2019

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Alexis Kuerbis

M. Carrington Reid
*Weill Cornell Medical College*

Jordan Lake
*University of California, Los Angeles*

Suzanne Glasner-Edwards
*University of California, Los Angeles*

Jessica Jenkins
*University of California, Los Angeles*

*See next page for additional authors*

HHS Public Access

Author manuscript

*Alcohol*. Author manuscript; available in PMC 2020 June 01.

Published in final edited form as:

*Alcohol*. 2019 June ; 77: 31–39. doi:10.1016/j.alcohol.2018.10.003.

# Daily Factors Driving Daily Substance Use and Chronic Pain among Older Adults with HIV: An Exploratory Study Using Ecological Momentary Assessment

**Alexis Kuerbis, LCSW, PhD**[1], **M. Carrington Reid, MD, PhD**[2], **Jordan E. Lake, MD, MSc**[3], **Suzette Glasner-Edwards, PhD**[4], **Jessica Jenkins, MS**[5], **Diana Liao, MPH**[6], **Jury Candelario**[7], and **Alison A. Moore, MD, MPH**[6]

[1] Silberman School of Social Work, Hunter College at City University of New York, 2180 Third Avenue, New York, NY 10035, United States, ak1465@hunter.cuny.edu

[2] Joan and Sanford I. Weill Department of Medicine, Weill Cornell Medicine, New York, NY

[3] Division of Infectious Diseases, University of California, Los Angeles, CA

[4] Integrated Substance Abuse Programs, Department of Psychiatry and Biobehavioral Sciences; School of Nursing, University of California, Los Angeles, CA

[5] Department of Psychiatry and Human Behavior, Charles R. Drew University of Medicine and Science, Los Angeles, CA; Department of Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine at UCLA, Los Angeles, CA

[6] Division of Geriatrics, Department of Medicine, University of California, Los Angeles, Los Angeles, CA

[7] APAIT, A Division of Special Services for Groups, Los Angeles, CA

## Abstract

**Background:** Adults 50 and older make up approximately 50% of persons living with HIV. Multiple co-morbidities are common among this group, including chronic pain and substance abuse, yet little is known about the daily factors that either enhance or inhibit these experiences or behaviors. This study explored daily drivers of substance use, pain, and relief from pain among older adults living with HIV utilizing ecological momentary assessment (EMA).

**Method:** Participants (N=55), ages 49–71, completed seven consecutive days of daily EMA online surveys prior to treatment initiation within a randomized controlled trial. Multilevel

**Corresponding Author:** Alexis Kuerbis, Silberman School of Social Work, Hunter College at the City University of New York, 2180 Third Avenue, New York, NY 10035. Telephone: 917-301-7903, ak1465@hunter.cuny.edu.
*J. Lake is now at the McGovern School of Medicine at the University of Texas Health Sciences Center, Houston, TX; J. Jenkins is now at the Department of Psychology, University of California, Los Angeles, CA; A. Moore is now at the Division of Geriatrics, Departments of Medicine and Psychiatry, University of California, San Diego, La Jolla, CA;

modeling tested predictors of pain, substance use, and relief from pain by examining within- and between-person relationships.

**Results:** Results revealed an associational, reciprocal relationship between daily worst pain and daily drinking, where greater worst pain ratings predicted heavier drinking and heavier drinking predicted greater daily and overall pain. Greater happiness and poorer quality of sleep predicted greater daily worst pain. Exercising and overall confidence to cope with pain without medication were associated with lower levels of daily worst pain. Finally, spending less time with a loved one over time and reporting any coping behavior were associated with relief from pain.

**Conclusion:** Investigation of daily factors that drive pain and substance use behaviors among this unique population help inform which daily factors are most risky to their health and well-being. Alcohol use emerged as the only substance associated with both driving pain and responding to pain. Findings suggest key points for prevention and intervention.

### Keywords

older adults; ecological momentary assessment; HIV; chronic pain; substance use; alcohol use

## 1 Introduction

Due to an increasing incidence of new cases and advances in medicine, people living with HIV over the age of 50 constitute a rapidly expanding group (Sangarlangkarn & Appelabaum, 2016). Of all current cases of HIV in the US, over 50% are persons 50 and older. Older adults living with HIV often present with unique complications due to high rates of multi-morbidity (Rodriguez-Penney et al., 2013; Sangarlangkarn & Appelabaum, 2016), including chronic pain and substance use (Edelman, Tetrault, & Fiellin, 2014; Jiao et al., 2016; Lum & Bruce, 2016; Parsons, Starks, Millar, Boonrai, & Marcotte, 2014). Such multi-morbidity results in, at a minimum, poor health outcomes and high health care utilization (DeLorenze, Tsai, Horberg, & Quesenberry, 2014; Jiao et al., 2016; Parsons et al., 2014). Thus, to improve health outcomes and potentially reduce need for costly intensive services, research is needed to elucidate potential targets for both prevention and treatment by understanding the interaction of these multi-morbidities on a daily level.

### 1.1 Chronic Pain, Substance Use and Older Adults with HIV

Empirical research on substance abuse, pain, HIV and aging typically occurs in silos, while research that examines the intersection of these factors is limited. Within the literature on HIV, higher levels of illicit drug use have been consistently observed among individuals with (versus those without) HIV (Green et al., 2010). While in the general population, drug and alcohol use tend to decrease as individuals age, these trends are less common for aging individuals with HIV (Skalski, Sikkema, Heckman, & Meade, 2013). This is particularly problematic given that medication non-adherence, including medications critical for treating HIV, is associated with substance use both across the life span, as well as specifically among those in later life (Parsons et al., 2014). Interestingly, many of these studies do not measure pain or consider it in their analytic approach.

A relationship between pain and substance use among individuals living with HIV is well-established (Uebelacker et al., 2015), yet this relationship has yet to be fully explored among individuals later in life when presumably the intersection of these factors may have increasingly dire consequences for health and well-being. In addition, evidence suggests that both psychic pain (e.g., anxiety, grief, depressed mood) and physical pain are critical to understanding substance use, well-being, and best practices for prevention and treatment among individuals living with HIV (Merlin et al., 2014).

Chronic pain, substance use, and the psychosocial/physical factors that drive both conditions on a daily basis have been underexplored among older adults. Two primary theories used to explain substance use in this population are the stress-coping model (Brennan, Schutte, & Moos, 2005; Sinha, 2001) and the self-medication model of substance abuse (Khantzian, 1999), in which pain and/or stress drives individuals to use substances to cope and/or self-medicate. Interestingly, these hypotheses have yet to be directly tested among older people living with HIV. Understanding potentially unique aspects of the intersection of pain, substance use, and psychosocial/physical factors in this population could provide critical information for heat of the moment interventions to prevent unnecessary health deterioration, reduce harm, and increase health and well-being.

### 1.2 Use of Ecological Momentary Assessment with Middle-aged and Older Adults

One way to understand daily relationships between pain and substance use and factors associated with both over time is through ecological momentary assessment (EMA). EMA is defined as “repeated collection of real-time data on subjects’ behavior and experience in their natural environment” (Shiffman, Stone, & Hufford, 2008, p. 3). In EMA, constructs are assessed daily (or more frequently), providing data with reduced recall bias, and it includes methods such as daily diary assessments. EMA has been used widely in empirical studies on pain (May, Junghaenel, Ono, Stone, & Schneider, 2018), many of which include older adults. While studies using EMA to assess alcohol use among older adults exist (e.g., Kuerbis et al., 2018; Sacco et al., 2015), EMA is not widely used among this population in relation to alcohol and other substance use.

To our knowledge, only one published study used EMA to examine pain and substance use among older adults with and without HIV (Paolillo et al., 2017). Importantly, this study demonstrated convergent validity of substance use reports, as well as the feasibility of using EMA across different health and mental health conditions among older adults; however, the small number of participants reporting living with HIV ($n = 22$) in this study limit its generalizability to people living with HIV. This investigation demonstrated that both mood and pain predicted subsequent substance use among this group, supporting the stress-coping and self-medication models of addiction. Unfortunately, the reciprocal relationship between pain and substance use, nor the impact of daily factors (e.g., exercise, spending time with a loved one) that are known to impact experience of pain, were not explored. Thus, much remains unknown about the dynamic patterns of pain and substance use among older adults with HIV.

### 1.3 The Current Study

As part of a pilot investigation testing the preliminary effects of a combined cognitive-behavioral therapy, tai chi, and motivational text messaging intervention to simultaneously reduce chronic pain and substance use for older adults with HIV, this study used pre-treatment data from seven consecutive days of daily diary assessment (DDA) to explore the intersection of psychosocial factors, physical factors, pain, and substance use on a daily basis. We specifically sought to assess: 1) whether daily rating of pain predicted use of alcohol, marijuana, and other substances; 2) which daily factors were associated with rating of daily worst pain; and 3) which daily factors were associated with reported relief from pain.

## 2 Method

Data were collected during the week prior to treatment initiation in a pilot randomized controlled trial with older adults with HIV and chronic pain who screened positive for at risk substance use. All procedures were approved by the Institutional Review Board at the University of California at Los Angeles. Detailed procedures of the pilot study are reviewed elsewhere (Moore et al., under review).

### 2.1 Participants

Participants (N=55) were recruited from a community-based agency in Southern California serving individuals living with HIV. After screening, eligible participants were enrolled in the study.

**2.1.1. Inclusion criteria.—**Inclusion criteria were: 1) age ≥50 years (3 persons were inadvertently enrolled who were aged 49 at the time of study entry); 2) able to read and understand English; 3) HIV+; 4) self-reported pain of ≥3 months duration on most days (not due to an active malignancy); 5) at-risk substance use, e.g., consuming ≥5 drinks on more than one occasion in the past three months and/or use of any substances (e.g., cocaine, amphetamine/methamphetamine, marijuana, opiates/heroin) ≥1 weekly, without a prescription or more than prescribed, in the past three months (National Institute on Alcohol Abuse and Alcoholism, 2013; National Institute on Drug Abuse, 2012); 6) self-reported ability to participate in a low intensity exercise program; 7) owned a phone with internet access and text message capability; and 8) not currently enrolled in substance abuse treatment.

### 2.2 Procedures

After providing written consent, participants completed a series of global self-report assessments. Participants were informed of their condition assignment (cognitive behavioral therapy + Tai Chi + motivational text messaging (CBT+TC+TXT), Support Group (SG), or Assessment Only (AO)) at the end of this assessment visit and trained on DDA. No data from the treatment period are included in the present analysis.

**2.2.1 Daily diary assessment (DDA) procedures.—**Participants were asked to complete a once daily online survey for all seven days prior to treatment initiation. Each day,

participants received a text message prompt to complete the survey. Participants who did not have a smartphone with reliable internet access were instructed to use a computer to complete the survey. Participants chose the specific timing of the prompts to align with their schedules for optimal response rates. A majority of participants (68.6%) elected to complete the survey in the evening, with 21.6% and 9.8% completing the surveys in the morning and afternoon, respectively. Surveys were completed in about 5 to 10 minutes. Participants were compensated $1 for each day they completed the survey and given a $3 bonus for completing all seven days.

## 2.3 Measures

**2.3.1. Sociodemographics.—**Age, gender, educational and occupational information, race and ethnicity were collected via a self-report demographic questionnaire.

**2.3.2 Daily-level assessments.—**Primary predictors and outcome variables were assessed via the daily online surveys.

**2.3.2.1 Pain.:** Pain was assessed using two items. *Any pain in the last 24 hours* was assessed by asking “In the past 24 hours, did you experience any pain?” The response set was dichotomous, with 1 “yes” and 0 “no. If the participant responded no, they skipped the questions about coping with pain and relief from pain in the past 24 hours. Participants who answered “yes” were asked to “rate the pain they experienced at its WORST in the last 24 hours” (*worst pain*). The response set on these items ranged from 0 “no pain at all” to 10 “Pain as bad as you can imagine.” These questions were taken from the Brief Pain Inventory (BPI) (Cleeland & Ryan, 1994).

**2.3.2.2 Alcohol and substance use.:** Four items assessed participants’ substance use. One item asked participants to report how many standard drinks they had consumed in the last 24 hours. Another asked whether the participant had used marijuana in any form in the last 24 hours, with a response set consisting of 0 “no”, 1 “Yes, I smoked or vaped marijuana”, 2 “Yes, I ate something with marijuana in it”, and 3 “Yes, I both smoked and ate marijuana”. The third item asked “In the last 24 hours, have you taken any pain medications that were NOT prescribed to you (such as Percocet, oxycodone, codeine, hydrocodone, etc.)?” Response items included 0 “No”, 1 “Yes, I took them for pain”, 2 “Yes, I took them for fun/recreation”, and 3 “Yes, I took them for both pain and fun/recreation”. The fourth item asked “In the last 24 hours, have you taken any mood altering substance, such as a benzodiazepine (e.g., Xanax, Ativan, Valium), heroin, methamphetamine, cocaine, or K2 (or Spice)?” The response set was identical to the above item on pain medication. Due to the few days in which an opioid pain medication or other drugs were reported, these two variables were combined to create a binary other drug outcome variable.

**2.3.2.3 Coping with Pain.:** Also adapted from the BPI, one item asked, “When you were feeling pain at its WORST in the past 24 hours, which of the following did you do in response?” Participants could choose from a set of 10 responses and provide their own. Participants could also select more than one. Responses included options such as “Nothing”, “Took an over the counter medication”, “Took a medication prescribed by your doctor,”

"Took a medication NOT prescribed by your doctor", and "Performed a deep relaxation exercise."

**2.3.2.4 Relief from pain.:** Another item taken from the BPI asked "How much relief did doing the [coping activity/activities] provide?" The response set ranged from 0% "No relief" to 100% "Complete relief."

**2.3.2.5 Mood and emotional state.:** Several items were used to assess overall mood and emotional state. Each item asked the extent to which participants felt a certain way over the last 24 hours, with the response set ranging on these items from 0 "Not at all" to 10 "Extremely." The constructs measured were stress, boredom, anger, loneliness, sadness, happiness, agitation, and calmness. These items were used in previous studies and their predictive validity is established (Armeli, Feinn, Tennen, & Kranzler, 2006; Kuerbis et al., 2018; Morgenstern et al., 2016).

**2.3.2.6 Sleep quality.:** One item adapted from the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) asked participants to "rate your sleep quality last night overall." The response set for this item ranged from 0 "No sleep or extremely poor quality" to 10 "Best, most restful sleep."

**2.3.2.7 Exercise.:** One dichotomous item asked participants "In the last 24 hours, outside of what you may have received in this study, did you do any form of exercise (e.g., go for walk, lift weights, tai chi)?" Response set was yes or no.

**2.3.2.8 Time with loved one.:** One dichotomous item asked participants "Did you spend time with someone you cared about in the 24 hours?"

**2.3.2.9 Pain-related fear.:** Two items adapted from the Tampa Scale for Kinesiophobia (Kori, Miller, & Todd, 1990) and the Pain Catastrophizing Scale (Sullivan, Bishop, & Pivik, 1995; Vlaeyen, de Jong, Geilen, Heuts, & van Breukelen, 2001) comprised a short scale to measure pain-related fear. Items included "When I feel pain, I sometimes think something dreadful will happen" and "When I'm in pain, I keep thinking about how badly I want the pain to stop." The response set for each ranged from 0 "Totally disagree" to 10 "Totally agree." These items together yielded Cronbach's alpha=.72.

**2.3.2.10 Confidence to cope with pain.:** One item asked "How confident are you that you will be able to cope effectively with any pain you might have today?" The response set on these items ranged from 0 "not at all" to 10 "extremely." This variable was adjusted prospectively for analyses so that it was aligned with the next day's reports of substance use and pain.

**2.3.2.11 Confidence to cope with pain without medication or a mood altering substance.:** One item asked participants "How confident are you that you will be able to cope effectively with any pain you might have today without using a prescribed medication or a mood altering substance?" The response set on these items ranged from 0 "not at all" to

10 “extremely.” This variable was adjusted prospectively for analyses so that it was aligned with the next day’s reports of substance use and pain.

**2.3.2.12 Weekday/weekend.:** A covariate designating whether a particular assessment day was a weekday (0) or weekend (1) was calculated from the date that they survey was completed.

## 2.4 Analytic Plan

Descriptive statistics were generated to explore potential group differences and identify additional covariates. For all of the models, daily ratings of each of the predictors were averaged to create estimates of person-level (level 1, between-person or grand mean) averages and daily-level values were averaged within person (level 2, within-person mean) for each construct. Person-level averages were used as covariates in their respective models to isolate the within-person (i.e., daily) changes in the predictors and their impact on subsequent drinking from the between-person changes (Bolger & Laurenceau, 2013).

For each of the six outcome variables (number of daily drinks, marijuana use, other drug use, *any pain in the last 24 hours*, *worst pain*, and *relief from pain*), multilevel models (MLMs) with daily ratings (level 1) nested within persons (level 2) were estimated. MLMs account for the non-independence of observations due to nesting, are robust to missing data, and can include random terms to model individual variability (Gibbons, Hedeker, & DuToit, 2010; Raudenbush & Bryk, 2002; Singer & Willett, 2003). Models were initially constructed to allow for random intercepts and slopes to account for individual variability or random effects, which provided good model fit only for *worst pain* and *relief from pain*. For number of daily drinks, only intercepts varied randomly across participants. An unstructured variance-covariance matrix was specified for models focusing on these three outcomes, and all MLMs utilized restricted maximum likelihood estimation.

For all of the binary outcome variables (marijuana use, other drug use, and *any pain in the last 24 hours*), random intercepts and slopes did not vary significantly. Therefore models examining these outcomes were constructed using generalized estimating equations (GEE, Liang & Zeger, 1986; Zeger & Liang, 1986). GEE shares similar strengths with MLM, such as its ability to account for correlation of observations in repeated measures designs (Stokes et al., 2000). For these models, a binomial distribution with logit link function was specified with an exchangeable working correlation matrix, which provided good model fit for each of this set of outcome variables (Stokes et al., 2000).

First, age, gender, education, employment, condition, time (count of day of DDA), and a variable indicating whether a day was a weekday or not were tested independently (alone for each outcome) as covariates. All but time and the weekday variable were insignificant ($p > .05$). Both time and weekday were significant and retained as covariates for all the models (Bolger & Laurenceau, 2013). Given the difference in DDA compliance rates across condition, condition was also retained as a covariate.

Next, models tested whether daily pain predicted substance use (alcohol, marijuana use, and other drug use, independently). Then, models independently tested which daily factors

(substance use; coping with pain; level of relief from using coping strategy; overall health; mood; sleep; exercise; time spent with a loved one; and pain-related fear) were associated with rating of daily worst pain. Predictors significant at the $p < .05$ level were put into a final model. Lastly, the same model building procedure was used to test which of the aforementioned factors were independently associated with reported relief from pain. In all models, an interaction term (time X focal predictor) was added to the model to test for changes in focal predictors' impact on outcomes over time (e.g., boredom X time). Where non-significant, interaction terms were removed. All models were tested using SAS 9.4 (SAS Institute Inc., 2002–2012).

# 3 Results

## 3.1 Sample Description and Condition Differences

Table 1 shows basic demographics across condition. Mean age was 55, and a majority of the participants were cisgender male, Black, non-Latino, and reported being unemployed or disabled. A majority had received schooling beyond high school.

Overall, participants reported experiencing at least some pain five or more days (M=5.5, SD=2.7) during the week. Of the days they completed the survey, they reported drinking an average of 41.3% of days, ranging from 0 days to 7 days, and drank less than two drinks (M=1.2, SD=1.9) per day. Participants reported using marijuana three days out of the week (M=2.9, SD=3.4). Other drugs were used about two days (M=1.8, SD=3.1) out of the week. Table 2 shows descriptive statistics for the seven days (pre-treatment) of DDA by group. Individuals in CBT+TC+TXT demonstrated greater DDA compliance and more alcohol use than the other two conditions. In addition, a greater proportion of participants in CBT+TC +TXT reported prescription medication use as a means of coping with pain. Finally, those participants in SG reported a significantly greater proportion of days using marijuana for pain only compared to the other two groups who reported using marijuana for both pain and recreation.

## 3.2 Daily Pain Predicting Daily Substance Use

*Any pain in the last 24 hours* was not a significant predictor of same day substance use (alcohol, marijuana, or other drug use) (Table 3). Daily rating of *worst pain* in the last 24 hours was a significant predictor of only alcohol use (Table 3), such that for every one unit increase in *worst pain* beyond an individual's personal mean, alcohol use increased by a quarter drink.

## 3.3 Daily Predictors of Daily Worst Pain

Table 4 lists the independent predictors of daily *worst pain*. Independent models revealed greater number of daily drinks, less daily happiness, more daily stress, poorer quality sleep, no exercise, and lower confidence to cope with pain without medication as significant independent predictors of daily *worst pain*. These variables were then entered into a final model. Daily stress was rendered insignificant and removed from the final model. Results of the final reduced model (Table 4) revealed more daily and person level number of drinks, less daily happiness but more overall happiness, poorer quality sleep overall, no exercise,

and lower confidence to cope without medication or other substances emerged as significant predictors of daily *worst pain*.

### 3.4 Daily Predictors of Daily Relief from Pain

Table 5 shows the results of the independent and final models for *relief from pain*. Independent models revealed that person level greater quality sleep, spending less time with a loved one across time, decreasing fear of pain across time, and doing anything to cope with pain significantly predicted *relief from pain*. When all of these variables were entered into a final model together, only spending less time with a loved one across time and doing anything to cope with pain were associated with *relief from pain* (Table 5). Figure 1 demonstrates the relationship between relief of pain and time with a loved one across the seven days, revealing that relief from pain is more variable without time spent with a loved one, demonstrating more peaks than valleys, whereas for those with a loved one, relief is more consistent and steady across days.

## 4 Discussion

This study aimed to explore and identify daily factors that predicted substance use, pain presence and level, and degree of pain relief among older adults living with HIV using EMA. Findings revealed that daily alcohol use was associated with daily reports of pain. While temporal order and thus causality cannot be determined, this associational relationship may point to a self-medication model of substance use. Alcohol may also exacerbate pre-existing pain. This correlational relationship is consistent with empirical literature that finds a strong positive association between chronic pain and heavy alcohol use in a general population of older adults (Brennan et al., 2005), and it provides evidence that this association exists on a daily level among older adults living with HIV. Interestingly, there was no relationship between use of other substances and reported pain or pain relief. A previous study that used EMA with substance using older adults with and without HIV found that pain was predictive of substance use earlier in the day (Paolillo et al., 2017); however this was not differentiated by type of substance (e.g., alcohol or drug use).

Worst pain appears to be driven by lower levels of happiness, poorer quality sleep, lack of exercise, and low confidence to cope with pain without medication or another mood altering substance. These findings are consistent with previous studies with other populations that show a relationship between increased pain and negative mood (Merlin et al., 2014), sleep disturbance (Ağargün et al., 1999; Cappelleri et al., 2009), lack of exercise (Dzierzewski et al., 2014; Geneen et al., 2017), and low self-efficacy coping with pain (Jensen, Turner, & Romano, 1991). These findings provide important information about potential avenues for intervention—primarily improving quality of sleep, encouraging exercise, and increasing confidence to cope with pain without medication—all behaviors which can be relatively easily addressed with cognitive behavioral therapy (CBT). Given that CBT is already an empirically supported treatment for both chronic pain and substance use (Lunde, Inger, Nordhus, & Pallesen, 2009; Monti, Kadden, Rohsenow, Cooney, & Abrams, 2002; Rotgers, 2003), these findings provide further support for broadening the use of CBT to target a wider variety of behaviors with this group to reduce both pain and substance use—and to adapt

these interventions to potentially intervene on a daily level, using mobile technology (Kuerbis, Mulliken, Muench, Moore, & Gardner, 2017).

Analyses did not reveal any significant predictors of daily relief from pain, with the exception of doing nothing to cope with pain and spending time with a loved one, both of which reduced rather than increased relief. While results suggest that any method of coping with pain is better than nothing, no one type of coping method emerged as a significant predictor of relief in this sample—suggesting they were a perfect target group for intervention. In contrast to extant empirical literature on pain (Hughes et al., 2014; Roberts, Klatzkin, & Mechlin, 2015), spending more time with a loved one reduced pain relief. This relationship may have emerged due to the variability of relief when participants were without a loved one. Relief experienced with a loved one is more stable—albeit slightly lower than without. There is no clear explanation for why this might be, particularly in light of the measurement of time with a loved one. There were no detailed questions about the quality, pleasantness, length of time spent, or the activities shared with the loved one. Further research is needed to elucidate this relationship.

Limitations of this study require that findings be interpreted with caution. Given the small sample, generalizability is limited to older adults living with chronic pain, substance use, and HIV. The lack of adjustment for gender in the inclusion criteria also limits generalization to women who binge drink at higher intensity. In addition, data were collected once a day for seven consecutive days—limiting data collection to retrospective recall of the past 24 hours. It may be that daily factors driving pain, substance use, and relief from pain may have differed if participants were assessed several times a day, as in Paolillo et al. (2017), or over a longer period. Even with these limitations and a small sample, power was adequate to discover important relationships between daily factors of interest.

Compliance with the EMA was a challenge for this study. While all phones used in the study had internet access, several participants did not own a smartphone—limiting the ability to collect data easily. Internet speed was quite slow on such devices, and compliance suffered as a result. In addition, publicly funded phones or phones provided by social service providers are often shared within families or social networks, limiting the access to the participant at times. Future EMA research with this population needs to include provision of smartphones for improved compliance rates. In addition to potential challenges with devices themselves, individuals in AO specifically had dramatically lower rates of EMA compliance. One potential explanation is that those participants knew their condition assignment during the seven day assessment period. As a result, knowing they would not receive treatment, they may have lost motivation to participate with EMA. Other studies using EMA have demonstrated that when blind to condition, compliance rates during periods prior to treatment initiation are comparable (e.g., Kuerbis, Armeli, Muench, & Morgenstern, 2013). Despite statistically significantly different compliance rates across condition, a sensitivity analysis was performed using only the two treatment groups. Results of all the findings reported here were identical. In addition, we used compliance as an additional covariate, again with identical results.

Among those days when participants did respond, it is possible that they learned that specific skip pattern responses made it possible to complete a shorter survey. Given the main skip pattern was related to the presence or absence of pain and that there was ample data on pain, this was not likely a factor in reducing the quality of the data. Additionally, any physical limitations that participants may have experienced (e.g., a tremor) that made a touch screen more difficult to provide precise answers (e.g., clicked the wrong button for a category) may have affected the data (Kuerbis et al., 2017). Given consistency of data across time, we are confident that this level of human error remained relatively low.

Despite these challenges to data collection, participants reported a surprising amount of positive feedback about the EMA during their debriefing interviews. Several participants reported that EMA helped them to “reflect on” their day, raised awareness about their own behavior and how they were feeling, and helped them to “stay focused”. While this is a positive sign for potential intervention using mobile technology with this group, it may also be indicative that assessment reactivity may have influenced the ability to determine the “true” daily factors driving pain, substance use, and relief from pain.

Future research on substance using older adults living with chronic pain and HIV should include a wide variety of data collection methods and much larger samples to obtain the most accurate and detailed data with the greatest ability for generalizability. Mobile technology should continue to be utilized across the life span and across a variety of health conditions and problematic behaviors, as it can provide unique information about when and how providers can intervene to improve health.

## Acknowledgments

This study was supported by the National Institutes of Health grant R21DA038163. Authors were also supported by K24AG053462 (AAM), K23AI110532 (JEL), P30AG028748 (AAM and AK), P30AG021684 (AAM). The authors have no competing interests to declare.

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## Highlights

- Ecological momentary assessment measured daily pain and substance use.
- An associational relationship between daily alcohol use and pain was demonstrated.
- Findings point to key targets for psychosocial interventions.

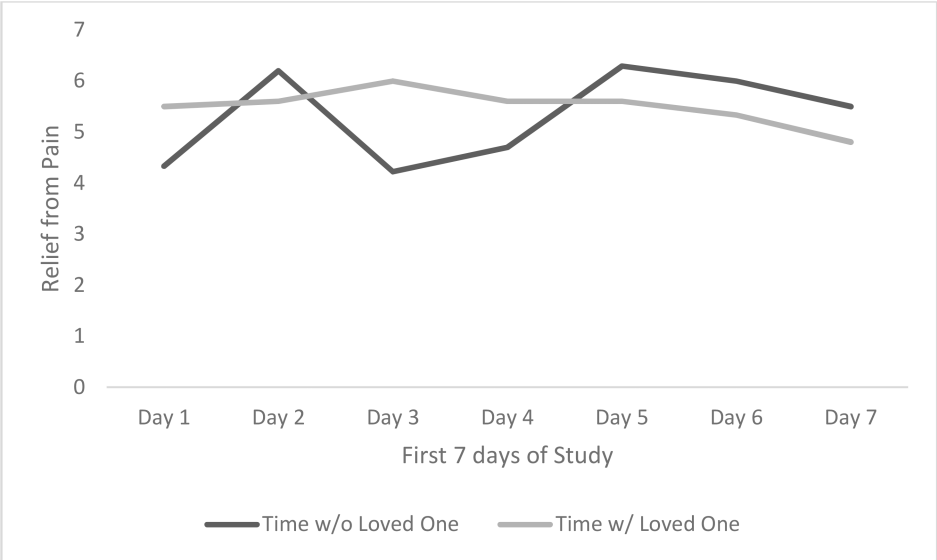


**Figure 1.**

Interaction of time by time spent with loved one predicting relief from pain. The higher the number, the greater the relief from pain.

## Table 1

Baseline Characteristics of Study Sample by Condition

| | CBT+TC+ TXT (N=18) M (SD) or % | Support Group (N=19) M (SD) or % | Assessment Only (N=18) M (SD) or % | Total (N=55) |
|---|---|---|---|---|
| **Demographics** | | | | |
| Age (range 49–71) | 53.3 (4.8) | 55.2 (5.0) | 56.8 (6.0) | 55.1 (5.4) |
| Gender | | | | |
| Male | 77.7 | 73.7 | 77.7 | 76.4 |
| Female | 11.1 | 15.8 | 16.7 | 14.5 |
| Transgender | 11.2 | 10.5 | 5.6 | 9.1 |
| Race/Ethnicity | | | | |
| Hispanic/Latino | 38.9 | 31.6 | 22.2 | 30.9 |
| Black, Non-Hispanic | 50.0 | 57.9 | 50.0 | 52.7 |
| Other, Non-Hispanic | 11.1 | 10.5 | 27.8 | 16.4 |
| Education | | | | |
| High School/Equivalent or Less | 38.9 | 47.4 | 27.8 | 38.2 |
| Beyond High School | 61.1 | 52.6 | 72.2 | 61.8 |
| Employment | | | | |
| Working Full or Part Time | 11.1 | 5.6 | 11.1 | 9.3 |
| Unemployed or Disabled | 88.9 | 94.4 | 88.9 | 90.7 |

Note: Table is a reproduction of a table in (Moore et al., under review). There were no significant differences across conditions. CBT+TC+TXT= Arm consisting of CBT, Tai Chi, and text messaging support messages.

**Table 2**

Descriptive Statistics of Daily Variables over Seven Days

| | Range | CBT+TC+TXT *M* (SD) or % | Support Group *M* (SD) | Assessment Only *M* (SD) | *F* or $x^2$ or Fisher's Exact Statistic | *p*-value |
|---|---|---|---|---|---|---|
| | | **(N=126 possible responses)** | **(N=133 possible responses)** | **(N=126 possible responses)** | | |
| Compliance[a] | 0 -- 100 | 71.4 | 60.2 | 43.7 | 11.2 | < .001 |
| Overall mean % days completed (out of 126 (133 for Support) responses possible) | | 71.4 | 60.2 | 43.7 | | |
| Mean days completed | | 5.1 (3.2) | 4.2 (3.4) | 3.1 (3.5) | | |
| | | **(N=90 completed responses)** | **(N=80 completed responses)** | **(N=55 completed responses)** | | |
| **Pain** | | | | | | |
| Experienced pain in last 24 hours | -- | 84.4 | 78.8 | 69.1 | 4.8 | .09 |
| Worst pain | 0 – 10 | 7.2 (1.9) | 6.8 (1.9) | 7.2 (1.8) | 1.0 | .37 |
| **Substance Use** | | | | | | |
| Alcohol (# of drinks per day) | 0 – 12 | 1.7 (2.3) | .78 (1.4) | 1.1 (1.4) | 5.4 | < .01 |
| Used marijuana in past 24 hours | -- | 38.7 | 37.7 | 48.1 | 1.6 | .44 |
| Reason used marijuana | | | | | 30.0 | < .001 |
| Fun/recreation | -- | 20.6 | 0.0 | 12.0 | | |
| Pain | -- | 23.5 | 75.9 | 36.0 | | |
| Both pain and recreation | -- | 55.9 | 13.8 | 52.0 | | |
| Neither | -- | 0.0 | 10.3 | 0.0 | | |
| Used other drugs in past 24 hours | -- | 29.9 | 27.3 | 19.2 | 2.0 | .38 |
| **Pain coping techniques** | | | | | | |
| Nothing | -- | | | | 3.7 | .16 |
| OTC Med | -- | 25.3 | 31.7 | 39.5 | 2.4 | .30 |
| Prescribed Med | -- | 58.7 | 36.5 | 42.1 | 7.2 | .03 |
| Non-prescribed Med | -- | 10.7 | 9.5 | 0.0 | 4.2 | .12 |
| Relaxation exercise | -- | 9.3 | 12.7 | 5.3 | 1.5 | .47 |
| Exercised | -- | 24.0 | 20.6 | 13.2 | 1.8 | .40 |
| Marijuana, not prescribed | -- | 18.7 | 9.5 | 15.8 | 2.3 | .32 |
| Alcohol | -- | 22.7 | 9.5 | 21.1 | 4.5 | .11 |
| Rested | -- | 32.0 | 41.3 | 31.6 | 1.6 | .46 |

| | Range | CBT+TC+TXT *M* (SD) or % | Support Group *M* (SD) | Assessment Only *M* (SD) | *F* or $x^2$ or Fisher's Exact Statistic | *p*-value |
|---|---|---|---|---|---|---|
| | | (N=126 possible responses) | (N=133 possible responses) | (N=126 possible responses) | | |
| Other illicit drug | -- | 6.7 | 3.2 | 15.8 | 1.6 | .45 |
| **Relief from pain** | 0 – 10 | 5.5 (2.6) | 5.3 (2.4) | 5.2 (2.3) | .24 | .79 |
| **Mood/emotional state** | | | | | | |
| Bored | 0 – 10 | 3.1 (2.9) | 3.2 (2.9) | 2.8 (2.9) | .24 | .79 |
| Stressed | 0 – 10 | 4.9 (3.3) | 3.8 (2.8) | 4.4 (3.0) | 2.6 | .08 |
| Anger | 0 – 10 | 3.3 (3.0) | 3.1 (3.1) | 3.2 (3.1) | .10 | .95 |
| Lonely | 0 – 10 | 3.3 (3.4) | 3.3 (3.2) | 3.0 (3.0) | .20 | .82 |
| Sad | 0 – 10 | 2.8 (2.6) | 3.2 (3.0) | 2.0 (2.4) | 2.7 | .07 |
| Happy | 0 – 10 | 4.9 (3.0) | 4.5 (3.3) | 4.9 (2.9) | .43 | .65 |
| Agitated | 0 – 10 | 3.7 (3.0) | 3.5 (3.1) | 3.6 (2.8) | .07 | .94 |
| Calm | 0 – 10 | 4.8 (2.8) | 4.2 (3.6) | 3.9 (2.5) | 1.6 | .20 |
| **Quality sleep** | 0 – 10 | 6.2 (5.9) | 5.5 (2.6) | 5.8 (1.9) | 2.0 | .14 |
| **Exercised in last 24 hours** | -- | 40.9 | 53.2 | 49.1 | 2.6 | .27 |
| **Spent time with loved one** | -- | 55.8 | 66.2 | 69.2 | 3.1 | .21 |
| **Fear of pain** | 0 – 20 | 11.3 (5.4) | 11.1 (4.5) | 11.4 (4.1) | .07 | .93 |
| **Confidence to cope** | 0 – 10 | 5.7 (2.8) | 5.0 (2.9) | 5.1 (2.0) | 1.7 | .18 |
| **Confidence to cope w/o Meds** | 0 – 10 | 4.2 (3.0) | 4.3 (3.2) | 3.8 (2.4) | .50 | .61 |

[a] Significant differences were between the two treatment arms and the control. There were no significant differences between the two treatment arms.

Note: CBT+TC+TXT= Arm consisting of CBT, Tai Chi, and text messaging support messages.

## Table 3

Results of Independent Models Testing Pain Predicting Substance Use

| | Alcohol Use (# of Drinks) | | | Marijuana Use | | | Other Drug Use | | |
|---|---|---|---|---|---|---|---|---|---|
| **Independent Predictors** | *B* | *SE* | *p* | *B* | *SE* | *p* | *B* | *SE* | *p* |
| Pain in last 24 Hours[a] | .21 | .27 | .46 | .34 | .30 | .25 | .37 | .30 | .21 |
| Pain 24*Time | .05 | .27 | .68 | .16 | .17 | .34 | .02 | .18 | .91 |
| Daily Worst Pain[a] | **.23** | **.10** | **.02** | .04 | .04 | .32 | −.11 | .16 | .50 |
| Person-average Worst Pain[a] | .09 | .15 | .56 | .29 | .19 | .13 | −.34 | .17 | .05 |
| Daily Worst Pain*Time | −.07 | .06 | .24 | .01 | .03 | .59 | .01 | .05 | .78 |

[a]Parameter estimates are those without the interaction term, given that it was not significant.

## Table 4

Parameter Estimates of Significant Independent and Final Multilevel Models of Focal Predictors of Daily Worst Pain

| | Independent Models | | | Final Reduced Model | | |
|---|---|---|---|---|---|---|
| **Predictors** | ***B*** | ***SE*** | ***p*** | ***B*** | ***SE*** | ***p*** |
| Daily number of drinks | **.16** | **.07** | **.02** | **.48** | **.12** | **<.001** |
| Person average drinks | .23 | .15 | .12 | **.32** | **.12** | **<.01** |
| Daily drinks × Time | −.05 | .04 | .18 | | | |
| Marijuana Use | .43 | .36 | .29 | | | |
| Marijuana Use × Time | .04 | .13 | .77 | | | |
| Other Drug Use | .38 | .30 | .23 | | | |
| Other Drug Use × Time | .01 | .14 | .95 | | | |
| Daily sad | .13 | .07 | .05 | | | |
| Person average sad | .16 | .09 | .09 | | | |
| Daily sad × Time | −.02 | .04 | .66 | | | |
| Daily happy | **−.12** | **.06** | **.04** | **−.21** | **.09** | **.03** |
| Person average happy | −.08 | .08 | .033 | **.33** | **.09** | **<.001** |
| Daily happy × Time | −.04 | .03 | .17 | | | |
| Daily loneliness | .08 | .05 | .11 | | | |
| Person average loneliness | .12 | .09 | .17 | | | |
| Daily loneliness × Time | −.01 | .03 | .69 | | | |
| Daily stressed | **.11** | **.05** | **.03** | | | |
| Person average stressed | .10 | .09 | .27 | | | |
| Daily stressed × Time | −.01 | .03 | .66 | | | |
| Daily boredom | .02 | .05 | .68 | | | |
| Person average boredom | .15 | .10 | .13 | | | |
| Daily boredom × Time | 0.0 | .02 | .84 | | | |
| Daily anger | .07 | .05 | .19 | | | |
| Person average anger | .06 | .09 | .51 | | | |
| Daily anger × Time | .01 | .03 | .83 | | | |
| Daily agitated | .04 | .06 | .47 | | | |
| Person average agitated | .07 | .10 | .45 | | | |
| Daily agitated × Time | −.03 | .03 | .37 | | | |
| Daily calm | .00 | .04 | .96 | | | |
| Person average calm | −.09 | .11 | .39 | | | |
| Daily calm × Time | .02 | .02 | .24 | | | |
| Daily Quality Sleep | −.08 | .06 | .19 | −.03 | .08 | .77 |

| | Independent Models | | | Final Reduced Model | | |
|---|---|---|---|---|---|---|
| **Predictors** | ***B*** | ***SE*** | ***p*** | ***B*** | ***SE*** | ***p*** |
| Person Quality Sleep | **−.35** | **.11** | **<.01** | **−.29** | **.09** | **<.01** |
| Daily Quality Sleep × Time | −.05 | .04 | .22 | | | |
| Exercise | **−.66** | **.23** | **<.01** | **−.67** | **.25** | **.02** |
| Exercise × Time | −.05 | .11 | .61 | | | |
| Daily Fear of Pain | .06 | .03 | .06 | | | |
| Person Average Fear of Pain | .03 | .06 | .59 | | | |
| Daily Fear of Pain × Time | .01 | .02 | .67 | | | |
| Daily Confidence to Cope | .19 | .10 | .06 | | | |
| Person Average Confidence to Cope | −.20 | .10 | .05 | | | |
| Daily Confidence to Cope × Time | .14 | .07 | .05 | | | |
| Daily Confidence to Cope w/o Meds | −.02 | .06 | .79 | −.06 | .06 | .27 |
| Person Average Confidence to Cope w/o Meds | **−.26** | **.10** | **<.01** | **−.34** | **.10** | **<.01** |
| Daily Confidence to Cope w/o Meds × Time | .05 | .04 | .13 | | | |

Note: In cases where the interaction term is not statistically significant, the parameter estimates shown here are those without the interaction term.

## Table 5

Parameter Estimates of Significant Independent and Final Multilevel Models of Predictors of Relief from Pain

| | Independent Models | | | Final Reduced Model | | |
|---|---|---|---|---|---|---|
| **Predictors** | ***B*** | ***SE*** | ***p*** | ***B*** | ***SE*** | ***p*** |
| Daily number of drinks | .05 | .10 | .59 | | | |
| Person average drinks | −.31 | .21 | .13 | | | |
| Daily drinks × Time | −.03 | .06 | .64 | | | |
| Marijuana Use | .42 | .51 | .46 | | | |
| Marijuana Use × Time | .05 | .18 | .77 | | | |
| Other Drug Use | .66 | .41 | .14 | | | |
| Other Drug Use × Time | −.12 | .18 | .50 | | | |
| Daily Quality Sleep | .06 | .09 | .47 | | | |
| Person Quality Sleep | **.40** | **.16** | **.02** | | | |
| Daily Quality Sleep × Time | −.04 | .05 | .41 | | | |
| Exercise | .23 | .32 | .48 | | | |
| Exercise × Time | .05 | .15 | .76 | | | |
| Loved one | −.07 | .37 | .86 | .14 | .35 | .69 |
| Loved one × Time | **−.34** | **.15** | **.03** | **−.39** | **.14** | **<.01** |
| Daily Fear of Pain | .00 | .04 | .96 | | | |
| Person Average Fear of Pain | .07 | .08 | .35 | | | |
| Daily Fear of Pain × Time | **−.06** | **.02** | **<.01** | | | |
| Doing Nothing to Cope | **−2.06** | **.58** | **<.01** | **−2.3** | **.58** | **<.01** |
| Doing Nothing to Cope × Time | .42 | .24 | .08 | | | |
| OTC Medication | .07 | .39 | .85 | | | |
| OTC Medication × Time | .06 | .17 | .72 | | | |
| Prescribed Medication | .76 | .41 | .08 | | | |
| Prescribed Medication × Time | .06 | .15 | .69 | | | |
| Non-prescribed Medication | .66 | .57 | .29 | | | |
| Non-prescribed Medication × Time | −.28 | .35 | .43 | | | |
| Relax | .19 | .50 | .71 | | | |
| Relax × Time | −.16 | .25 | .54 | | | |
| Coping by exercising | −.32 | .42 | .47 | | | |
| Coping by exercising × Time | .10 | .19 | .60 | | | |
| Coping by using marijuana | .42 | .52 | .44 | | | |
| Coping by using marijuana × Time | .26 | .23 | .26 | | | |

| | Independent Models | | | Final Reduced Model | | |
|---|---|---|---|---|---|---|
| **Predictors** | ***B*** | ***SE*** | ***p*** | ***B*** | ***SE*** | ***p*** |
| Coping by using alcohol | .44 | .39 | .27 | | | |
| Coping by using alcohol × Time | −.12 | .20 | .54 | | | |
| Rest | .70 | .36 | .06 | | | |
| Rest × Time | .16 | .15 | .29 | | | |
| Cope by using illicit drugs | 1.69 | .71 | .10 | | | |
| Cope by using illicit drugs × Time | −.36 | .33 | .27 | | | |

Note: B = parameter estimate; SE = standard error. Daily variables were centered at the individual person-mean. All others were centered at the grand mean. Covariates time, condition, and weekday were entered into all models.