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Feasibility and Acceptability of Post-Hospitalization Ecological Momentary Assessment in Patients with Psychotic-Spectrum Disorders

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Abstract

Background—Up to 50% of patients with psychotic-spectrum disorders are medication nonadherent. The use of real-time assessment via ecological momentary assessment (EMA) on mobile devices might offer important insights into adherence behaviors that cannot be measured in the clinic. However, existing EMA studies have only studied acutely ill patients during hospitalization or more stable patients in the community.

Methods—Feasibility and acceptability of EMA in 65 patients with psychotic-spectrum disorders who were recently discharged from the hospital were assessed. EMA was administered for four weeks via study-provided mobile devices. Feasibility was measured by study recruitment/retention rates, patients' connectivity, and completion rates. Quantitative and qualitative acceptability data were collected.

Results—Participants completed 28-31% of offered EMA assessments. The only significant predictor of reduced EMA completion was recent cannabis use. EMA completion was maintained from weeks 1-3 but significantly dropped at the fourth week. Patient acceptability feedback was generally positive; negative comments related primarily to technological problems.

Conclusions—This was the first study to use EMA in recently discharged patients with psychotic-spectrum disorders. EMA is feasible and acceptable in this population, but completion rates were lower than in more stable samples. Future research should consider limiting the assessment period, screening for substance use, and integrating assessment with intervention elements to increase EMA engagement.

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Keywords

schizophrenia; psychosis; ecological momentary assessment; mobile technology; psychiatric hospitalization

1. Introduction

Although prevalence rates for psychotic-spectrum disorders (i.e., schizoaffective disorder, schizophrenia) are fairly modest [1-3], the disability rates associated with these disorders are high [4] and treatment costs are substantial [5]. This disproportionate burden of psychosis on patients, their family members, and their communities is likely due to the significant functional impairments associated with the long-term management of these disorders [6-8] as well as factors that make treatment difficult and costly.

For instance, research indicates that up to 50% of patients with schizophrenia are medication nonadherent [9]. Nonadherence is predictive of poorer outcomes, including relapse, rehospitalization, self/other harm, and homelessness [10]. Given these adverse effects of nonadherence in patients being treated for psychotic-spectrum disorders, new methods for monitoring and promoting treatment adherence are needed which engage the patient beyond the confines of clinical settings. As the psychiatric field continues to refine approaches to helping patients manage these disorders and adhere to their treatments, there is a growing movement to leverage mobile technology to: (a) reduce provider burden; (b) lower treatment costs; (c) improve treatment engagement; and, (d) better understand and support patients' functioning in their natural environments.

1.1 Using ecological momentary assessment (EMA) in psychotic-spectrum disorder populations

Mobile devices, such as smartphones, have become the ideal technological platform for collecting *in vivo* data. Real-time assessment using ecological momentary assessment (EMA) [11] reduces risk of retrospective biases in reporting and can provide insights into patients' daily lives that could not be captured at clinic appointments. Clinical characteristics associated with psychotic-spectrum disorders, such as low motivation and cognitive impairments [12], may lead to a pessimistic stance on the feasibility of methods such as EMA which demand focused and regular engagement from participants. Yet, preliminary research supports the short-term feasibility and acceptability of EMA in psychosis via mobile devices [13, 14]. Various studies show that people with schizophrenia accept and can be trained to use EMA and that compliance is comparable to that of nonclinical populations [14-19]. Notably, EMA has demonstrated incremental validity over traditional retrospective reports in assessing symptoms associated with schizophrenia [18, 20]. For example, Ben-Zeev et al. [18] found that EMA was able to capture greater variability in affective and psychotic experiences than traditional retrospective reports in a sample of 24 individuals diagnosed with schizophrenia. In sum, these studies show that mobile technology-based EMA can be feasible and acceptable to patients with psychotic-spectrum disorders. However, extant research on the implementation of EMA in psychosis has mainly recruited from outpatient treatment settings [15, 16, 21], where patients might exhibit higher levels of

functioning and stability. Moreover, many of these studies used EMA-based *interventions* for psychosis, suggesting that participants might have been more engaged in the EMA because they were receiving a treatment (e.g., [16]).

In addition to studies of stable outpatients with psychosis, EMA studies in acutely ill samples have typically been conducted exclusively during an inpatient hospitalization when adherence to procedures may be different than when patients are living in the community. For instance, Kimhy and colleagues [22] administered EMA to 10 hospitalized patients with psychosis. Patients were given mobile devices and asked to complete up to 10 samples during one day. On average, these 10 individuals completed 8 surveys during the one-day assessment period. Completion rates were fairly high but as the authors note, this was a very small sample with a very short assessment period in a restrictive environment, meaning that the novelty of EMA and oversight might have boosted the completion rate. In another study in an inpatient sample by Kimhy and colleagues [23], a similarly short assessment period of two days was used, in which 33 participants received 10 EMA prompts per day on a study-provided device. Completion rates were quite high as well (81%). Lastly, So and colleagues [24] recruited 26 patients at admission for an acute psychotic episode to complete EMA for seven times per day for 14 days during hospitalization. In this longer assessment paradigm, EMA completion significantly reduced as only 16 of 26 patients completed at least 30 EMA samples, which was set as the "minimum compliance rate" (at least 30% of available assessments). Thus, 38.4% of participants completed less than 30% of EMA surveys. Taken together, these studies show that EMA during inpatient hospitalization is feasible but it appears that engagement reduces over time.

A notable research gap is in the study of acutely ill patients with psychosis *following a hospital discharge* when risk of relapse or other negative outcomes is highest for this population. Palmier-Claus and colleagues [25] conducted an EMA study with a subgroup of 12 participants recruited within four weeks of starting, restarting or changing their medication because of worsened symptoms or within 30 days of a hospital admission. Of these 12 individuals, six (50%) completed <33% of EMA assessments over a one-week period. More recently, Ben-Zeev et al. [26] examined use of an mHealth intervention in 342 individuals with schizophrenia-spectrum disorders recruited within 60 days of a hospitalization and followed for up to 6-months. They found that 44% of the sample used the intervention an average of 4.3 days per week. These studies suggest that EMA feasibility/acceptability might vary depending on patients' clinical status and recruitment context. To our knowledge, no previous studies have recruited patients with psychosis during a hospitalization for an acute episode and assessed their use of EMA *immediately following discharge* when risk of negative outcomes is highest.

1.2 Rationale for the present study

In the current study, we targeted patients who were recently hospitalized for psychosis and its negative sequelae (e.g., suicidality). The post-hospital period is a critical time to study patients because treatment nonadherence is particularly prevalent and problematic immediately following discharge. Moreover, the transition from inpatient to outpatient treatment produces the highest risk of nonadherence and drop out [27, 28]. The goal of the

present study was to assess the feasibility and acceptability of using EMA to study adherence in the first month after discharge from a psychiatric hospitalization. Given the low treatment adherence rates post-hospitalization, we expected EMA to be challenging for many patients. However, if the field is to advance its support of patients during this important transitional period, more research is needed to understand the actual limitations and barriers of technology-based assessments. We explored if EMA methods would be feasible, measured by patients' familiarity with and ability to use mobile devices, and willingness to participate and remain in the study. We also examined EMA acceptability, characterized by survey completion rates, ratings of usability and satisfaction with survey completion, and qualitative feedback. These pilot data were collected to inform and optimize future EMA research methods for patients with psychosis transitioning from inpatient to outpatient treatment.

2. Material and methods

2.1 Participants

Eligibility criteria were: (a) currently hospitalized (inpatient or partial psychiatric hospital); (b) DSM-5 criteria for a psychotic-spectrum disorder (i.e., schizophrenia, schizoaffective disorder, delusional disorder, schizophreniform disorder, psychosis NOS) or a mood disorder (major depression or bipolar disorder) with psychotic features based on diagnostic interview (Structured Clinical Interview for DSM-IV modified to assess DSM-5 criteria; [29]); (c) 18 years or older; (d) prescribed oral antipsychotic medication; and (e) ability to speak and read English sufficiently to complete the assessments. Exclusion criteria were: (a) planned discharge to supervised living settings or participation in outpatient adherence programs (e.g., medication packaging/monitoring); (b) pregnancy or medical condition contraindicating use of antipsychotics (e.g., dementia); or (c) homelessness. Current or past risk for self-harm/suicidality and harm to others were assessed at intake but were not exclusion criteria.

A total of 65 patients were initially enrolled in the study, with 70.7% (n=46) recruited from inpatient units and 29.3% (n=19) recruited from the partial hospital setting. Participants averaged 37.2 (SD=13.4) years of age, 45% were male, 79% were non-Latino White, 5% were African American, 9% were Latino, and 4% were of other ethno-racial origins. A majority of participants were either single, divorced, or separated (76.6%), with only 23.4% being married or living with their significant other. Most participants had at least a high school degree (77.4%) but only 15.4% completed a college degree. Only 8% were employed full-time and nearly half (49%) were psychiatrically and/or physically disabled. Household income was <\$30,000/year for most participants (73%).

2.2 Procedures

Recruitment occurred during patients' inpatient or partial hospitalization at a large psychiatric hospital in the New England region of the U.S.A. The study was approved by the Institutional Review Board of the hospital. Electronic medical records for newly admitted patients were regularly reviewed by a research assistant after obtaining a Protected Health Information waiver. If a patient appeared likely to meet eligibility criteria, permission to

approach the patient was obtained from the attending physician, and the research assistant approached the patient and explained the purpose and procedures of the study. Patients who consented to join the study received an initial assessment of symptoms and functioning while in the hospital, at which point their eligibility for the study was either confirmed or denied. Participants were compensated for study participation as follows: \$25 for the baseline assessment; \$50 for completion of the 1-month EMA phase and returning the device, and \$25 at 2- and 4-month in person follow-up assessments (follow-up data are not reported here). To incentivize participants to complete EMA prompts, \$0.50 was given for each of the EMA assessments completed, for up to an additional \$60 in compensation. The present results are drawn from a larger study (that will be reported elsewhere) that used EMA to assess post-hospitalization adherence to medication and outpatient therapies, via assessment of a number of variables hypothesized to predict adherence (see [30] for further details).

We used the open source *MyExperience Tool* [31] software package to design and administer our EMA protocol on Windows-compatible mobile devices (i.e., Palm Treo 850 Pro) provided to patients as part of the study (see Figure 1 for screenshot of an EMA prompt). We considered using patients' own devices but chose instead to provide the devices to ensure standardized formatting and delivery of EMA. At discharge and following completion of informed consent and a baseline interview, devices were given to patients. All patients were given a brief EMA educational training (approximately 5 minutes) and opportunity to practice the survey procedure in the presence of research staff to address any questions or concerns. The EMA period lasted for one month post-discharge when patients returned to the clinic to return their device.

The EMA protocol consisted of two schedules: (a) *Random schedule*: this was generated within the EMA software to allow for daytime hours (9am – 9pm) to be split into three, 4-hour segments, scheduling a random sample in each of these three segments. The random schedule was specified such that each assessment would be at least 30 minutes removed from a prior or subsequent assessment; and (b) *End of Day schedule*: one assessment occurring at the same time every evening, with 9:00 pm set as the default; but personalized as needed. We included a feature that allowed participants to delay the administration of an interval assessment for 15, 30, 45, or 60 minutes at a time prior to the alarm sounding when they were too busy or unable to complete an assessment. Participants had only 5 minutes to respond to the alarm and to begin the survey, and a maximum of 2 minutes to complete each question, if an assessment was accepted. Failure to start the survey or to answer a question within the allotted time resulted in the termination of the data collection procedure for that sample.

Once per week, study staff contacted participants to provide technology trouble-shooting. As needed, staff helped participants resolve issues that might have interfered with their ability to complete EMA surveys; but this was not a prompt to complete EMA surveys. As needed, staff held follow-up calls after the initial troubleshooting contact to ensure that technical problems were resolved.

2.3 Measures of feasibility and acceptability

In addition to collecting patients' demographic characteristics and diagnoses, we assessed patients' mobile device use and connectivity; their ease using the devices for EMA; their need for EMA training or trouble-shooting; as well as potential baseline predictors of EMA completion rates, which included demographics; alcohol use (*Alcohol Use Disorders Identification Test-C (AUDIT-C)*; [32]); drug use (*Addiction Severity Index (ASI)*; [33]); positive, negative, and affective symptoms associated with psychotic-spectrum disorders (*Brief Psychiatric Rating Scale (BPRS)*; [34, 35]); and, cognitive functioning (*Trail Making Test (TMT)*; [36]). In a qualitative exit interview at the 1-month follow-up when EMA concluded, we asked participants about positive and negative aspects of using the device and how it affected them.

2.4 Statistical analyses

All statistical analyses were conducted in SPSS. Acceptability was measured via EMA completion rates, rate of responding to EMA over time (i.e., "fatigue effects; [37]), device likeability/usability ratings adapted from Kimhy et al. [22], and qualitative exit interviews of patients about their experiences using the devices. We calculated descriptive statistics for a majority of our outcomes variables. We compared those who did and did not complete EMA on independent-samples t-tests and chi square tests as appropriate. Finally, we conducted bivariate correlations and multiple regression analyses to examine factors associated with EMA adherence, and analyses of variance (ANOVAs) to examine "fatigue effects."

3. Results

3.1 Study Recruitment and Retention

See Figure 2 for participant flow. Of the 132 patients approached for the study, 87 (66%) agreed to participate in the study. Twenty-two (17%) of these participants were deemed to be ineligible based on further screening; 65 began the study. Of these 65 individuals, 55 (85%) completed the baseline assessment and were given an EMA-programmed mobile device. The remaining 10 did not complete the baseline assessment because they were either discharged before baseline assessment procedures were completed or they ultimately declined further participation in the study. Six (11%) of the 55 individuals withdrew from the study prior to completing the full month of EMA. Reasons for withdrawal included lack of interest (n=3), feeling overwhelmed (n=1), and losing contact (n=2). A total of 49 individuals (89%) remained in the study and had the mobile device for the full 1-month assessment period. During the EMA phase, 10 participants were rehospitalized. EMA paused at rehospitalization as participants were not allowed to have mobile devices on inpatient units and the study's focus was on post-hospitalization. However, when interested, these individuals were given the opportunity to recommence EMA at discharge and continue EMA until they reached a cumulative 1-month of sampling.

3.2 Personal Technology Access/Usage

Due to an undetected error in our assessment battery, technology access/usage was only assessed in a subsample of 26 participants. Results revealed that 96% (n=25) were mobile

phone users and of these individuals, 65% (n=17) had smartphones with unlimited texting plans. Twenty (77%) participants reported having internet access from their mobile phones. Lastly, 21 (81%) participants reported having internet access from a non-phone device (e.g., computer, tablet) and having an active email address.

3.3 EMA Feasibility and Completion Rates

Of the 55 patients who initially received devices at hospital discharge, 93% were returned intact (n=51), 4% were returned damaged or malfunctioning (n=2), and 4% were never returned (n=2). Of the 55 participants who received devices at discharge, 37 (67%) completed at least one survey. We used independent-samples t-tests or chi square tests as appropriate to explore differences between EMA completer vs. non-completer characteristics. We compared these groups on demographics (age, educational attainment, non-Latino White vs. minority ethnicity/race, sex); alcohol and other substance use (AUDIT, DUDIT); positive, negative, and affective symptoms associated with psychotic-spectrum disorders (BPRS); and cognitive functioning (TMT). Results revealed that participants who did not complete any EMA surveys reported significantly more use of cannabis in the past 30 days compared to those who completed any EMA ($t(36)=2.73$, $p=.01$). Otherwise, there were no statistically significant differences between the groups (all $p>.05$). Notably, negative psychotic symptoms, as measured by the BPRS, were nearly identical between the two groups: EMA completers $M=7.97$ ($SD=3.43$) vs. EMA non-completers $M=7.92$ ($SD=3.73$).

In the group of 37 EMA completers, a total of 931 random assessments ($M=23.7$, $SD=23.4$), representing 28% of the total possible random samples (n=3330), were completed. Regarding end-of-day assessments, 345 were completed ($M=8.8$, $SD=8.2$), representing 31% of the total possible end-of-day samples (n=1110). Of the individuals who completed any EMA, sixteen (43%) completed the minimally acceptable amount of 30% of available surveys. Average time to complete random assessments was 2 minutes ($SD=2$ minutes; range: <1 minute-50 minutes); average time to complete end-of-day assessments was 1 minute ($SD=1$ minute; range: <1 minute-50 minutes). There were 14 incomplete random surveys (1.5% of total random surveys completed) and 4 incomplete end-of-day surveys (1.2% of total end-of-day surveys completed).

We conducted a repeated-measures ANOVA of number of surveys completed in weeks 1 through 4 to examine possible “fatigue effects,” or decreases in response rates over time (see Figure 3). A significant main effect for time was found representing a decreasing rate of responses over the 4 weeks, $F(3, 108)=3.16$, $p=.028$, partial eta squared=.081. Follow-up post-hoc comparisons (all $p<.05$) revealed that survey completion rates at week 4 ($M=6.4$; $SD=7.2$) were significantly lower than weeks 1 ($M=9.6$; $SD=8.5$), 2 ($M=9.2$; $SD=9.4$), and 3 ($M=8.3$; $SD=9.0$). No other significant differences were found among the other weeks.

3.4 Factors Associated with EMA Completion

We conducted correlational analyses to further assess demographics, clinical characteristics and related symptoms, alcohol and other drug use, and/or cognitive functioning in relation to EMA completion rates. Results revealed that being a female was significantly associated

with completing more random and end-of-day EMA samples ($r=.29$, $p=.031$; $r=.35$, $p=.009$, respectively). Results also showed significant negative correlations between frequency of cannabis use and completion of random and end-of-day EMA samples ($r=-.43$, $p=.008$; $r=-.45$, $p=.005$, respectively), meaning that response rates decreased as reported cannabis use increased. Otherwise, none of the predictor variables, including negative psychotic symptoms, significantly correlated with EMA response rates ($ps>.05$). In stepwise multiple linear regressions using random or end-of-day completion as the dependent variable and sex and past month cannabis use as predictors, only cannabis use remained statistically significant (random assessment: $\beta=-.41$; 95% CI: -1.58 , -0.24 ; $p=.009$; $R^2=.167$; end-of-day assessment: $\beta=-.43$; 95% CI: -0.53 , -0.10 ; $p=.006$; $R^2=.183$).

3.5 EMA Usability and Acceptability Ratings

According to the usability/likeability scale [22], results showed that overall acceptability was high in this sample (range: 24-50; $M=39.9$; $SD=6.59$). See Table 1 for a summary of participants' positive and negative ratings of their experiences doing EMA for this study. In general, results revealed that participants were satisfied with their experience and reported that they would be willing to use EMA in the future. Negative ratings were minimal, and related to the challenges of operating the mobile device. We created a composite measure of negative versus positive attitudes by calculating average scores for these items. Mean positive attitude score was 4.0 ($SD=0.79$) and mean negative attitude score was 2.0 ($SD=0.78$). A dependent-samples t-test indicated that participants reported significantly higher positive attitudes toward EMA use compared with negative attitudes, $t(43)=9.99$, $p<.001$, Cohen's $d=2.54$.

We tracked participant comments during our weekly trouble-shooting calls to assess themes of problems and the degree of staff support needed to help participants resolve their issues. As planned, staff had approximately one call with participants each week: Week 1: mean telephone contact=1.22 ($SD=0.64$); Week 2: mean telephone contact=0.95 ($SD=0.44$); and, Week 3: mean telephone contact=1.09 ($SD=0.29$). On average, 1.24 problems ($SD=0.95$) were reported by participants during the month of EMA. The most common problems that required troubleshooting were: the device not correctly prompting for EMA surveys ($n=26$; 51%), the participant reporting that the prompts were inconvenient or frustrating to receive ($n=11$; 22%), and the device not powering on or other battery issues ($n=8$; 16%).

3.6 Qualitative feedback

At the conclusion of the 1-month EMA period, we conducted qualitative interviews to better understand participants' experiences using EMA. Feedback was mixed, but mainly positive. Of the 18 individuals who did not complete any EMA surveys, four completed the qualitative interview. These individuals explained that they did not complete surveys because they did not understand the procedures and/or could not get the device to work properly. One participant noted that she would have completed surveys if she could have done so at times of her choosing instead of from device prompts. Table 2 provides examples of representative comments from participants for the different interview questions, including comments from non-completers. Positive sentiments included comments that the survey questions were interesting and some reported that the device was easy to use. EMA also seemed to help

some participants increase their awareness of symptoms and their management, as well as serving as a reminder for treatment adherence. Others reported feeling good about answering the surveys because their responses would help others through the research. Negative comments centered around technical problems using the device, the repetitive nature of the questions, and that sometimes surveys were missed because they came at inconvenient times. Some reported feeling annoyed or frustrated using the device.

4. Discussion

This study examined the acceptability and feasibility of conducting EMA in adults who were recently discharged from the hospital for psychotic-spectrum disorders and their associated problems. A majority of eligible patients initially agreed to participate in the study (66%). An internal survey in a subsample of participants indicated that most individuals had personal cell phones (96%), the majority of which were smartphones (65%). These data are consistent with recent reports on connectivity among individuals with psychotic-spectrum disorders [38] and suggest that most patients with psychotics-spectrum disorders, even those who are acutely ill, likely have familiarity with using mobile devices. For example, a recent meta-analysis showed that device mobile access among individuals with psychosis is increasing, with 81.4% of those surveyed over the past 2 years reporting mobile phone ownership [39]. Furthermore, in the current study patients generally reported more positive than negative attitudes toward EMA via smartphones and troubleshooting calls in the month post-discharge were able to resolve many of the technical problems identified. Two of the three main complaints from participants related to the device not working properly. More reliable hardware would likely alleviate these concerns in future work, especially as mobile technology reliability improves. Combined, these data suggest that conducting EMA research in recently hospitalized individuals with psychotic-spectrum disorders is feasible in general, perhaps because most patients are already familiar with using mobile devices. Also, participants required minimal oversight to complete EMA and most problems were confined to either low motivation to complete EMA or technical issues that were specific to the smartphones we used to administer EMA.

Of those who met eligibility criteria and were given a phone at hospital discharge, 93% returned the devices intact, and 67% completed at least one EMA survey over the following month. Significant predictors of higher completion rates were being female and less use of cannabis. EMA research among cannabis users shows higher completion rates than in the present study (e.g., 60-80% completion; [40, 41]). However, an important difference is that these cannabis-focused EMA studies exclude individuals with psychosis and often target non-clinical college samples. Some data show that cannabis abuse is characterized by low motivation [42, 43], although this may be better explained by psychiatric comorbidities (e.g., depression [44]). Additionally, the neurological effects of frequent cannabis use, such as impaired attention and reduced goal orientation [45, 46], might hinder participants' interest and ability to complete EMA samples. In light of the present results, we suggest that the sequelae of cannabis use interact with participants' psychiatric comorbidities, particularly psychosis, to undermine EMA completion. Thus, it is not surprising that EMA completions rates drop as cannabis use rises.

Although the overall acceptability of EMA in the current sample was high, participants only completed an average of about 30% of possible EMA surveys over the 1-month period. Although lower than what has been reported in higher functioning samples with psychotic-spectrum disorders (e.g., [16, 21]), this completion rate meets what has been defined as a minimal acceptable rate to ensure external validity in EMA studies in psychosis (e.g., > 20%) [47]. In the very short-term assessment studies conducted by Kimhy and colleagues [22, 23] in inpatient samples, who were likely even more acutely ill than the current sample, EMA completion was much higher. In 1- and 2-day EMA assessment paradigms, completions rates were about 80%. However, in a longer inpatient EMA assessment study conducted by So et al. [24], the present results are somewhat similar as nearly 40% of participants completed less than 30% of possible EMA surveys over two weeks. These data suggest that length of EMA assessment period might be a crucial factor influencing EMA completion in less clinically stable patients, including the present sample.

Our current results showed that participants who completed EMA showed decreasing rates of responding to EMA prompts over time, but this drop off in survey completion only showed up at the 4 week mark. Typically, EMA studies in populations with serious mental illness are conducted in 1-2 week periods (e.g., [19]). Our data show that future studies conducted with a similar design might consider limiting the EMA window to three weeks or less. Further, the data show that different methods might be required for gathering EMA data during more than three weeks of assessments. Although we did not collect specific data on why EMA compliance dropped off at week 4, based on our qualitative interviews, it appeared that some patients became fatigued by having to carry a separate device, found answering the same questions multiple times per day repetitive, and overall thought that the “novelty” of using the device waned over time.

Moreover, we note that this study's EMA completions rates were lower than those published in other EMA studies in samples with psychosis. However, it is important to keep in mind that this is the only study to our knowledge in which EMA was attempted in recently hospitalized patients with psychosis who were acutely ill. In comparison, Granholm and colleagues' studies recruited community-dwelling patients who were enrolled in outpatient group therapy, many of whom were residing in structured living settings [14, 17, 48]. Furthermore, data from Depp and colleagues [15] showed that EMA and mobile device-based interventions were feasible for patients with psychosis, but again, samples were limited to individuals who were fairly stable, engaged with case managers, or residing in settings with significant psychosocial support resources. Ben-Zeev and colleagues [21] also recruited their sample from patients engaged in outpatient treatment groups. Indeed, psychotic symptom severity appears to be substantially worse in this cohort than in samples with higher EMA completion rates. For instance, Positive and Negative Syndrome Scale (PANSS [49]) mean ratings from Granholm et al.'s and Ben-Zeev et al.'s samples were: 62 [14]; 64 for EMA "completers" and 69 for "noncompleters" [16]; and, 78 [21]. Our study used the BPRS, another widely used measure of psychotic symptoms. According to equipercentile linking methods used by Leucht et al. [50], the mean BPRS score of 51 in our sample corresponds to a PANSS score of 91. We suggest this is a clinically meaningful difference, indicative of the acute state of our sample.

As previously discussed, Ben-Zeev et al.'s [25] recent study of patients with psychosis recruited within 60 days of a hospitalization showed that 44% used of an ecological momentary intervention over 6 months (an average of 4.3 days per week). Thus, it is not surprising that completion rates in the current sample were lower in that participants had greater current severity and impairment, relative to other EMA studies, given their recent hospitalization. In addition, our sample was experiencing the acute turmoil that often accompanies transition back into the community. Therefore, it is not surprising that completion rates will likely vary based on the context of recruitment and the individual characteristics of the sample. However, despite the lower completion rates, acceptability data and participant feedback indicated that EMA was generally acceptable and feasible in our sample. In addition, qualitative feedback suggested that some participants found aspects of EMA therapeutic for increasing awareness of symptoms and remembering to take medications.

4.1 Limitations

This study has limitations that will need to be addressed in future research. First, only 67% of participants who received EMA devices completed at least one sampling and only 43% completed at least 30% of possible surveys. If mobile device-based assessments and interventions are to be useful in this population at this critical treatment juncture, further research is needed to understand how to engage and increase compliance rates so that more patients can potentially benefit from this approach. Second, our sample was fairly small and future research should include larger samples. However, we note that our sample, although small, was relatively diverse (18% of minority backgrounds) and mostly female (55%), which is less common in studies in this area. Third, we incentivized patients to complete EMA surveys which likely affected their adherence rates and motivation level. However, the compensation provided to patients in our study was similar to the amount/type used generally used in EMA research. Lastly, we relied on study-provided mobile devices for all EMA assessments. We did this to ensure that EMA sampling was consistent across participants. Given emerging data, including our own, that show that most of these patients have mobile devices, many of which are smartphones, wider implementation of EMA-based research and intervention might be more financially feasible and acceptable if patients are able to use their own devices.

5. Conclusions

In sum, these data show that using EMA in patients with psychotic-spectrum disorders who were recently discharged from the hospital can be feasible and acceptable. However, EMA completion rates may be lower than in patients recruited in other phases of illness (residual) or other settings (outpatient). Given the salience of the transition from inpatient to outpatient care in the treatment continuum, future research should build on these results to determine how to further leverage technology to support patients' recovery post-hospitalization. Qualitative feedback from participants suggested that self-monitoring was helpful and increased insight into illness. Our data suggest that the following modifications could help to improve EMA acceptability/completion rates in this population in future research: a) use more modern and stable devices or participants' own phones when feasible; b) consider

limiting EMA period to 1-3 weeks when possible; c) combine EMA with ecological momentary *intervention* to improve motivation and adherence to procedures; and d) screen for excessive substance abuse, particularly cannabis use, given its relationship to lower survey completion rates.

Although the current study was assessment only, future research should explore the use of mobile technologies to improve patients' ability to cope with illness post-discharge to improve outpatient treatment adherence and engagement. Use of EMA and related procedures may help clinicians in the future better monitor recently discharged patients and help to identify and intervene on problems before a crisis or rehospitalization is necessary. Future research should also explore how to integrate mobile assessment plus self-management intervention strategies for recently discharged patients to provide further support during this critical period. For example, EMA can be used to help patients and providers monitor symptoms and functioning post-discharge as patients periodically respond to questions delivered by the mobile device. If a certain symptom (e.g., increased paranoia) or stressor is endorsed via EMA, the device could prompt the patient to use various self-management techniques to cope with the problem. In addition, a web-based portal can be linked to the device where providers can log in to view patients' results and contact them for follow-up if needed. We collected and will report post-hospital adherence predictor data from this research in a future study, and plan to pursue future research on mobile interventions that can be used post-hospital discharge in this population.

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Figure 1.
EMA screenshot.

Figure 2.
Recruitment and retention in the EMA study.

Figure 3.
EMA completion rates over time.

Table 1

Summary of participant-reported EMA usability/likeability (n=44).

Item	Mean (SD)
Negative attitudes	
Difficulty understanding EMA questions.	1.50 (0.95)
Difficulty typing responses.	1.91 (1.25)
Difficulty operating EMA mobile device.	2.41 (1.52)
Assessments interfered with activities.	2.09 (1.20)
Overall experience was challenging.	2.34 (1.36)
Overall experience was stressful.	1.73 (1.11)
Positive attitudes	
EMA mobile device was comfortable to carry.	3.39 (1.42)
Overall experience was pleasant.	4.02 (1.15)
Interested to participate in similar future studies.	4.21 (1.17)
Would recommend similar studies to others.	4.27 (1.11)

* Scale=1-5, with higher ratings meaning greater agreement with the item.

Table 2

Sample qualitative feedback

Interview Question	Positive Comments	Negative Comments
<i>In general what did you think about using the device to answer the questions?</i>	<ul style="list-style-type: none"> The cell phone was user friendly. It was easy to use and completing the surveys was not a problem. Helpful. Reminded me to take my pills. Simple and understandable. It was fine. No stress or anything. Easy to use, pleasant, and kind of fun. 	<ul style="list-style-type: none"> At first a little complicated. Then got used to it and not knowing when it'd go off but looking forward to expressing how I was feeling. It was tough at first, getting the phone to work properly. However, once it did it was very easy to handle. Couldn't complete the survey in time.* Extremely annoying.
<i>What aspects of using the device did you like or find most helpful?</i>	<ul style="list-style-type: none"> Gave me something to do. Making me aware of my feelings. The surveys were direct and simple. Done very quickly. The questions made me stop and think that I had good and bad days. 	<ul style="list-style-type: none"> Not sure. Just used it. Didn't think about it.
<i>Which aspects of using the device did you find difficult or unhelpful?</i>	<ul style="list-style-type: none"> Nothing. 	<ul style="list-style-type: none"> Would have been better as an app on the iPhone. Sometimes goes off at inconvenient times. Repetitive questions. Found the phone confusing and hard to use. Carrying a separate device. Just another thing to carry. Getting it to run was the biggest difficulty.*
<i>Do you have any suggestions for improving the experience for future participants who use the device?</i>	<ul style="list-style-type: none"> Good just the way it is. 	<ul style="list-style-type: none"> Take a survey whenever you want instead of waiting for it to go off.* Questions are kind of repetitive. No variation. Switch it up. Use a different phone. Add a feature where you can write something in.
<i>What did you get out of your participation in the study, if anything?</i>	<ul style="list-style-type: none"> Gave me a great understanding of what actually consists of a productive day. Self-reflection. Learned about my emotions and how I really felt about my recovery. It gave me a lot more personal insight into my day to day thoughts and emotions. Focused more on my problems a little bit for a while. 	<ul style="list-style-type: none"> Not sure. More beneficial for the researchers.

Interview Question	Positive Comments	Negative Comments
	<ul style="list-style-type: none">• Felt like I was helping others.• Symptoms became less confusing. Answering questions made me aware of consistent, multiple psych problems.• Helped me still feel involved in my treatment.• I was more mindful of my meds because I felt like someone was watching me.	

* Comments from participants who did not complete any EMA surveys.