Feasibility and acceptability of using smartphone-based EMA to assess patterns of prescription opioid and medical cannabis use among individuals with chronic pain

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ABSTRACT

Background: Intensive longitudinal studies are needed to examine the co-use of prescription opioid medication and medical cannabis and their effects on chronic pain. The current study sought to investigate the feasibility and participant compliance with a smartphone-based Ecological Momentary Assessment (EMA) data collection protocol among individuals who use multiple substances and suffer from chronic pain.

Methods: A total of 46 participants (mean age = 44.8 years; 78% female; 85% Non-Hispanic White) were recruited online and completed a 30-day EMA phase where they responded to prompted surveys (four random past-hour surveys and one daily diary per day) about opioid medication use, medical cannabis use, and pain symptoms. Qualitative follow-up interviews were conducted with a subset of 10 participants. Linear and logistic regression models were used to examine baseline participant characteristics in relation to EMA compliance. Qualitative indicators of participant study experience were extracted from interviews.

Results: Participants responded to an average of 70% of past-hour surveys and 92% of daily diaries. Female participants were more likely to complete all daily diaries and at least one past-hour survey per day on all 30 days, respectively (OR = 5.60, 95% CI: 1.02–30.77, p < .05; OR = 7.08, 95% CI: 1.28–39.16, p < .05). Female participants were also more likely to complete at least 75% of their prompted past-hour surveys (OR = 4.67, 95% CI: 1.00–21.69, p < .05). Interview participants reported a positive study experience overall, although some mentioned problems related to smartphone notifications, redundant questions, or being prompted when they were not feeling well. Participants also mentioned problems with reporting the amount of medical cannabis used (e.g., milliliters of vaping liquid).

Conclusions: Study results demonstrate both feasibility and acceptability of using EMA methodology to examine use patterns of medical cannabis and prescription opioid medication among individuals with chronic pain.

1. Introduction

Chronic pain affects over 50 million Americans (Centers for Disease Control and Prevention, 2018), and frequently, opioids are prescribed to aid patients in managing such pain. A recent estimate suggests that as many as 25% of patients with chronic pain misuse prescription opioids, and 10% may meet criteria for opioid use disorder (Vowles et al., 2015), compared to 0.2% of the general population (Degenhardt et al., 2014). While the current surge in opioid overdose rates is mainly driven by synthetic opioids, the misuse of prescription opioids remains a major risk factor for later heroin use (Jones, 2013). In light of the risks associated with prescription opioid misuse, clinical practice guidelines stress the importance of non-opioid treatments for chronic pain (Dowell et al., 2016). As such, cannabis and cannabinoid products have been increasingly recommended to patients by their providers for chronic pain management (Boehnke et al., 2019). Recent evidence suggests that these systematic recommendations may result in co-use patterns among patients whereby they either substitute some portion of their opioid use with medical cannabis or use both concomitantly.
medication with cannabis or replace the opioid medication completely (Boehne et al., 2016; Corroon et al., 2017; May et al., 2018).

Intensive longitudinal studies are needed to examine co-use of these two substances, opioid medication and medical cannabis, and their effects on pain (Nugent et al., 2018). Existing cross-sectional studies have not had the level of sensitivity needed to evaluate patterns of co-use, including product switching and substitution, and associations with pain symptoms. Moreover, cross-sectional surveys do not elucidate the time-course of opioid medication and medical cannabis use on a day-by-day level, or the trajectories from opioid use to co-use of both substances.

Ecological Momentary Assessment (EMA) is a data collection method that repeatedly captures brief self-reported behavioral, cognitive, affective, and functional states in close-to-real-time. EMA is ideally suited for collecting fine-grained data on medication use frequency and pain-related symptoms, as it has low recall bias and high ecological, or real-world, validity (Shiffman, 2009; Shiffman et al., 2008). By capturing routine behaviors, emotions, and cognitions in close-to-real-time, EMA overcomes the influences of memory degradation and heuristic biases that commonly confound retrospective surveys (Coughlin, 1990; Shiffman, 2009; Stone and Broderick, 2007). Findings from an EMA study focusing on patterns of co-use would strengthen existing results by providing naturalistic evidence for or against the potential opioid-sparing effect of cannabis on a daily basis. Such a study could also help determine sociodemographic characteristics and co-use trajectories that are associated with likelihood of transitioning from opioid medication to medical cannabis.

EMA studies typically involve participants receiving multiple short surveys per day, generating the potential for high participant burden and resulting non-response and dropout, and it is important to understand study compliance in detail (Stone and Shiffman, 2002). An EMA study’s compliance, or survey completion rates, indicates the study’s ability to capture representative information from participants (Sokolovskiy et al., 2014; Wen et al., 2017). Previous reviews and meta-analyses have shown completion rates of 85–86% for chronic pain-focused EMA studies (May et al., 2018; Ono et al., 2019). The effect of pain intensity on compliance is unclear, given that higher pain may cause individuals to be distracted and miss prompts or could motivate participation in support of pain research (Ono et al., 2019). Compliance in reporting on substance use behaviors in EMA studies has been more variable (Shiffman, 2009), with a recent meta-analysis demonstrating a lower compliance of 75% (Jones et al., 2019). Poly-use of recreational substances may also be associated with low compliance, reflecting heightened impairment causing individuals to miss or disregard survey prompts (Messiah et al., 2011). To our knowledge, compliance with an EMA methodology that is focused on opioid medication and medical cannabis co-use, and in the context of persons who have chronic pain, has not been examined.

To address this open question in the existing literature, the current study examines the feasibility and acceptability of conducting an intensive longitudinal study using a 30-day smartphone-based EMA approach to investigate the relationship between prescription opioid medication use, medical cannabis use, and chronic pain.

2. Methods

2.1. Study overview

The current study included online surveys, smartphone-based EMA data collection, and qualitative interviews to investigate prescription opioid medication and medical cannabis use in relation to chronic pain.

2.2. Participants

Study investigators recruited participants from December 2019 to June 2020 from 11 states (Alaska, California, Colorado, Illinois, Maine, Massachusetts, Michigan, Nevada, Oregon, Vermont, and Washington) and Washington D.C., which all had legalized recreational cannabis use at the time of recruitment. Recruitment occurred through targeted Facebook and Instagram ads and through the Colorado-based Realm of Caring Foundation focused on medical cannabis, who shared recruitment information on social media. Ads contained a link that directed interested individuals to more information about the study, the eligibility questionnaire, and the online informed consent form. Individuals were deemed eligible based on the following self-reported criteria: were at least 18 years of age, had a prescription for opioid medication for pain symptoms, used opioid medication in the past 30 days, received a recommendation for or started using medical cannabis in the past 30 days, had a pain disorder, reported pain as at least a 3 on a scale of 0 to 10 on at least 10 days of each month for the past 3 months or longer, had an iPhone or Android smartphone, and currently lived in a state with legalized recreational cannabis use. Individuals who reported having a severe mental illness such as schizophrenia, psychosis, or dementia were excluded from the study.

2.3. Procedures

After screening into the study and consenting to participate, eligible participants were required to send study staff a picture of a valid identification (e.g., driver’s license) to validate their age, identity, and place of residence. Enrolled participants completed a baseline survey hosted by Qualtrics to report demographic characteristics, substance use history and current behavior, and pain. Participants were also asked to identify any long-acting and/or short-acting oral and non-oral opioid medication(s) they had used in the past 30 days. They were similarly asked to select from a list all medical cannabis products (flowers, oil, concentrates, edibles, topical, prescription medications) that they used in the past 30 days.

After completing the baseline survey, participants moved to the EMA phase of the study, which was conducted using the PiLR EMA study app, developed by MEI Research Ltd., on their personal smartphones. Before they began responding to surveys, participants engaged in a three-day demo period during which they received training from study staff on how to use the app and then had multiple days to practice using the app by answering sample questions. Participants received an email containing written instructions on how to install and use the study app and information on survey timing, frequency, and incentives. During the demo period, study staff conducted follow-up telephone calls to answer questions and confirm that participants understood how to use the app. Sample questions for the demo period were replicas of the questions asked on the actual past-hour surveys.

After the demo period, participants began the 30-day EMA phase where they responded to prompted surveys about opioid use, cannabis use, and pain symptoms. On each of the 30 days, participants were prompted to complete five surveys, four of which were prompted at random times between 8 am and 11 pm of their device’s local time, pertained to the past hour, and had a 1-h time window to complete. The 1-h time interval for the randomly prompted surveys was selected to maximize the probability of observing situations in which opioid medications and cannabis products were used by participants, while limiting the recall window for time-coverage in a way that would minimize participant recall bias. In absence of gold standards for time coverage in EMA studies, the 1-h time interval for coverage was selected after deliberation among research team members and should be treated as an ad-hoc decision for this particular study. The fifth survey was a daily diary that was prompted between 10 am and 11 am, pertained to the entire previous day, and had a 12-h time window for completion.

For each individual participant, EMA surveys were pre-populated with the prescription opioid medication(s) and medical cannabis product(s) the participant had reported currently using in the baseline survey. The number of survey items in each survey ranged based on the number of prescription opioid medication(s) and medical cannabis
Fig. 1. Participant flow through phases of study using smartphone-based EMA

*Includes individuals who declined consent ($n = 1$) and who did not answer consent questions correctly after three attempts ($n = 58$).
product(s) reported at baseline and was affected by skip patterns (e.g., questions about quantity and pain relief were only asked if the participant reported using any medication or cannabis product). The total range was 11 to 29 items in the daily diary survey and 19 to 30 items in the past-hour survey. Each EMA survey took a maximum of two minutes to complete, for an expected maximum time commitment of no more than 10 min per day to complete all five prompted surveys.

During the EMA phase, study staff sent participants SMS text message check-ins about their current compliance rate at Days 3, 4, 14, and 21 and communicated via email and text message if participants had questions or comments. The study team monitored participant EMA survey activity and conducted regular check-ins to understand and troubleshoot issues and work with the survey app programming team to address technical problems on the backend.

After completing the EMA phase, participants completed a follow-up Qualtrics survey about past 30-day substance use, pain, quality of life (“The World Health Organization Quality of Life Assessment (WHO-QOL: development and general psychometric properties”, 1998), sleep (Bastien et al., 2001), and functioning (Feragno et al., 1983; Rodriguez et al., 2012). Finally, qualitative telephone interviews were conducted with a subset of participants (n = 10) to explore experiences with the study. The subset of participants included individuals who marked “yes” on the screening form for being willing to participate in the follow-up telephone interview and finished the full EMA data collection period.

Topics covered in the interviews included overall experience in the study; experiences with tracking and reporting prescription opioid use, medical cannabis use, and pain levels; and experiences interfacing with the smartphone app and surveys. Participants each received $2 for each day they completed at least one survey, for a maximum possible $60, and an additional $60 was given if they completed multiple surveys per day and reached a completion rate of at least 75%. Participation in the qualitative interview was incentivized with an additional $25. Incentives were provided in the form of electronic gift cards, which were emailed to participants at the end of their participation in the study.

2.4. Measures

Outcomes were related to study feasibility and acceptability. Overall study feasibility was measured by examining the prevalence of the study sample moving through subsequent study phases. For feasibility related specifically to the EMA surveys, participation and compliance were assessed. Participation was characterized by the number of past-hour surveys and daily diary surveys completed, and the number of days on which surveys were completed. Compliance was characterized by survey response rates and early dropout prior to the end of the 30 days. In particular, compliance outcomes included the proportion of surveys completed, response to all 30 days of surveys (n = 0, yes = 1), and completion thresholds (90% for daily diaries and 75% for hourly surveys; no = 0, yes = 1), all assessed at the participant level. Dropout was operationalized as non-response to all prompted surveys on a given day and no subsequent response thereafter through Day 30. Acceptability of the study design was also examined from the participants’ perspective according to their responses from the qualitative telephone interviews at follow-up. Responses of interest focused on lessons learned about methodology, implementation, and participant experience.

Participant characteristics were measured at baseline and included: sex (male = 0, female = 1); age (younger than 40 years = 0, 40 years or older = 1); race (Non-Hispanic White = 0, Other = 1); education (less than college degree = 0, college degree or higher = 1); any past three-month illicit drug use at baseline (n = 0, yes = 1); maximum frequency of past three-month illicit drug use at baseline (daily or almost daily vs not daily); any alcohol use in a typical week (n = 0, yes = 1); number of days of opioid medication use in the past 30 days; number of days of medical cannabis use in the past 30 days; average, least, and worst pain in the past 30 days (rated 0 to 10); and Graded Chronic Pain Scale category (Grade I: low disability-low intensity, II: low disability-high intensity, III: high disability-moderately limiting, IV: high disability-severely limiting) (Von Korff et al., 1992).

Study process-related characteristics included what type of smartphone operating system (OS) the participant used to complete the EMA surveys (Android = 0, iPhone = 1) and whether the participant experienced a problem with receiving notifications for prompted surveys at any point during the EMA phase (n = 0, yes = 1).

2.5. Statistical analysis

Analyses were both quantitative and qualitative. Study investigators examined descriptive characteristics of the study sample, overall feasibility, and EMA participation and compliance. Univariate linear and logistic regression models were also used to examine whether baseline participant characteristics and study process-related characteristics were related to EMA compliance. Study investigators also extracted themed responses from the qualitative interviews to understand participants’ acceptability of the study design and overall experience with the study. In this process, one member of the study team read the interview transcripts in their entirety and extracted and coded emerging themes in Dedoose, with a second member of the team then reviewing and revising all transcripts and codes for completeness. Codes addressed pre-determined themes based on sets of interview questions and included the following: overall participant experience in the study; experiences with tracking and reporting prescription opioid use, medical cannabis use, and pain levels; and participant experiences of using the smartphone app and completing surveys.

3. Results

The study sample consisted of 46 participants who were majority female (78%; n = 36). On average, they were 45 years of age (m = 44.8; SD = 12.9), and most were non-Hispanic White (85%; n = 39). Slightly more than half had a two- or four-year college degree or beyond (59%; n = 27). For past three-month illicit drug use at baseline, two participants reported any use, with both reporting use of sedatives daily or almost daily. Given this low prevalence, illicit drug use was not examined in relation to the outcomes. Approximately one-fifth of participants (22%; n = 10) reported drinking any alcohol during a typical week. Participants used opioid medications an average of 19.6 days (SD = 11.1) in the past 30 days, with 48% (n = 22) reporting use on all 30 days, and used medical cannabis an average of 23.1 days (SD = 9.4), with 57% (n = 26) reporting use on all 30 days. Average pain score in the past 30 days was 6.0 (SD = 1.2) on a scale of 0 to 10, with the average score for worst pain being 8.6 (SD = 1.3) and average score for least pain being 3.6 (SD = 1.8). Over half of participants (57%; n = 26) reported pain that was Grade IV (high disability-severely limiting), with 30% (n = 14) reporting Grade III pain and 13% (n = 6) reporting Grade I or II pain. Grades I through III were combined in the analyses to examine the association between the most severe pain and the outcomes.

For smartphone type, 52% (n = 24) of participants used an iPhone to complete their EMA surveys, and 48% (n = 22) used an Android. Nineteen participants (41%) reported experiencing some level of notification issues during their EMA phase. Notification problems were associated with either participants not having notifications turned on for the EMA app or temporary issues with backend programming of the survey app and notifications.

3.1. Overall study feasibility

The participant flow through the study phases is shown in Fig. 1. A total of 115 participants were eligible for the study, and of those, 55% (n = 63) submitted their identification and were then verified for study enrollment. Over three-quarters (83%; n = 52) of enrolled participants completed the baseline survey. Approximately 88% (n = 46) of those who completed the baseline survey participated in the entire 30-day...
3.2. EMA assessments

Overall, 5142 observations were reported, of which 1268 were daily diaries and 3874 were past-hour surveys (Table 1). The mean number of past-hour completed surveys per person was 84.2 (SD = 28.7; range: 13–116), out of a maximum possible 120 prompted surveys (70% overall compliance). Approximately half of participants (54%; N = 25) completed at least one past-hour survey on each of the 30 days, and on days when there was at least one survey completed, approximately three surveys were completed (m = 3.1; SD = 1.0), out of a maximum of four. The mean number of daily diaries was 27.6 (SD = 3.9; range: 11–30) out of a maximum possible 30 (92% overall compliance), and 50% (N = 23) of participants completed daily diaries on all 30 days. Over 70% (72%; N = 33) of participants completed at least 90% of their prompted daily diaries, and over half (59%; N = 27) of participants completed at least 75% of their prompted hourly surveys.

3.3. Associations with compliance

Associations between participant and study characteristics and compliance outcomes are included in Table 2. Participants who had higher average pain for the past 30 days at baseline completed marginally fewer daily diary surveys (b = −0.03, SE = 0.02, p < .10). Female participants were more likely to complete all daily diaries and at least one past-hour survey on all 30 days, respectively (OR = 5.60, 95% CI: 1.02–30.77, p < .05; OR = 7.08, 95% CI: 1.28–39.16, p < .05), and compared to participants with lower grade pain, those with Grade IV pain were marginally more likely to complete all 30 days of daily diaries (OR = 2.97, 95% CI: 0.87–10.12, p < .10). Female participants were also more likely to complete at least 75% of their prompted hourly surveys (OR = 4.67, 95% CI: 1.00–21.69, p < .05), as were those with a college degree or higher (OR = 3.27, 95% CI: 0.94–11.32, p < .10). Neither of the study process-related characteristics was significantly associated with any of the outcomes for either the daily diaries or the past-hour surveys.
participants, who comprised the majority of the study sample, were more likely to have higher compliance with both types of EMA surveys, and those with at least a college degree were marginally more likely to have high compliance with past-hour surveys. Although such analyses conducted within a larger sample size would help confirm the current findings, non-significant relationships between participant demographic and pain-related characteristics and EMA survey completion have also been reflected in a recent meta-analysis on factors that affect EMA completion rates in chronic pain studies (Ono et al., 2019). In the current study, participant characteristics of interest, namely substance use, participants found it difficult to respond to surveys or keep up with compliance based on substance use or pain. Many participants also reported perceived value in the study to help monitor their medical cannabis and opioid medication use, even though the study was not purposely meant to help with this aspect. It is possible that as a result of the pain, and especially more intense and more limiting pain, individuals are more invested in the process of trying to find a remedy and used the study as a cue to action (Rosenstock, 1974) to track and manage their pain and treatment regimen.

Interview feedback also uncovered opportunities for improvement for future EMA studies focused on individuals with chronic pain. Future work might focus on the timing of EMA survey prompts since participants might find it difficult to respond when surveys are prompted outside of their normal waking hours. Participants expressed the need for maintaining sleep schedules when possible, especially since pain frequently interfered with sleep quality. Participants also spoke about their difficulty rating subjective pain, especially if there were multiple bodily areas with differing pain levels. Although patients were extensively trained on the use of the EMA software application, we did not provide targeted training on how to make pain ratings, a practice that has been shown to enhance the precision of pain assessment (Gewandter et al., 2020; Treister et al., 2018). Future studies should incorporate specific training on how to make pain ratings repeatedly in the context of an EMA assessment schedule. Finally, interviews uncovered participants’ problems with reporting types and amounts of cannabis use. Given the evolving landscape of the cannabis product market (Luc et al., 2020; Spindle et al., 2019) and evidenced by feedback that some

### Table 2
Univariate associations of participants and study characteristics with survey compliance.

| Baseline characteristics | Daily diaries | Past-hour surveys |
|--------------------------|--------------|------------------|
|                          | Proportion of surveys OR (95% CI) | Responded to all 30 days OR (95% CI) | Responded to 90% of surveys OR (95% CI) | Proportion of surveys OR (95% CI) | Responded to all 30 days OR (95% CI) | Responded to 75% of surveys OR (95% CI) |
| **Gender**               |              |                  |                                          |
| Male                     |               |                  |                                          |
| Female                   | 0.02 (0.05)  | 5.60 (1.02-30.77) | 2.00 (0.45-8.87) | 0.11 (0.08)  | 7.08 (1.28-39.16) | 4.67 (1.00-21.69) |
| Age                      |              |                  |                                          |
| Younger than 40 years    |               |                  |                                          |
| 40 years or older        | 0.04 (0.05)  | 1.85 (0.38-9.03)  | 1.22 (0.21-7.15) | 0.13 (0.09)  | 3.00 (0.53-17.11) | 6.30 (0.69-57.67) |
| Race                     | Non-Hisp White | 0.06 (0.05)  | 2.92 (0.49-17.22) | 2.67 (0.28-25.25) | 0.12 (0.10)  | 6.32 (0.68-58.89) | 5.14 (0.55-47.97) |
| Other                    |              |                  |                                          |
| Education                | Less than college degree | –0.02 (0.04) | 2.49 (0.74-8.45)  | 0.85 (0.22-3.20) | 0.04 (0.07)  | 2.34 (0.69-7.86) | 3.27 (0.94-11.32) |
| College degree or higher | –0.02 (0.04) | 2.49 (0.74-8.45)  | 0.85 (0.22-3.20) | 0.04 (0.07)  | 2.34 (0.69-7.86) | 3.27 (0.94-11.32) |
| Any alcohol use in a typical week |               |                  |                                          |
| No                       | 0.04 (0.05)  | 1.68 (0.40-7.08)  | 1.76 (0.31-9.86) | 0.05 (0.09)  | 1.34 (0.32-5.67) | 0.38 (0.09-1.61) |
| Yes                      |               |                  |                                          |
| Number of opioid medication use days* | 0.000 (0.002) | 1.04 (0.99-1.10) | 1.01 (0.95-1.07) | 0.002 (0.003) | 1.03 (0.98-1.09) | 1.04 (0.99-1.10) |
| Number of cannabis use days | 0.001 (0.002) | 1.03 (0.96-1.10) | 1.05 (0.98-1.12) | –0.001 (0.004) | 1.03 (0.96-1.10) | 0.97 (0.91-1.04) |
| Average pain†            | –0.03 (0.02)  | 1.30 (0.79-2.16)  | 0.68 (0.38-1.22) | –0.05 (0.03)  | 0.88 (0.53-1.47) | 0.71 (0.41-1.24) |
| Least pain†              | –0.002 (0.01) | 1.14 (0.83-1.57)  | 0.88 (0.64-1.20) | –0.01 (0.02)  | 0.93 (0.66-1.31) | 1.03 (0.75-1.44) |
| Worst pain†              | –0.02 (0.02)  | 1.13 (0.70-1.84)  | 0.82 (0.51-1.31) | –0.04 (0.03)  | 0.95 (0.59-1.52) | 0.74 (0.45-1.20) |
| Graded Chronic Pain Scale | Grade I - III Ref | Ref | Ref | Ref | 1.16 (0.32-4.29) | –0.02 (0.07) | 1.36 (0.42-4.46) | 1.89 (0.57-6.30) |
|                          | Grade IV      | 0.001 (0.04)     | 2.97 (0.87-10.12) | 1.16 (0.32-4.29) | –0.02 (0.07) | 1.36 (0.42-4.46) | 1.89 (0.57-6.30) |
| Study process-related characteristics |               |                  |                                          |
| Smartphone type          | Android       | Ref              | Ref | Ref | Ref | Ref | Ref |
|                          | iPhone        | –0.04 (0.04)    | 1.00 (0.31-3.22) | 0.91 (0.25-3.34) | –0.03 (0.07) | 0.48 (0.15-1.60) | 0.97 (0.30-3.18) |
| Notification issues      | No            | Ref              | Ref | Ref | Ref | Ref | Ref |
|                          | Yes           | 0.02 (0.04)     | 0.84 (0.25-2.74) | 1.18 (0.31-4.45) | –0.001 (0.07) | 0.89 (0.27-2.92) | 0.95 (0.28-3.15) |

SE = standard error; OR = odds ratio; CI = confidence interval.

* p < .05.
† p < .10.
‡ p < .01.
§ Past 30 days.
participants had added or removed products based on what worked best for their specific pain, future work should include questions that are flexible in allowing reporting on changing cannabis regimens.

A substantial subset of 41% of participants reported experiencing some level of notification issues during their EMA phase in the current study. Since our study relied on participants’ own phones (“bring your own device” or “BYOD”), this design decision could have impacted these notification issues and consequently compliance with EMA surveys. While our analyses controlled for OS type and notification issues, and found that these predictors were not significant, EMA researchers nonetheless should be aware that relying on BYOD designs could increase technical difficulties compared to studies in which participants receive dedicated study phones. On the other hand, potential advantages of BYOD studies include that researchers do not have to purchase devices and the fact that participants are already familiar with their own device and do not need to manage an additional device (e.g., keeping it charged and carrying them on) for the duration of the study. Pros and cons of either approach should be carefully weighed by EMA researchers before committing to a study design.

One key limitation of the results is they are derived from a small sample, which may have limited power. Future work will be needed to replicate findings in a larger sample to confirm the absence of associations between key participant characteristics and compliance outcomes. Future work may also explore the associations between within-person parameters, such as changes in pain, and likelihood of survey response. Moreover, our sample was predominantly female and non-Hispanic White, and future efforts to increase diversity among study participants are needed. An additional limitation was the self-report nature of inclusion criteria for the study, which could have been susceptible to participants being untruthful about their substance use and/or chronic pain diagnosis. A substantial number of participants did not confirm their identity in order to be included in the study. This may have been due to potentially fraudulent responses of individuals trying to enroll in the study for the monetary incentives but could also highlight discomfort with disclosing identity information in the context of a study on substance use and chronic health conditions. Balancing participant confidentiality and data quality safeguards are an ongoing challenge for online studies. Finally, the potential impact of participant training on EMA compliance was not systematically investigated in the current study and future research is needed to explore this research question.

EMA methodology allowed us to conduct this pilot study completely remotely, facilitating access to participants on a nationwide scale. Our results demonstrate both feasibility and acceptability of using such methodology to examine use patterns of medical cannabis and prescription opioid medication among individuals with chronic pain. Results from this work pave the way for larger-scale epidemiologic studies, opportunities to conduct intervention work, and expansion of assessment to capture increasing geographic representation by participants as recreational and medical cannabis laws continue to evolve.

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Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: PHF is on the advisory board for Ninnion Therapeutics. RV has received consulting fees and honoraria for service on the scientific advisory board for the following companies within the past 12 months: Canopy Growth Corporation, MyMD Pharmaceuticals Inc., Syqe Medical Ltd. KED has no conflicts of interest related to this project. In the past 3 years, she has been paid as a consultant for Grüntenthal, Inc. and MindMed; received honoraria for advisory board work for Canopy Corporation and Beckley-Canopy; served as a paid expert witness for the Baltimore District Attorney; served as an unpaid advisor to Peabody Corporation; and received research and salary support from the National Institutes on Drug Abuse and the Ashley Addiction Treatment Center.

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