fact, researchers have identified several positive outcomes associated with cannabis use. The National Academies' report (2017) presented evidence that cannabis can be effective as an antiemetic, and as a therapeutic for chronic pain. Other researchers have observed self-reported improvements in MS-related spasticity symptoms and short-term sleep issues among persons who use cannabis (Lim, See, & Lee, 2017; Park & Wu, 2017; Whiting et al., 2015). More recently, Lum et al. (2019) found older persons using medical cannabis reported improved symptoms of arthritic pain as well as anxiety and depression.

While this previous work has illuminated a range of outcomes that might be experienced by older persons who use cannabis, the work falls short in a few critical ways. Some of these studies relied on large sample surveys such as the National Survey of Drug Use and Health that were purposely grounded in an abuse/addiction framework and appeared to be focused on negative outcomes such as co-occurring substance use or need for specialty treatment (Cohn, Johnson, Ehlke, & Villanti, 2016; Han et al., 2017a; Mattson, Lipari, Hays, & Van Horn, 2017; SAMHSA, 2014). Most studies did not consider the range of outcomes that might be experienced by any individual at any given point in time, and we found few, if any, studies that evaluated the range of outcomes most relevant to older persons who use cannabis for a medical purpose (Bobitt et al., 2019; Lum et al., 2019).

A comprehensive model of medical cannabis outcomes

We considered the *Proximal/Distal* model of health-related outcomes, detailed by Brenner, Curbow, and Legro (1995) and refined by other researchers (Chan et al., 2011; Kindig, 2007) well suited for understanding a broad range of outcomes in older persons using medical cannabis. In this model, health outcomes can be organized into four categories: a general factor capturing health-related quality of life (HRQL), healthcare service use (HCU), condition-related symptoms, and adverse events. More immediate, or proximal, outcomes are those most objectively identifiable with clinical data that measure acute changes in persistent symptoms; more distal outcomes reflect global indicators such as health quality and satisfaction and often do not manifest immediately after cannabis use. Brenner et al. (1995) indicate that researchers tend to focus on more proximal measures especially when examining outcomes pertaining to the treatment of an underlying disease or disorder. While they sometimes consider how changes in these proximal outcomes may or may not be associated more distal ones (e.g., cannabis use may reduce a clinically measurable amount of eye pressure in persons with glaucoma, but the individual may or may not report any changes in quality of life), few researchers fully explore relationships among proximal and more distal outcomes within the same sample even though therapeutic and negative impacts are observed in the literature, and users report experiencing both at the same time.

As such, we believe it necessary to consider outcomes collectively and offer a comprehensive view of the outcomes experienced by older persons who use cannabis for a medical purpose. Moreover, given the need to understand the therapeutic value of medical cannabis, we think these outcomes should be conceptualized in terms of their distance (immediate or not) and valence (from positive to negative).

Research objectives

The goal of this study is to offer empirical support for this expanded conceptualization of self-reported outcomes experienced by older persons who use cannabis for a medical purpose. Specifically, we aim to assess the relative fit of a four-factor structure of cannabis use outcomes and contrast this model with more parsimonious factor structures; we then identify associations between cannabis use and these self-reported outcomes. For clinicians, we believe this work illuminates the range of outcomes any particular older adult who uses cannabis for a medical purpose may experience. We also determine if these outcomes are independent or related and estimate the impact of cannabis use on a range of self-reported outcomes.

Methods

Using cross-sectional data from surveys of older persons in Colorado and Illinois, this study explores a range of 14 self-reported outcomes experienced by individuals using cannabis for medical purposes such as pain reduction and as an antiemetic for cancer-associated nausea. Participants provided consent prior to completing the survey instrument. Approval for this research was granted by the Internal Review Boards at the University of Colorado, Colorado Springs, and the University of Illinois at Urbana Champaign.

Sample

Our survey sampling frame consisted of persons over the age of 60, residing in one of the two states permitting the use of cannabis products for medical use. Respondents were recruited in Colorado from June 2017 through November 2017, and Illinois from February 2018 to August 2018. The survey respondents were recruited at local health departments, senior centers, wellness and health clinics, state-registered cannabis clubs, and cannabis retail shops and dispensaries across the two states. We used this purposive sampling strategy because the estimated prevalence of past-year cannabis use is relatively low (Han et al., 2016; Han & Palamar, 2020), and would require us to deploy a much larger (and more expensive) sampling strategy to achieve both a sufficiently large and random analytic sample. Of the 470 older adults who completed the survey, we observed 167 respondents aged 60

and older who reported using cannabis in the past year for a medical purpose, a recreational purpose, or both. Of these, 139 reported using cannabis for a medical purpose and were included in the analytic sample for this study.

Comprehensive outcomes range

We hypothesized that the outcomes would align with four factors: health-related quality of life (HRQL), health-care utilization (HCU), symptom effects, and adverse events. We considered negative outcomes to include: (1) decline in *HRQL*, specifically worsening sense of health and well-being and quality of life, reduced productivity satisfaction, and reduced day-to-day functioning; (2) increased *HCU*, specifically self-reported utilization of mental health and substance use disorder (MH&SUD) services, Emergency Department utilization, doctor visits, and overnight hospital stays; (3) increased *symptom effects*, including the worsening of pain symptoms and sleep issues; and (4) increasing impact on *adverse events*, including issues with memory and thinking, falls and balance, driving problems, or accidents.

We considered positive outcomes to include: (1) improvement to *HRQL*, specifically improved quality of life, improved overall sense of health and well-being, increased day-to-day functioning, and increased productivity satisfaction; (2) decreased *HCU*, specifically self-reported utilization of mental health and substance use disorder (MH&SUD) services, Emergency Department utilization, doctor visits, and overnight hospital stays; (3) decreased *symptom effects*, specifically the reduction of pain symptoms, sleep issues; and (4) no effect on *adverse events*, including falls and balance, driving problems, or accidents.

Survey data

Our survey included 83 structured questions overall, with sections for *Attitudes and Beliefs, Patterns of Cannabis Use* (specific to both medical and recreational use), *Additional Substance Use Behaviors*, and *Health-Related Outcomes*. The 14 outcome measures were adapted from previously validated instruments including the Patient-Reported Outcomes Measurement Information System (PROMIS) and the National Survey on Drug Use and Health (NSDUH), in addition to symptom-specific self-reports. The construction and validation of our survey are presented in another publication (Arora et al., 2019a). The full outcomes scale is presented in Appendix A.

PROMIS global health measures

The PROMIS Global Health Scale is a verified method for the collection of self-reported health status (Hays, Bjorner, Revicki, Spritzer, & Cella, 2009). PROMIS collects several measures for physical, mental, and social health dimensions, and provides factor-based scores for physical health and mental health. The indicators are global by design, collecting distal, generic measures of individual health. The PROMIS Scale is included here to capture global health status and provides standardized ratings of health for respondents. We calculated PROMIS scores for global, physical, and mental health. Four PROMIS indicators were used to capture perceived medical cannabis effects on health-related quality of life, general health and well-being, functioning, and productivity.

NSDUH measures

In addition to PROMIS measures, we looked to the National Survey on Drug Use and Health (NSDUH) measures for proximal indicators of substance use-related health-care utilization (need for emergency care upon cannabis intoxication). Four NSDUH indicators were used to capture mental health and substance use disorder (MH&SUD) service use, doctor visits, emergency department (ED) use, overnight hospital stays. Four other measures were used to capture adverse events such as falls and balance issues, memory and cognition issues, accidents and injuries, and problems driving. In addition, we include two measures to capture self-reports about pain and sleep.

Analysis

To fit the hypothesized four-factor model structure, we performed confirmatory factor analysis (CFA) using the Stata 16.0 Structural Equation Model builder with maximum likelihood mean-variance-adjusted (MLMV) estimation, along with a series of reduced model estimations as a robustness check (Sanchez et al., 2005; Schreiber, 2008; Schreiber,

2017). To address missing data on our observed outcome measures, we engage full information maximum likelihood (FIML) estimation, which allows for unbiased parameter estimates and estimates of uncertainty that accommodate for the increased variability resulting from missing data (Beauducel & Herzberg, 2006; Enders & Bandalos, 2001; Li, 2016). Model fit was assessed using standard goodness of fit indices, including the chi-square statistic (X^2) with degrees of freedom (df), the p-value of $p > X^2$, the root-mean-square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker–Lewis index (TLI), and the coefficient of determination (CD). A good fit for the data is found when chi-square values are not significant, RMSEA less than 0.05, CFI and TLI are greater than 0.95, and the CD is close to 1 (Beauducel & Herzberg, 2006; Browne & Cudeck, 1993; Hooper, Coughlan, & Mullen, 2008; Hu & Bentler, 1999).

The four latent factors included (1) *Health-Related Quality of Life* (*HRQL*), measured with the indicators health and well-being, quality of life, functioning, and productivity; (2) *Health-Care Utilization* (*HCU*), measured with the indicators mental health and SUD service utilization (MH_SUD), doctor visits, emergency department (ED) utilization, and overnight hospital stays; (3) *Symptom Effects*, measured with the indicators pain, and sleep issues; and (4) *Adverse Events*, measured with the indicators memory, falls and balance, driving, and accidents. We used a pair of reduced model estimations as a robustness check, one framing three latent factors within the outcome scale, the other framing a dual-factor structure.

OLS outcome models

We use OLS regressions to examine if self-reported changes in health-related quality of life, health-care utilization, pain symptoms, and memory issues are associated with higher incremental frequencies of medical cannabis use. The outcome variables capture self-reported changes to standardized health-related quality-of-life scores (*HRQL*) and health-care utilization scores (*HCU*), in addition to changes in pain symptoms (*Pain*), and problems with memory and cognition (*Memory*) at the individual level. The primary independent variables we test for capture medical purpose only cannabis use behavior (*medical*) and cannabis use frequency (*frequency*), while adjusting for other key variables including age in years, sex, primary diagnosis with a pain-related condition or report cancer-associated pain, past-year opioid use, method of use, and prior negative experiences with cannabis. The empirical models for this analysis take the following form:

$$Y_i = \beta_0 + \beta_1 medical + \beta_2 frequency + \beta_3 condition + \beta_4 opioids + \beta_5 smoke + \beta_6 liquid + \beta_7 edible + \beta_8 negexp + \beta_9 demographics + \varepsilon$$

Results

Of the total 167 individuals responding to the surveys who reported using cannabis in the past year, 139 (83%) report using cannabis for a medical purpose in the past year. The full analytic sample structure is presented in Figure 1. The mean age of the 139 medical cannabis users was 68.62 years (SD 6.00) [Median = 68; Range = 60–88]. Over 17% of these users were over age 75. The majority were male (51%), white (88%), and partnered (69%). The majority have a college degree or more (53%), are retired (84%), and experience financial insecurity (80%). Nearly two-thirds of medical users reported formal diagnosis with a pain-related condition or specifically report cancer-associated pain (61%), and a majority also reported using opioids in the past year (52%). Medical users reported cannabis dosing by means of smoke inhalation (62%). Almost half (45%) of the sample used medical cannabis because of side-effects associated with their prescription medications. Table 1 details the characteristics of the sample and identifies key differences between mixed purpose users and medical purpose only users.

Outcomes experienced by medical cannabis users are presented in Table 2. The full list of measures included in the outcomes scale is included in Appendix A. Structural equation modeling showed that only the hypothesized four-factor model structure reached sufficient goodness of fit for the data. The four-factor SEM is presented in Figure 2. The four-factor test model produced a chi-square value of 81.63, with 67 degrees of freedom, and a p-value of 0.108. The RMSEA value of

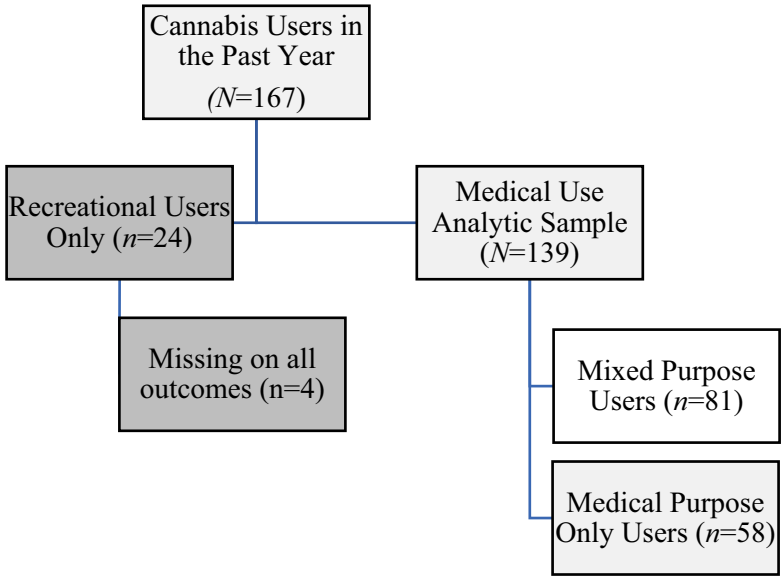

Figure 1. Analytic Sample Structure (*N*= 139).

Table 1. Univariate analysis of sample characteristics by medical cannabis use purpose (*N*= 139).

Variable	All cannabis users (*N* = 139) *n* (%)	Mixed-purpose users (*n* = 81) *n* (%)	Medical only users (*n* = 58) *n* (%)	*p*-Value
Age (SD)	68.62 (6.00)	67.14 (4.44)	70.69 (7.21)	0.209
Age 75 years or more	25 (17%)	6 (7%)	19 (33%)	<0.001
Females	68 (49%)	31(38%)	37 (64%)	0.003
Nonwhite	17 (12%)	8 (10%)	9 (16%)	0.317
College degree or higher	73 (53%)	42 (52%)	31 (54%)	0.853
Married	96 (69%)	60 (74%)	36 (62%)	0.131
Retired	117 (84%)	63 (78%)	54 (93%)	0.015
Financially secure	28 (20%)	14 (17%)	14 (24%)	0.320
Pain-related condition	101(73%)	66 (81%)	35 (60%)	0.006
PROMIS Global Health Score (SD) *n* = 124	35.46 (7.76)	37.21 (7.21)	32.69 (7.84)	0.220
PROMIS Physical Health Score (SD) *n* = 130	14.20 (3.32)	15.01 (3.24)	13.06 (3.10)	0.284
PROMIS Mental Health Score (SD) *n* = 133	14.30 (3.36)	14.77 (3.20)	13.53 (3.47)	0.546
Past-year opioid use	72 (52%)	45 (55%)	27 (47%)	0.295
Past-year benzodiazepine use	49 (35%)	30 (37%)	19 (33%)	0.603
No personal prior negative cannabis experience	100 (72%)	51 (63%)	49 (84%)	0.005
Cannabis dosing method:				
Smoke inhalation	86 (62%)	62 (76%)	24 (41%)	<0.001
Vaporizer	67 (48%)	47 (58%)	20 (34%)	0.006
Capsules or pills	12 (9%)	8 (10%)	4 (7%)	0.537
Edibles	41 (29%)	32 (40%)	9 (16%)	0.002
Topical cream	37 (27%)	25 (31%)	12 (21%)	0.181
Liquid tincture	52 (37%)	29 (36%)	23 (40%)	0.643
Dabbing	3(2%)	3 (4%)	0(0%)	0.138
Other	6 (4%)	4 (5%)	2 (3%)	0.67
Reasons for medical cannabis use:				
My prescribed medications did not help.	42 (30%)	19 (23%)	23 (40%)	0.040
My prescribed medications had side effects.	63 (45%)	40 (49%)	23 (40%)	0.256
Prescription medications can be addicting.	48 (35%)	25 (31%)	23 (40%)	0.282
I prefer not to take prescription medication.	45(32%)	30(37%)	15 (26%)	0.165

Standard deviation.

0.040 is sufficiently below the 0.05 threshold of a good fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). The CFI (0.985) and the TLI (0.98) fit indices are both above the 0.95 threshold, and the coefficient of determination is equivalent to 1, indicating an ideal fit (Hooper et al., 2008). Goodness-of-fit measures for all three model specifications are presented in Table 3.

Table 4 presents the results of the OLS regression modeling. Statistically significant associations were

Table 2. Comprehensive structure of medical cannabis use outcome measures.

Proximal positive	Proximal negative
Decreased MH&SUD service utilization	Increased MH&SUD service utilization
Decreased doctor visits	Increased doctor visits
Decreased ED utilization	Increased ED utilization
Decreased overnight stays	Increased overnight stays
Reduced pain symptoms	Increased pain symptoms
Reduced sleep disturbances	Increased sleep disturbances
Distal Positive	**Distal negative**
Improved HRQL	Decline in HRQL
Improved health and well-being	Worsening sense of health and well-being
Increased day-to-day functioning	Reduced day-to-day functioning
Increased productivity	Reduced productivity
No falls and balance issues	Increased falls and balance issues
No memory and thinking issues	Increased memory and thinking issues
No driving problems	Increased driving problems
No accidents or injuries	Increased accidents and injuries

Table 3. Cannabis health outcomes scale SEM goodness of fit indices (n= 139).

Model:	X^2 (df)	$p > X^2$	RMSEA	CFI	TLI	CD
Four factor	81.63 (67)	0.108	0.040	0.98	0.98	1.0
Three factor	1216.80 (86)	0.000	0.308	0.00	-	1.0
Two factor	1216.97 (81)	0.000	0.318	0.000	-	1.0

SEM: structural equation model;
df: degrees of freedom;
RMSEA: root-mean-square error of approximation;
CFI: comparative fit index;
TLI: Tucker-Lewis index;
CD: coefficient of determination.

observed between the frequency of self-reported cannabis use and their self-reported changes in health-related quality of life (HRQL), health-care utilization (HCU), and pain symptom severity when controlling for other variables including diagnosed conditions, opioid use in the past year, cannabis dosing methods, and relevant demographics. Cannabis use frequency reported at 1– 4 times per week was associated with 3.30 additional points on the 20-point self-reported HRQL score ($p < .001$), 2.72 additional points on the HCU score ($p < .01$), and 1.13 additional points on the 5-point pain improvement scale ($p < .001$). Cannabis use frequency reported at 5– 7 times per week was associated with 4.71 additional points on the 20-point self-reported HRQL score ($p < .001$), and 1.09 additional points on the 5-point pain improvement measure ($p < .001$).

No significant effects were found between the HCU scores and medical cannabis use purpose when adjusting for certifying physician, condition, opioid use, and age. Finally, there is not sufficient evidence of an association between the adverse effect of declines in memory and thinking, when controlling for medical cannabis use purpose, conditions, dosing methods, and relevant demographics.

Discussion

We fitted a four-factor model to a wide range of 14 self-reported outcomes experienced by older persons using medical cannabis, suggesting that as clinicians increasingly encounter older adults who use cannabis for a medical purpose, they should consider how use may involve health-related quality of life, health-care utilization, symptom effects, and adverse events, and how individuals can experience these outcomes in term of both positive to negative effects.

Our regression modeling identified a strong positive association between higher frequency of cannabis use and improvement to HRQL and HCU scores. This could be because using medical cannabis may require additional doctor visits to

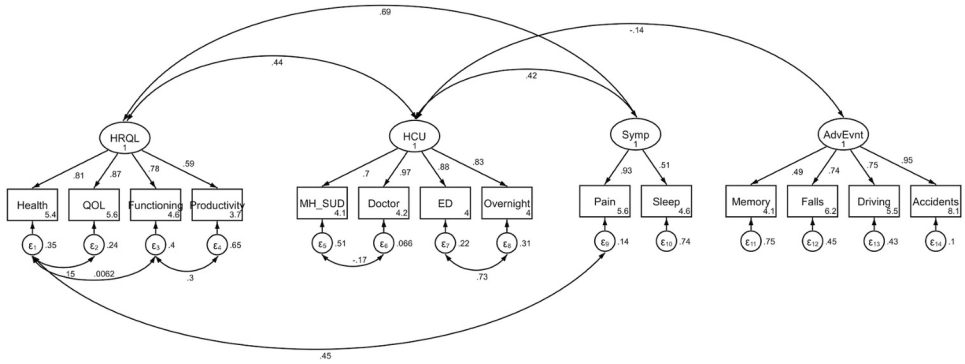

Figure 2. Four Factor Outcome SEM with Standardized Coefficients and Goodness-of-Fit Indices. X^2_ms(67) **= 81.63**, $p > X^2$ **= 0.108**, RMSEA **= 0.040**, CFI **= 0.985**, LFI = **0.980**, CD **= 1.000**

Table 4. OLS associations between cannabis use frequency and self-reported outcomes.

	HRQL[a] Scores (*n*=110)			**HCU[b] Scores** (*n*=97)			**Pain Levels** (*n*=107)			**Memory and Thinking Issues** (*n*=107)		
Variable	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value	Coef.	Std. Err.	p-value
Medical purpose use only	0.33	0.70	0.637	0.58	0.76	0.450	-0.17	0.20	0.417	0.14	0.29	0.637
Frequency of use:												
1-4 times per Week	3.30	0.98	0.001	2.72	0.97	0.006	1.13	0.29	<0.001	0.18	0.42	0.677
5-7 times per Week	4.71	0.71	<0.001	1.13	0.74	0.128	1.09	0.21	<0.001	-0.25	0.29	0.389
Age	1.42	0.62	0.023	1.56	0.66	0.021	0.04	0.00	<0.001	0.06	0.01	<0.001
Female	0.16	0.02	<0.001	0.14	0.02	<0.001	0.27	0.18	0.126	-0.09	0.25	0.719
Diagnosed condition	0.75	0.58	0.200	0.83	0.64	0.196	0.49	0.18	0.007	0.08	0.25	0.740
Opioid use in past year	0.69	0.60	0.250	0.41	0.64	0.516	0.25	0.16	0.130	0.13	0.23	0.590
Smoke inhalation	0.26	0.55	0.634	0.46	0.60	0.444	0.34	0.19	0.067	-0.01	0.27	0.979
Liquid tincture use	0.62	0.57	0.282	1.34	0.60	0.028	0.07	0.17	0.695	0.09	0.25	0.705
Edible use	-0.37	0.69	0.590	-0.98	0.71	0.171	0.03	0.20	0.901	-0.13	0.28	0.655
Prior negative experience	0.15	0.61	0.801	-0.50	0.66	0.448	0.02	0.18	0.905	0.11	0.27	0.674

HRQL: health-related quality of life; HCU: health-care utilization.

secure and maintain certification for their state's medical cannabis program.

Our regression modeling also identified a strong positive relationship between higher frequency of cannabis use and self-reported improvements to pain symptoms. These results echo findings from previous studies of older adults using cannabis for a medical purpose (Abuhasira, Bar-Lev Schleider, Mechoulam, & Novack, 2018; Bar-Lev Schleider et al., 2018; Sexton, Cutler, Finnell, & Mischley, 2016). The positive relationship between near-daily use and improved reports offers further evidence of the perceived value of medical cannabis as a therapeutic approach for pain management. Further research, including more randomized-control studies with representative samples, is essential to fully explore these relationships.

The failure to see a statistically significant association with the Adverse Events measure for declines in memory and thinking was surprising. This failure may be due to a relatively small amount of respondents reporting negative values as adverse cognitive effects are well established in the literature (National Academies of Sciences, Engineering, and Medicine, 2017). Given the lack of a statistically significant association in the sample, we may be seeing a washout effect, as the only significant factor in the negative OLS model exploring Adverse Events was age in years. There also is a possibility of missing data on adverse events resulting from the perceived stigma around cannabis use behaviors or social desirability bias that could lead some respondents to underreport negative effects. Still, we find limited evidence respondents had negative experiences with cannabis, with few reporting any prior in the past-year, and the low frequency of lower values across the four factors indicates that, while population members are experiencing some level of adverse effects, the low frequency observed is not inconsistent with previous studies (Black & Joseph, 2014).

The study also demonstrates the importance of considering the patient perspective when assessing the success of alternative treatment approaches (Bonn-Miller, Boden, Bucossi, & Babson, 2014; Harris et al., 2000; Sexton et al., 2016). These self-reported measures offered us expanded notions of the experiences older adults have when using cannabis. Future research should consider how this approach compares to other approaches with more clinical, physically based measures. While self-reported outcomes are not as concrete as more proximal vital sign measures or blood assays, these measures do provide context that researchers can use to frame hypotheses for clinical exploration.

Another area for continued exploration concerns the potential impact of non-response and social-desirability biases among our study participants. While these types of biases are common in studies asking questions related to substance use behaviors (Bradburn, Sudman, & Wansink, 2004; Dillman, Smyth, & Christian, 2014; Groves et al., 2009), they are also particularly challenging to questions about medical cannabis use among older users, who may have long-held stigma-based view of cannabis use. On one hand, survey respondents often perceive questions about substance use behavior as *threatening* and misreport their actual experience or outright refuse to answer the questions, resulting in biased estimates (Bradburn et al., 2004; Dillman et al., 2014). Moreover, even with the changes in the

drug's legal status that lead new and former users to cannabis, many users are still influenced by the associated social stigma and this can manifest as survey participants inaccurately report on their cannabis use experience (Satterlund, Lee, & Moore, 2015). On the other hand, given the respondents are active cannabis users, it is more likely they have a preexisting positive opinion of cannabis use and its potential as a therapeutic, and it is possible some respondents may have over-stated the positive effects they experienced. While we cannot address this here, such a bias lends further reason for the need to develop other measures concerning cannabis outcomes that are not self-reported (Furnham, 1986; Kalton & Schuman, 1982).

Limitations

We recognize there are other limitations to this study. One concerns our reliance on cross-sectional design that prevents us from obtaining estimates that account for temporality, whether the outcome followed cannabis exposure in time. Another limitation comes from the sample structure drawn from populations in Colorado and Illinois, which have different pathways for legal cannabis use. Indeed, in conducting sensitivity analyses (not reported here), we observed some statistically significant differences between users in Colorado and Illinois in terms of dosing methods and the composition of the sample in terms of sex and education, we had no reason to believe these differences adversely impacted our analyses. Still, before any conclusive statements can be offered about the outcomes experienced by older persons who use cannabis for a medical purpose, researchers need to deploy studies designed with a greater range of outcome measures (more than self-reports), a temporally sensitive lag between use and outcomes, and a more nationally representative sampling.

Conclusion

This study adds to an emerging body of research that explores the outcomes of medical cannabis use among older patients. In particular, this study supports findings from larger *N*, longitudinal studies of medical cannabis patients indicating cannabis use being associated with improvements for pain symptoms (Abuhasira et al., 2018; Bar-Lev Schleider et al., 2018; Bobitt et al., 2019; Sexton et al., 2016). Strong positive associations between frequency of cannabis use and improvements to both quality of life and pain symptoms were observed, while the relationship between cannabis use frequency and changes to health-care utilization and adverse events requires additional exploration.

However, the findings are a strong starting point for framing hypotheses to test in the future research in larger, more representative samples. The study offers the unique benefit of examining health-related outcomes of cannabis use in two states with differing pathways and restrictions for legal use, and differences in population and cannabis policy. Regardless of the limitations on generalizability, these findings provide a sound starting point for objective assessment of patient-reported health outcomes related to medical cannabis use.

Clinical implications

- Clinicians should recognize how older adults who use cannabis for a medical purpose experience a range of outcomes both positive and negative.
- Given how these outcomes are statistically independent, clinicians should consider how older adults using cannabis can experience positive and negative outcomes simultaneously or separately.
- While cannabis use appears to improve a range of self-reported outcomes, patients may under-report negative effects and clinicians must be careful to include direct assessment of potential risks and harms for older adults using cannabis for a medical purpose.

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Appendix A. Cannabis use outcomes scale

		How has using cannabis affected you in the following areas?
1	*Makes it worse*	Overall health and well-being
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Quality of life
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Day to day functioning
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Productivity
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Creativity
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Spiritual awareness
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Relaxation
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Social connections
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Participation in wellness activities (like yoga)
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Participation in recreation activities
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Use of mental health & substance abuse services
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Visits to my doctor
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Emergency/Urgent care visits
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	

(*Continued*)

		How has using cannabis affected you in the following areas?
1	*Makes it worse*	Overnight hospital stays
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Other
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
text		**Other, please specify**: – Text
		If you have any of the following symptoms, how does your use of cannabis impact them?
1	*Makes it worse*	Lack of energy
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Lack of appetite
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Pain
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Dry mouth
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Weight loss
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Feeling drowsy
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Shortness of breath
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Constipation
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Difficulty sleeping
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Difficulty concentrating
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Nausea
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	

(*Continued*)

		How has using cannabis affected you in the following areas?
1	*Makes it worse*	Worrying
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Feeling sad
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
1	*Makes it worse*	Feeling nervous
2	2	
3	*No Change*	
4	4	
5	*Makes it Better*	
		My use of cannabis has impacted my . . .

(*Continued*)

		How has using cannabis affected you in the following areas?
1	*None*	Memory
2	2	
3	*Some*	
4	4	
5	*A lot*	
1	*None*	Falls/Balance
2	2	
3	*Some*	
4	4	
5	*A lot*	
1	*None*	Driving
2	2	
3	*Some*	
4	4	
5	*Alot*	
1	*None*	Accidents/Injuries
2	2	
3	*Some*	
4	4	
5	*A lot*	