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Abstract

Background: Ecological momentary assessment (EMA) is an increasingly popular and feasible form of data collection, but it can be intensive and intrusive. Especially for at-risk, vulnerable populations like people who use drugs (PWUD), poor experiences with EMA may exacerbate existing chronic struggles while decreasing response rates. However, little research queries participants' experiences with EMA studies.

Objectives: We explore participants' positive and negative experiences with EMA, identifying what they liked about the study, the problems they experienced, and suggested solutions to these problems.

Methods: Results come from semi-structured interviews from 26 PWUD (6 women; 20 men) in Nebraska who participated in a two-week EMA pilot study on drug

use with a study-provided smartphone. Participant responses were recorded by interviewers into open-text fields in Qualtrics. Data were analyzed with an iterative open coding procedure.

Results: We found that many participants enjoyed the study and seamlessly incorporated the phone into their daily lives. There were a number of negative study aspects identified, however, as many participants experienced functional issues (e.g., running out of high-speed data, trouble keeping the phone charged, not able to answer questions within the two-hour timeframe) that detracted from their experience, especially if they were homeless.

Conclusion: Our findings provide methodological considerations for studies with EMA components among at-risk, vulnerable populations, like PWUD. These suggestions are targeted toward the continued ethical collection of high-quality data in clinical and non-clinical settings.

Introduction

Ecological momentary assessment (EMA) has become an increasingly popular form of data collection (1). EMA broadly refers to a collection of research methods that capture data on events, behaviors, and feelings as they unfold in their natural, real-world setting (2). All technology- based EMA techniques collect time-stamped responses at (potentially) fine grained-intervals. Respondents are prompted to answer questions during specific times of day or during certain events (or soon after). Recent work has collected EMA with smartphones; with this method of administration, assessments can also be prompted based on GPS location and/or Bluetooth proximity to other devices (3,4).

EMA methods are advantageous because they improve upon weaknesses associated with other forms of data collection. In cross-sectional surveys, for example, causal relationships and naturally occurring fluctuations are lost or cannot be studied, but these are possible with EMA data (2,5). Additionally, individuals tend to underreport sensitive or socially devalued behavior, like substance use, in cross–sectional reports (6). EMA minimizes this systematic bias by shortening the recall period, or span of time under consideration, as well as the amount of time between the behavior and moment of recall. Both improve the accuracy of reports and reduce the tendency to misreport by generalizing (7–11).

In light of these advantages, EMA may be particularly useful for vulnerable populations susceptible to underreporting biases, such as people who use drugs (PWUD). Indeed, a large literature has employed EMA methods among this population. This work confirms that EMA yields data with improved validity compared to other methods (9,12). It also demonstrates general feasibility, concluding that EMA is a reasonable method of data collection for PWUD (13).

Though encouraging for researchers, this previous work does not explore how EMA is incorporated into participants' daily lives. This means that little is known about what influences EMA feasibility among PWUD, including the factors that, from their perspective, lead to successful (or unsuccessful) EMA participation. Such considerations are important because PWUD face a unique set of structural hardships and competing demands that may impede the ability to participate consistently in EMA studies. For example, participants may be unwilling or unable to complete assessments while using drugs (14,15). If PWUD are also homeless, these individuals will also face difficulties obtaining consistent access to electricity in addition to facing acute day-to-day stressors that require immediate attention (e.g., food, warmth, etc.). Furthermore, all who are economically disadvantaged, including PWUD, are more likely to have fluctuating work schedules, which may lead to inconsistent participation (13).

Additionally, PWUD may already be less willing to trust researchers (16); poor experiences with data collection may further erode trust (17). Participants in one study were posed with a hypothetical EMA scenario and reported data security concerns, fearing legal and social repercussions if data were obtained by law enforcement (18). Similarly, poor experiences can exacerbate the chronic struggles faced by many PWUD. One study found that after participating in a brief, lab–simulated EMA situation, PWUD worried that participating in EMA research would heighten the salience of drugs, causing anxiety and intensifying the desire to use (17). Further research is needed to identify what problems PWUD actually encounter with EMA data collection, and how, from their perspective, such issues might be resolved or alleviated. The identification and resolution of potential issues is crucial for the ethical collection of EMA data among this population.

It is also important to identify any benefits that participants derive so that such factors can be augmented in future work (19). Especially

among PWUD that are currently homeless and/or without a personal cellphone or other reliable way to reach social contacts, the provision of advanced technology for EMA collection may provide temporary access to needed resources which can increase participants' social connectedness with others (19,20). Study participation may also come with other psychosocial benefits, such as providing insight for participants into patterns that lead them to use or want to use (20–22). Further research is needed to identify what PWUD like about EMA studies, what facilitates their consistent participation, and how they perceive EMA research participation to benefit them.

In this paper, we explore the perspectives of PWUD in Nebraska who participated in a two-week long EMA study on drug use. Using qualitative data collected from semi-structured exit interviews, we detail the positive and negative aspects that participants reported about the EMA experience. Specifically, we report on how participants incorporated the phones in their daily lives, what they liked about the study, and the issues they encountered while participating. We end the paper by offering possible solutions to the issues identified by our participants. This work is important because it provides novel insight into the EMA experience among PWUD, which carries great relevance for the successful and ethical collection of EMA data among this as well as other at-risk, vulnerable populations. The hope is that our results will inform future studies, making it possible to reduce systematic measurement error in EMA data by encouraging researchers to avoid methodological choices that impede consistent participation.

Method

Participants and recruitment

The data come from a recent pilot study conducted in October 2020. Since the data collection period occurred during the COVID-19 pandemic, extensive health and safety precautions were put in place to maximize participant and research staff safety while minimizing transmission risk (23). All study aspects were approved by the university's IRB. The study examined drug use in relation to daily interactions, social supports, and wellbeing among PWUD. It also

tested the feasibility of a smartphone-based ecological momentary assessment (EMA) app, called the Open Dynamic Interaction Network (ODIN) (24,25).

We began recruitment by soliciting individuals who had previously participated in the Rural Health Cohort (RHC) study. The RHC study is a longitudinal data collection effort by the Rural Drug Addiction Research (RDAR) COBRE to study active drug users in rural Nebraska. Eligibility for the RHC includes being 19 years of age or older and having used one or more illegal substances or illegally obtained controlled substances within the past seven days of recruitment. Wave 1 of the RHC recruited participations through respondent- driven sampling (26) in southeastern Nebraska from November 2019 to March 2020. Initial respondents, or "seeds," were recruited by RHC project leaders with ties to Lincoln and the surrounding communities.

For our EMA study, we were given access to the names and phone numbers of RHC participants who agreed to be contacted for participation in related studies. Eligibility for our study included being 19 years of age or above, being able to read and write in English, and feeling comfortable using a smartphone if given a tutorial on how to operate the device. Participants were accepted on a rolling basis. Initial participants often referred friends and other associates to our study, and we allowed these referrals (when eligible) to enroll. Our total enrollment included 28 PWUD. We reached our final sample shortly after contacting the last RHC participant on our list.

Intake appointment

Twenty-six participants completed all three study components: 1) smartphone data collection that occurred over the course of two weeks, 2) two electronic surveys programmed into Qualtrics, completed before and after the smartphone data collection period, and 3) an exit interview. Participants were compensated up to 120 USD in cash for participating in all components of the study.

First, participants attended an intake appointment in which they completed the consent process by being read the consent form by a research team member. After providing consent, participants completed the first survey which included baseline questions about demographics, drug use, and social support. Participants were then given

a smartphone device (with an unlimited talk, text, and data plan) on which the ODIN app was installed. A phone and a charger were distributed to each participant even if they already had a personal cellphone (19 of out 26 participants, or 73.08%, had their own personal device). Three different phone models were used: Nokia 2.3, Motorola Moto E, and Motorola Moto E6. Each participant was given a short tutorial demonstrating how to navigate the phone and the ODIN app. Participants were instructed to carry the phone with them for the next two weeks and to contact the research team if they encountered any problems during this time. Participants were compensated 20 USD in cash for completing the intake appointment.

EMA data collection

Next, participants completed two weeks of EMA data collection with the smartphone device. All EMA questions were sent to the phone through the ODIN app. Each participant was asked a minimum of 104 questions each week (15 questions daily from Monday-Saturday, 14 questions on Sunday). Questions were asked at four points throughout the day: three questions at 9:00 AM, four questions at 12:00 PM, two questions between 2:00 PM to 5:00 PM Monday-Saturday only, six questions at 7:00 PM, and one question at 4:00 PM on Sunday only. Questions expired two hours after they were sent. In addition to EMA data, all participants agreed to continuous GPS data collection as well as the capture of Bluetooth proximity information.

Overall, EMA compliance was good (13): participants completed nearly 66% of all assessment instances. Compensation for this portion of the study was calculated weekly and was prorated on the number of questions answered (minimum of 5 USD for 25 questions answered or less to a maximum of 30 USD per week for 88 questions or more). The maximum compensation for this portion of the study was 60 USD in cash. Participants received this compensation at the of the study.

Exit interview

Last, participants attended a final appointment where they returned the study equipment, completed a second survey, and a completed a semi–structured exit interview. Interviews lasted anywhere from 5–30

minutes. Each interviewer used an interview guide with eight open-ended questions. Questions involved participants' experience using the smartphone and the ODIN app as well as their experience in the study more broadly. Participants were also asked to provide suggestions on how to improve the study. In order to protect participant privacy, interviews were not audio-recorded; instead, responses and other notes were typed by interviewers into open-text fields on a Qualtrics survey. See Appendix A for the full set of questions included in the interview guide. Participants were compensated 20 USD in cash for completing the exit interview and were compensated up to 20 USD for returning the study equipment (5 USD for the charger, 15 USD for the phone).

Analysis

We used an inductive, iterative approach to analyze the typed responses to the eight open-ended questions for all respondents. We used Atlas.ti to open code this data (27). We first read responses across all participants to identify emergent themes. Then, codes were created and attached to specific participants. After applying codes, we revisited each response to identify and apply any themes that had emerged from later replies. Finally, we used Atlas.ti to generate groups of codes (subthemes) within larger groupings (major themes) across questions, tabulate statistical frequencies for each code, and cross–tabulate codes by major participant characteristics (homeless status, ownership of a personal device). This led to the emergence of three general themes that organize our presentation of results: how participants used the phone, what they liked about the study, and what they thought could be improved.

Results

Sample

We present basic descriptive statistics for our sample in **Table 1**. We restrict our analysis to the 26 participants who completed the exit interview. The average age of participants was 42 years, ranging from 22–70. Twenty participants were men, and six were women. Nine

Table 1. Participant demographics.

	Currently Homeless		Not Homeless		
	Personal Device	No Personal Device	Personal Device	No Personal Device	Total
Women					
White	1*	–	2	–	3
Hispanic/Latino	–	–	1	–	1
Black	–	–	1	–	1
Other/Multiracial	1	–	–	–	1
Men					
White	1	4	6	3	14
Hispanic/Latino	1	–	–	–	1
Black	2	–	2	–	4
Other/Multiracial	–	–	1	–	1
Total	8	5	11	2	26

Note: *This participant identified as transgender.

participants were a member of a racial/ethnic minority group. Half (N = 13) were currently homeless. Below, we present the themes in detail. Themes are not mutually exclusive; many participants expressed multiple themes simultaneously. In most cases, we present our results in the aggregate (see **Table 2**). However, we do note the few instances when important differences emerged by homeless status and personal device ownership.

Phone use

Our first theme includes how participants used the phones and incorporated them into their daily lives. Three subthemes appeared with respect to personal, social, and logistical use. First, many participants used several features on the smartphones for recreation and to maintain social connections. Just over half (53.85%; 14 of 26) of participants called and/or texted family, friends, or other social contacts, including over 60% (9 of 14) of those who had a personal device of their own. Half (13 of 26) searched the internet, and roughly 25% (6 and 7 of 26) connected to social media or played games. All participants listed at least one personal use of the device, suggesting that participants were at least partially engaged with the phone outside of its study-related purpose.

Table 2. Percentage of sample expressing subthemes (N = 26).

Major Theme and Subthemes	N Expressed	% of Sample
(1) Phone Use (N = 26*)		
● *Personal Use*	**26**	**100%**
○ Phone calls/texts	14	53.85%
○ Search internet	13	50.00%
○ Social media	7	26.92%
○ Play games	6	23.08%
● *Social Use*	**23**	**88.46%**
○ Comfortable using phone around others	21	80.77%
○ Disclosed status as study participant	9	34.62%
● *Logistical Use*	**23**	**88.46%**
○ Comfortable carrying phone at all times	21	80.77%
○ Only carried study phone[a]	3	15.79%
○ Let others use the phone	5	19.23%
(2) Likes and Benefits (N = 25*)		
● *Enjoying the Experience*	**25**	**96.15%**
○ Interesting study/would participate again	24	92.31%
○ Would recommend study to others	18	69.23%
● *Making a Difference*	**7**	**26.92%**
○ Provided unique perspective/felt important	7	26.92%
● *Self-Reflection*	**5**	**19.23%**
○ Prompted new thoughts	2	7.69%
○ Helped calm down	3	11.54%
● *Routine*	**5**	**19.23%**
○ Helped structure each day	5	19.23%
(3) Dislikes and Suggested Changes (N = 24*)		
● *Technological Problems*	**15**	**19.23%**
○ Battery died/charging problems	5	19.23%
○ Frozen/delayed features	7	26.92%
○ Ran out of 4G	12	46.15%
● *Other Annoyances*	**20**	**76.92%**
○ Need more time to answer questions	3	11.54%
○ Button not useful	18	69.23%
○ Would prefer ODIN on personal device[b]	3	42.86%

Notes: All 26 participants were asked all questions yielding the codes in this table, except where specified. Bolded numbers correspond to the discrete number of individuals who contributed to at least one code within the subtheme.

* This number corresponds to the discrete number of individuals who contributed to at least one subtheme corresponding to the theme.

a. Only the 19 individuals with a personal device were asked this question. The total percent reflects a sample of 19 for this code.

b. Only 7 individuals out of the 19 with a personal device were asked this question as a probe to another question. The total percent reflects a sample of 7 for this code.

Participants also used the phone in social situations, and this led to a range of behaviors. One participant reported discomfort using the phone around other people, leading him to answer the EMA questions in a private space. However, the majority of the sample (80.77%; 21 of 26) said they were comfortable carrying the phone with them, did so at all times, and used the phone when around other people. With respect to participants with personal devices, one mentioned discomfort at the idea of carrying both his personal device and the study device with him because he worried that carrying two phones looked strange to others. This participant, and two others (11.54%; 3 of 19 with personal devices) opted to only carry the study phone with them and used it as their primary device (in place of their personal device) during the study period.

Likes and benefits

Our second theme focuses on what participants liked about the study, including any benefits they saw as a result of participation. Four sub-themes were developed independently but are consistent with past cell phone studies conducted on vulnerable populations (20). Theses themes include: enjoying the experience, making a difference, self-reflection, and routine.

First, over 90% (24 of 26) of participants enjoyed their experience and mentioned one or more of the following: the study was interesting, it was easy to participate and answer the questions, they enjoyed using the phone and experiencing new technology, and they would participate in the study again. Two participants mentioned that they felt cared about as a study participant because answering the questions made them feel like they were talking to someone who was listening and who cared about their wellbeing. Nearly 70% (18 of 26) enjoyed the experience enough to report that they would recommend the study to others.

Over one-fourth (26.92%; 7 of 26) of participants felt like their participation made a difference and contributed to a greater cause. One participant mentioned that answering the questions made them feel important; another six said that they liked being able to provide their unique perspective. Thus, participating gave participants the space to document and discuss their vantage points as unique users.

Just under 20% (5 of 26) expressed that participation in the study facilitated self-reflection, which was viewed as a positive experience. Two participants stated that answering the questions helped them reflect upon their behavior in a new way. One of these participants mentioned that a large portion of the stressful experiences they encountered were related to drug use and that they made this connection by answering the study questions honestly and consistently. Three participants said that the questions helped them calm down because the questions gave them time to consider and express what they were thinking and feeling.

Last, 19.23% (5 of 26) noticed that we asked a large portion of the same EMA questions at the same times each day and came to expect the questions as a standard part of their routine. One participant suffering with chronic fatigue mentioned that she used the daily morning questions as motivation to get up and start her day. Another echoed that the questions helped keep structure to the day.

Dislikes and suggested changes

Our third theme involved what participants did not like about the study, including what could have been improved. We present two subthemes: technological problems and other annoyances. First, 19.23% (5 of 26) reported that their phone battery died and that they had issues keeping the phone charged. Of the five who reported trouble with reliable charging, three were homeless. Over one-fourth of participants (26.92%; 7 of 26) reported that their phones frequently froze or had delayed features. This delay was likely due to the common issue of reaching the maximum 4G data limit (the data plan was 4G up to 2GB used, after which, the speed was lowered, even though the data was still unlimited), an issue impacting 46.15% of the sample (12 of 26, 9 of whom were homeless). Some participants reached the 4G data limit as early as a few days into the study. These participants noted that once they reached the limit, the phone slowed down considerably and was less enjoyable to use.

The second subtheme, other annoyances, involved complaints about the study that were directly related to EMA questions and other features of the ODIN application. Three participants (11.54%) noted that the two-hour window to answer questions was not long enough. About

70% (18 of 26) said that they thought ODIN's button feature – an elective button that (once pressed) would prompt questions and space to discuss the current desire to use drugs – was not useful. In fact, the majority of participants never used it during the study. One participant said that he did not feel like he ever 'reached the point' where he 'needed use it or seek help,' indicating potential misunderstanding over the button's purpose. Another participant, however, said that he 'always wanted to use,' such that there was never a discrete moment of desire that prompted him to use the button.

Finally, we asked about the possibility of having the ODIN app installed on personal devices. This question was not asked to all participants because not all participants had their own personal device. Additionally, this question was included as a probe for the last of the eight open–ended questions, meaning it was only asked to maintain conversation as needed. Of those that were asked this question, 42.85% (3 out of 7 participants) said they would have preferred to use their own phone instead of having to use the study phone. Each of these participants reported other issues with the device, like trouble keeping it charged, difficulty keeping track of two phones, and not being comfortable using it around other people. The remaining four participants that preferred using the study phone said that they liked having the two phones, they shared the phone with others, or that they enjoyed interacting with new technology.

Conclusion

EMA provides many benefits as a form of data collection (2,7–11). Such benefits, however, must be weighed against the burden of EMA data collection on the participants, especially when dealing with vulnerable, at-risk populations. Here, we reported on the experience of 26 PWUD who participated in a two-week EMA pilot study. Overall, participants reported positive study experiences and successfully incorporated the phone into their daily lives. This was partially because the study offered an opportunity to contribute to something important and partially because of opportunities for self-reflection. Others enjoyed the routine that the study added to their day. Though many found the study phone easy to manage, there were other aspects of the

study that participants found less positive. Most of these concerns centered around the functioning of the phone. For example, some participants, particularly those who were homeless, had difficulty keeping the phone charged, while others quickly ran out of high speed data.

Compared to past work on other vulnerable populations, such as homeless youth (20), our sample of PWUD were less likely to mention money as a benefit. Our participants were also less likely to discuss the social/status benefits of being part of the study; getting attention from friends, for example, was less important in our adult sample. Similarly, most participants found the second phone useful, rather than a burden, and noted that they used the phone for more recreational (17) than instrumental purposes (e.g., keeping track of schedules, setting up appointments) (20).

Our results point to a number of practical suggestions for future studies employing EMA among at-risk populations. First, if the population is homeless (or otherwise economically disadvantaged), it is important to have a sufficient high-speed data plan on the study phone for the entire study period. This means having a high ceiling on 4G or 5G data plans and/or offering a list of locations where individuals can access free wi-fi. Likewise, it is important to make it easy to keep the phone charged. Researchers may, for example, provide portable chargers for participants. This is especially advisable if GPS and/or Bluetooth tracking information is collected alongside EMA data, as continuous collection of this additional data poses greater threat for battery drain than EMA alone. It might also be useful to provide a list of locations where individuals can charge the phone safely, without issue, and for free, ideally corresponding to locations where free wi-fi is available. However, researchers should be cognizant of potential risks for law enforcement surveillance or involvement as well as pandemic-related risks when selecting such locations for drug-using populations.

Next, it is important to have a sufficient window of opportunity to answer the EMA questions. For example, a researcher could prompt questions at specified times during the day but allow participants to answer them until the evening (rather than imposing a two-hour limit). Having more flexibility will likely increase response rates and decrease participant frustration. This flexibility, however, marks an important tradeoff, as recall bias increases as time passes (28). Future work should strive to find a reasonable balance between the two that accommodates the population of interest.

Finally, we suggest that future studies offer the option for participants to carry a study-provided phone *or* to install related apps, like the one used here, on their own personal phone. Noted above, providing a study phone is particularly important when studying economically disadvantaged populations with limited access to personal devices. For those with access to personal devices, however, allowing use of their own device for the study provides an additional layer of flexibility. This may facilitate consistent participation by accommodating respondent preferences.

Our study provides important information about how participants view being part of EMA data collection; however, it is not without limitations. First, our results come from a sample of 26 PWUD in Nebraska, which may not be representative of PWUD in general. It would be useful to verify if other concerns, like data security worries (17,18), emerge more prominently in other populations. Second, there were several important participant characteristics that we did not have access to. For example, we did not ask for information about past or current treatment for substance use, nor did we screen for substance use disorder or subjective assessments of dependence; these may impact participants' ability or willingness to consistently complete EMA prompts (13,14). Future work should consider participants' experiences with EMA across these and other characteristics.

Despite these limitations, data collection for this study was generally successful, and our conclusion confirms prior work: it is reasonable and feasible to distribute smartphones to collect EMA data from a vulnerable sample of PWUD, including individuals who are homeless (9,12,13). Our study arrived at these conclusions by querying *participants'* perspectives about their actual EMA experiences. We found that, though participants largely had a positive experience during the study, collecting EMA data on an at-risk population carries unique challenges that researchers 316 K. L. MARKOWSKI ET AL. should take into account when planning future studies. Most crucially, researchers must pay attention to details related to accessibility and resources, as 'mundane' problems related to phone maintenance and charging are particularly important when dealing with economically disadvantaged populations. The hope going forward is that our results will encourage more studies to use EMA among at-risk populations while considering our concrete suggestions on how best to ensure ethical data collection and sufficient participant engagement.

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Appendix A follows

Appendix A. Interview guide

(1) Do you have a personal cellphone that is separate from the one you signed-out for this study?

(2) Aside from answering the study questions, what did you use the study cellphone for?

● Probes:
    ○ Did you use the cellphone for personal use? If so, what were those personal uses?
    ○ Did you share the study cellphone with others? If so, how often? For what purpose?

(3) How often did you carry the study cellphone around with you? What made it difficult/easy?
    ● Probe:
        ○ How comfortable did you feel using the study cellphone around others?

(4) How much time did you spend each day answering the study questions?
    ● Probes:
        ○ Did you answer the questions right away? Why/why not?
        ○ Was it difficult to remember to answer the questions? Why/why not?

(5) How often did you use the buttons on the ODIN app (ex. to report desire to use drugs)?
    ● Probe:
        ○ Did you find the buttons useful? Why/why not?

(6) What other issues did you have with the study cellphone?
    ● Probes:
        ○ How often did you charge study cellphone? Did it ever run out of battery?
        ○ Did you run out of data?
        ○ Were you able to connect to Wi-Fi?

(7) What did you like about the study, if anything?
    ● Probes:
        ○ Would you participate in this study again?
        ○ Would you recommend others to participate in a study like this?

(8) What could we do to make a study like this better in the future?
    ● Probe:
        ○ Would it have been easier if you could have answered the questions on your own personal cellphone (if applicable)?