Methodological Characteristics and Feasibility of Ecological Momentary Assessment Studies in Psychosis: a Systematic Review and Meta-Analysis

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Background: Ecological momentary assessment (EMA) involves completing multiple surveys over time in daily life, capturing in-the-moment experiences in real-world contexts. EMA use in psychosis studies has surged over several decades. To critically examine EMA use in psychosis research and assist future researchers in designing new EMA studies, this systematic review aimed to summarize the methodological approaches used for positive symptoms in psychosis populations and evaluate feasibility with a focus on completion rates. *Methods*: A systematic review of PubMed, PsycINFO, MEDLINE, Web of Science, EBSCOhost, and Embase databases using search terms related to EMA and psychosis was conducted. Excluding duplicate samples, a meta-analysis was conducted of EMA survey completion rates and meta-regression to examine predictors of completion. *Results*: Sixty-eight studies were included in the review. Characteristics and reporting of EMA methodologies were variable across studies. The meta-mean EMA survey completion computed from the 39 unique studies that reported a mean completion rate was 67.15% (95% CI = 62.3, 71.9), with an average of 86.25% of the sample meeting a one-third EMA completion criterion. No significant predictors of completion were found in the meta-regression. A variety of EMA items were used to measure psychotic experiences, of which few were validated. *Conclusions*: EMA methods have been widely applied in psychosis studies using a range of protocols. Completion rates are high, providing clear evidence of feasibility in psychosis populations. Recommendations for reporting in future studies are provided.

Key words: Experience sampling methodology/ecological momentary assessment/psychosis/schizophrenia

Introduction

Ecological momentary assessment (EMA), otherwise known as experience sampling methodology (ESM), involves the repeated measurement of momentary experiences in the context of daily life.[1,2] Measuring experiences as they arise in their natural environment can overcome retrospective recall bias[3,4] and increase ecological validity.[5] Furthermore, repeat assessment results in micro-longitudinal data, enabling examination of temporal relationships between variables.[6–9] Analysis of EMA data can include group and individual level trends in momentary experiences over time,[10] including within treatment.[11–15]

EMA has been used within psychosis research for several decades.[16] While early research (eg, Delespaul and colleagues[17]) made use of paper and pencil questionnaires which participants were prompted to complete at set times by a beeper (digital reminder system), smartphone apps and other digital devices are now typically relied on in modern EMA studies,[18] affording automated data capture and more control over when the surveys can be completed. Such devices have also extended EMA methods to include the collection of "passive data," referring to data captured on an ongoing basis without direct input from the participant, such as motion tracking, geolocation or call/text logs.[19,20] This concept, often called digital phenotyping[21] and offers the advantages of EMA plus additional behavioral, cognitive, and environmental data (for systematic review, see Benoit et al[22]).

A rich history of EMA research in psychosis has revealed important insights and emerging trends in clinical treatment. Despite this legacy, the methodologies

employed in these studies are highly variable, making the design of new EMA studies and the synthesis of results challenging. Furthermore, while some articles provide guidance on best practices for conducting and reporting on EMA studies in psychiatric populations,[23–26] and some narrative reviews have reported overall findings in the field,[16,27] a thorough systematic examination of EMA methods in psychosis studies has never been conducted. Meta-analyses have been published on compliance with EMA surveys in psychiatric populations[25,28]; however, individuals diagnosed with a psychotic condition are a population with unique experiences that warrant explicit consideration in designing EMA studies. Positive symptoms are an important focus as distinct phenomenon that show a high degree of temporal variation and are theoretically well suited to self-report as they are relatively discrete and recognizable events. It is also important to understand the willingness of individuals to reflect on and report these experiences in the moment using EMA.

To address this gap in the literature, the current systematic review aimed to summarize the methodological characteristics employed in EMA studies in psychosis which measured positive psychotic symptoms and critically examine these approaches to assist future researchers in designing new EMA psychosis studies. A further aim was to evaluate the feasibility of EMA methods in psychosis, with a focus on EMA survey completion rates. The current review focused on digital EMA as the most common tool used in modern EMA research which produces more reliable, timestamped completion rate data. Furthermore, as the use of passive EMA data in psychosis has recently been reviewed[22] and the methodological considerations differ, the focus of the current review is on active EMA method only (ie, momentary experiences captured via surveys on a digital device).

Method

The current review followed the PRISMA protocol for conducting systematic reviews (see supplementary material S1 for checklist[29]) and the protocol was registered with PROSPERO (CRD42020153429). The search was conducted on May 20, 2023.

Search Protocol

Relevant studies were retrieved by searching PubMed, PsycINFO, MEDLINE, Web of Science, EBSCOhost, and Embase with combinations of the following search terms within keywords, title, or abstract (see supplementary material S2 for search syntax for each database):

(ema OR esm OR diary OR diaries OR "momentary assessment" OR "experience sampling" OR "ambulatory assessment" OR "ambulatory monitoring")

AND

(schizo* OR psychosis OR psychotic OR "positive symptom*" hallucinat* OR "hearing voices" OR "voice hear*" OR delusion* OR paranoi* OR "unusual beliefs" OR persecut*).

Identified studies were imported into Endnote, and duplicates were systematically removed. The abstract of each study was screened by IHB for basic criteria, and full texts were then independently evaluated by 2 authors (IHB and SA/EE/SC) against the inclusion and exclusion criteria, with an Excel spreadsheet used to record screening. Reference lists of studies meeting inclusion criteria and of prior relevant reviews were manually searched for additional articles.

Study Selection

Inclusion criteria were: (1) published in a peer-reviewed journal in English, between 1980 and the date of search, (2) more than 50% of study sample were individuals diagnosed with a psychotic disorder of any kind, (3) measurement of positive psychotic symptoms (eg, auditory verbal hallucinations, delusions, etc) using digital EMA, defined as a method of assessment undertaken in an ecologically valid context at multiple points throughout the day over an extended period using a digital device (ie, smartphone, personal digital assistant, SMS), and (4) full description of EMA protocol used ie, studies needed to report the EMA device used (smartphone app, PDA, or other), sampling frequency and length (ie, how often the surveys were delivered and over how many days), survey length (ie, number of EMA items), analytical approach (eg, multilevel modeling, aggregated analysis) OR EMA completion rates.

Exclusion criteria were: (1) case studies, reviews, theses, and book chapters, (2) EMA method was not digital (ie, paper and pencil surveys), (3) data collection did not occur within naturalistic settings, (4) insufficient reporting of methodological characteristics AND EMA completion rates, (5) collection of passive EMA data only; (6) EMI studies where EMA was not a distinct and separate part of the intervention, (7) data reported in another study (eg, where this was explicitly reported within the manuscript, with the larger or more study retained). Studies were identified as a duplicate sample if this was mentioned in the method, or where the sample details were very similar in which case authors were contacted to confirm. Note that these duplicate studies were retained in the overall systematic review to provide details on publications in this research area; however, were excluded from the data synthesis to avoid biased results. Studies were also excluded from the meta-regression if they did not report completion rates.

Data Extraction

Three authors (IHB, SA, and EE) agreed on the data extraction protocol, with one (IHB/SC) completing the full data extraction using an Excel spreadsheet and a second

(SA/EE/SC) checking a random selection of 80% of these. Extracted data included the following: (1) basic study information (authors, country, and year), (2) sample characteristics (number of participants, diagnosis, age, and gender), (3) EMA characteristics (length of assessment period, number of surveys per day), (4) EMA tool (smartphone, personal digital assistant, and SMS), (5) analytical approach (time-lagged, multilevel regression, group comparisons, summary statistics), (6) EMA survey completion rates (if reported), (7) EMA items used to measure psychotic symptoms (if reported), (8) variables assessed using EMA.

Meta-Analysis and Meta-Regression

Statistical analyses were performed with R[30] by author SA. Studies reporting a completion rate from unique samples were combined using a random-effects meta-analysis model and implemented with the meta-mean function from the meta package (v4.17-0[31]). This produced a weighted, pooled estimate of the population's total mean completion rate across studies. A forest plot was generated to show the effect sizes for each of the relevant studies with the estimated meta-mean and the corresponding 95% confidence intervals. To further contextualize completion rates, a series of exploratory univariate random-effects meta-regression analyses were conducted with the aim of explaining the heterogeneity using the moderator effects of covariates assumed to impact adherence. We assessed (1) participant reimbursement, (2) number of surveys a day, (3) length of protocol, (4) device type, (5) study reporting quality (indicated by total score on the STROBE), (6) participant age, (7) gender, (8) Positive and Negative Symptom Scale (PANSS) total score, and (9) inpatient status (compared to community outpatients and mixed samples). Heterogeneity between the studies was measured through the I^2 statistic (with a value higher than 75% considered large). The proportion of between-study variance explained by the model was calculated through tau squared. For both meta-analysis and meta-regression, we included data where covariate data were reported (ie, participant reimbursement, number of surveys, etc). Both the meta-regression and meta-analyses methods require an estimate of spread using standard deviations (SD). As SD information was unavailable for a minority of studies, we imputed missing SD using predictive mean matching.[32] Bajuat plots[33] were visually inspected to determine if there may be an influence of individual studies on the beta coefficients vs. its relative contribution to the overall heterogeneity estimate.

Study Quality Analysis

Author EE/SC rated each included study against the 16 items of the adapted STROBE Checklist for Reporting EMA Studies (CREMAS[34]). The extent to which the included studies fully met, partially met, or did not meet the criteria outlined in the CREMAS is reported quantitatively, along with a descriptive summary of the range of reporting practices.

Results

Of 3391 studies identified, 285 underwent detailed evaluation, and 68 met inclusion criteria for the systematic review see PRISMA flow diagram in figure 1). Of these 68 studies, 22 were removed from the data synthesis due to having duplicate samples leaving 46 studies with unique samples. A further 7 were excluded from the meta-regression because they did not report completion rates. One of the remaining 39 studies, one study[35] included 2 different samples, resulting in 40 independent samples included in the meta-regression.

The study characteristics and sample characteristics for all included studies are outlined in table 1 (see supplementary S3 material for a list of included studies). Of the 46 studies with a unique sample, 34 were observational studies aiming to examine psychosis mechanisms or processes, 6 examined the feasibility, acceptability, or validity of EMA measures or methodologies in psychosis samples, and 6 were clinical trials of digital interventions involving EMA or using EMA within the trial methodology. There was a total of 2655 participants across these 46 unique samples, with a mean age of 36.90 years (SD = 10.27 years) and an average of 43% females. The mean illness duration was 12.81 years (SD = 8.62 years). Psychotic symptom severity at the person level was captured using a variety of measures, most frequently using the (PANSS; mean Total score from 21 studies = 51.74; SD = 14.80).

The majority (25 studies) included samples with a psychotic disorder only, 16 had a mixed sample with psychotic disorders and mood disorders with psychotic features, 4 had a mixed sample including personality disorders, 5 included participants with first-episode psychosis or meeting ultrahigh risk criteria, and 2 had a mixed sample including PTSD. Most studies were recruited from community outpatient services (35 studies), 4 from psychiatric inpatient services only, 2 from both inpatient and outpatient services, and 5 were unclear.

Methodological Features of EMA Studies

table 2 presents details of EMA study methodology. Reporting of EMA protocols varied between studies. The most common EMA protocol, adopted in 10 studies, involved 10 surveys per day (range = 3–10) over 6 days (range = 1–30) delivered within a pseudorandomized schedule of prompts spread evenly across 4, 3-hour blocks during 12–15 waking hours (most often 9 AM to 9 PM), in which participants had 15 minutes to respond. Few studies provided a thorough justification for their approach. Eighteen studies included a financial reward
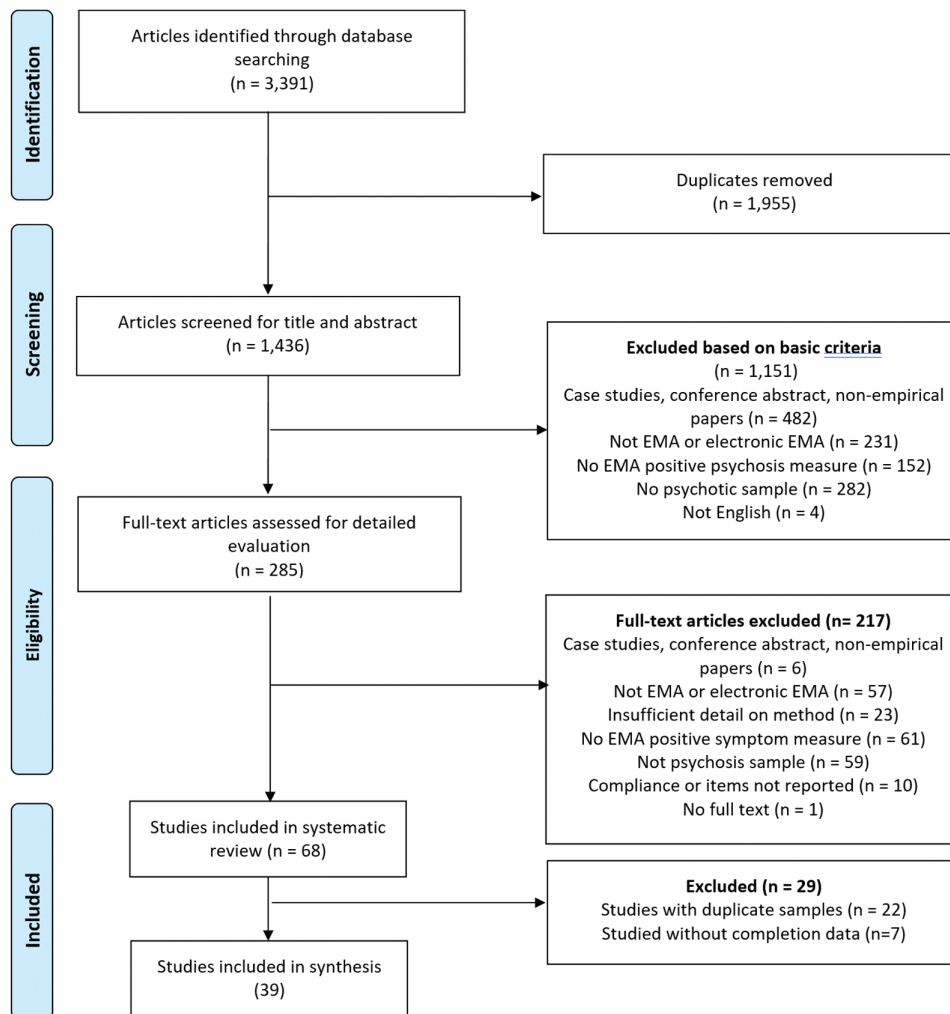
Fig. 1. PRISMA flow diagram.

for EMA completion, of which 14 provided a reward for participating in the whole EMA procedure and 4 provided rewards for each completed survey.

The most common device used was a smartphone (24 studies), followed by a PDA (17 studies), iPod (4 studies), SMS (2 studies), and computer (1 study). Notably, more recent EMA studies (published since 2017) tended to use specialized smartphone apps designed for EMA. Of the 35 studies that reported the EMA applications used, the most common was the Experience Sampling Program/iESP (7 studies) and Psymate (7 studies), followed by Movisens (6 studies), MyExperience (3 studies), Purdue Momentary Assessment Tool (2 studies), and individual apps used in only 1 study (ClinTouch, SMARTapp, CamNtech PRO-Diary, EFS Survey, iDialogPad, Ilumivu, mindLAMP, mobileQ, Omnitrack,).

The method of analysis used depended on the aims of the study. The most common aim was to examine momentary predictors of psychotic experiences using some form of multilevel modeling (61 studies). Some studies used time-lagged analysis only (12) to examine predictors

"over time" and others did both time-lagged and contemporaneous predictors "in the moment" (20 studies), or network analysis (3 studies). Five studies used descriptive statistics, correlations, or group comparison analyses based on aggregated EMA data.

Completion Rates of EMA Surveys

table 3 reports the completion rates across all 68 studies. Of the 40 unique samples that clearly reported a completion rate, results from the meta-analysis estimated the total meta-mean completion rate across studies was 67.15% (95% *CI* = 62.3, 71.9). A forest plot of mean completion rates for each study and overall meta-mean estimates is provided in figure 2. The Q value for heterogeneity was 1559.00, *P* < .001, and the I^2 index for the meta-analysis was 97.6%, suggesting high levels of heterogeneity between studies which supports the use of a random effect model. It is important to note that the total completion rate may be overestimated by studies, which derived this value from subsamples, which met

Table 1. Study and Sample Characteristics of all Included Studies

	Study	Location	Type of Study	Sample Size	Clinical Condition	Mean Age	Gender (% Female)	Mean Illness Severity and Measure	Mean Illness Duration	Recruitment Context
1	Ainsworth, Palmier-Claus[35]	UK	Acceptability study	24	SZ 92% SZA 8%	33.00	21	PANSS Total: 56.10	NA	Community outpatients
2	Bartolomeo, Raugh[36]	USA	Observational study	50	SZ or SZA 100%	39.53	66	PANSS Total 62.14	NA	Community outpatients
3	Bell, Rossell[11]	Australia	Clinical trial	17	BDwPF 11.8% SZA 29.4% SZ 52.9% USPD 5.9%	39.12	65	PSYRATS AVH Total: 28.47	Not reported	Community outpatients
4	Bell, Velthorst[37]	UK	Observational study	33	NAP 100%	39.1	21	PANSS Positive Mean: 1.85	NA	Psychiatric in-patients
5	Ben-Zeev, Ellington[38]	USA	Observational study	145	SZ 72% SZA 28%	46.50	39	PANSS Total: 66.77	24.35	Community outpatients
6	Ben-Zeev, Frounfelker[39]	USA	Observational study	24	SZ/SZA 100%	44.87	29	SAPS: 23.58 SANS: 10.54	16.95	Community outpatients
7	Ben-Zeev, McHugo[40]	USA	Validation study	24	SZ 100%	44.87	29	PANSS Total: 23.58	16.95	Community outpatients
8	Ben-Zeev, Morris[41]	USA	Observational study	130	SZ 72% SZA 28%	46.20	41	PANSS total: 66.69	25.37	Community outpatients
9	Berry, Emsley[42]	UK	Observational study	19	FEP 47% SZ 27% SZA 21% PNOS 5%	33.70	63	NA	NA	Community outpatients
10	Brand, Bendall[43]	Australia	Observational study	28	35.7% SZ 25% SZA 14.3% MDwPF 17.8% PNOS	44.96	64	PSYRATS Total = 28.21	22.27	Community outpatients
11	Buck, Munson[44]	USA	Observational study	465	BD 39.8% MDD 66.7% PTSD 43.2% SZA 25.6% SZ 29.2% SUD 32.5%	40.67	52	NA	NA	NA
12	Cristóbal-Narváez, Sheinbaum[45]	Spain	Observational study	96	FEP 100%	22.23	31	NA	NA	Community outpatients
13	Daemen, van Amelsvoort[46]	UK	Observational study	147	PD 100%	34.3	33	PANSS Positive symptoms Total: 12.1	12.29	NA
14	Daemen, van Amelsvoort[47]	UK, Netherlands Belgium	Observational study	194	PD 100%	34.5	35	NA	NA	NA
15	Dokuz, Kani[48]	Turkey	Observational study	57	SZ 92.7% SZA 4.9% DelD 2.4%	32.76	17	PANSS Positive Mean: 1.85	11.32	Community outpatients
16	Dupuy, Abdallah[49]	France	Observational study	33	SZ 100%	33.90	27	PANSS total = 69.00	9.54	Community outpatients
17	Fett, Hanssen[50]	UK	Observational study	29	SZ 79.3% SZA13.8% PNOS 6.9%	39.10	25	NA	NA	Community outpatients

Table 1. Continued

	Study	Location	Type of Study	Sample Size	Clinical Condition	Mean Age	Gender (% Female)	Mean Illness Severity and Measure	Mean Illness Duration	Recruitment Context
18	Fielding-Smith, Greenwood[51]	UK	Observational study	35	SZ 38.7% SZA 6.5% Other PD 9.7% BPD 32.3% MDDwPF 9.7% BD 3.2%	41.90	58	NA	NA	Community outpatients
19	Gaudiano, Ellenberg[52]	USA	Observational study	23	SZspectrum/MDwPF 100%	40.00	78	NA	NA	Recently released in-patients
20	Geraets, Snippe[53]	Germany	Clinical trial	91	SZ 87% SZA 5% PDNOS 8%	39.50	31	NA	15.65	Community outpatients
21	Gohari, Moore[54]	USA	Observational study	101	SZ or SZA 100%	NA	NA	NA	NA	
22	Granholm, Loh[55]	USA	Feasibility and validity study	54	SZ 79% SZA 21%	44.06	37	PANSS Total: 61.89	23.83	Community outpatients
23	Hanssen, Balvert[56]	Netherlands	Clinical trial	50	SZ spectrum 100%	39.10	36	PANSS Total = 57.30	NA	Community outpatients
24	Hartley, Haddock[57]	UK	Observational study	32	SZ 47% PDNOS 44% SZA 6% APD 3%	33.00	33	PANSS Total: 62.60	NA	Community outpatients
25	Hartley, Haddock[58]	UK	Observational study	32	SZ 47% PDNOS 44% SZA 6% APD 3%	33.00	33	PANSS Total: 62.60	NA	Community outpatients
26	Harvey, Miller[59]	USA	Validation study	173	SZ 59% BD 41%	40.6	59	NA	NA	Community outpatients
27	Jongeneel, Aalbers[9]	Netherlands	Clinical trial	95	SZ 44.4% PNOS 20% SZA 11.1% PTSD 8.9% BPD 5.6% Mood disorder 5.6% Other 4.4%	43.00	54	NA	15.90	Community outpatients
28	Kammerer, Meh[60]	Germany	Observational study	67	SZ 70% SZA 24% DelDx 6%	38.04	40	PANSS total = 66.31	NA	Community outpatients

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Table 1. Continued

	Study	Location	Type of Study	Sample Size	Clinical Condition	Mean Age	Gender (% Female)	Mean Illness Severity and Measure	Mean Illness Duration	Recruitment Context
29	Kimhy, Lister[61]	USA	Observational study	54	SZ 76% SZA 20% Szphreniform 4%	32.31	60	NA	NA	Community outpatients
30	Kimhy, Vakhrusheva[62]	USA	Observational study	33	SZ 100%	27.80	45	NA	NA	Inpatients
31	Kimhy, Wall[63]	USA	Observational study	40	SZ 68% SZA 18% PDNOS 7% SZphreniform 7%	30.50	38	NA	NA	Inpatients and outpatients
32	Kimhy, Delespaul[64]	USA	Feasibility and acceptability study	11	SZ 100%	34.50	55	NA	10.30	Inpatients
33	Klippel[65]	Netherlands	Observational study	59	FEP 54% ARMS 46%	NA	NA	NA	NA	Community outpatients
34	Ludwig, Mehl[66]	Germany	Observational study	71	Psychotic disorder 100%	37.80	42	PANSS Total = 66.32	13.46	Community outpatients
35	Lüdtke, Kriston[67]	Germany	Observational study	35	SZ 97% SZA 3%	39.00	54	NA	NA	Community outpatients
36	Lüdtke, Moritz[68]	Germany Norway	Clinical trial	30	NAP 100%	42.87	53	PANSS Positive Total: 13.03	NA	NA
37	Miller, Harvey[69]	USA	Validation study	173	SZ/SZA 59% BD 41%	40.60	57	NA	NA	Community outpatients
38	Moitra, Park[70]	USA	Feasibility and validation study	24	BDwPF 4.2% MDDwPF 8.3% SZA 45.8% SZ 4.2% USPD 37.5%	38.00	75	BPRS Total = 50.60	NA	Inpatients and outpatients
39	Monsonet, Rockwood[71]	Spain	Observational study	43	SZ 74.4% DDwPF 2.6% BDwPF 23%	24.59	31	NA	NA	Community outpatients
40	Morgan, Strassnig[72]	USA	Observational study	240	SZ 50.7% BD 49.2%	40.18	59	PANSS Positive Symptoms SZ Total: 15.88 BD Total: 10.32	NA	NA
41	Mulligan, Haddock[73]	UK	Observational study	22	SZ 59% SZA 5% NAP 36%	37.40	41	PANSS total: 64.80	12.00	Community outpatients
42	Nittel, Lincoln[74]	Germany	Observational study	37	SZ 72% SZA 22% SPD 3% DelD 3%	35.87	56	PANSS total 62.70	10.68	Community outpatients
43	Orth, Hur[75]	USA	Observational study	37	SZ 34.4% SZ-BD type 21.9% SZA depressive type 18.8% BPwPF 15.6% MDDwPF 9.4%	41.66	44	The Expanded Brief Psychiatric Rating Scale - the suspiciousness item 2.13	NA	Community outpatients

Table 1. Continued

	Study	Location	Type of Study	Sample Size	Clinical Condition	Mean Age	Gender (% Female)	Mean Illness Severity and Measure	Mean Illness Duration	Recruitment Context
44	Palmier-Claus, Ainsworth[18]	UK	Feasibility and validation study	44	SZ 53% SZA 8% SZphreniform 5%	31.43	22	PANSS Total = 56.70	7.70	Community outpatients
45	Parrish, Chalker[76]	USA	Observational study	96	SZ 10.4% SZA 42.7% BDwPF 16.7% MDDwPF 2.1%	43.90	55	PANSS positive= 18.0 PANSS negative = 13.30	NA	Community outpatients
46	Parrish, Chalker[77]	USA	Observational study	128	SZ 33.5% SZA 43.7% ADwPF 22.6%	43.4	56	PANSS Positive Symptoms 18.1	NA	NA
47	Perez, Tercero[78]	USA	Observational study	173	SZ 59% BD 41%	40.6	59	NA	NA	NA
48	Pieters, Deenik[79]	Netherlands	Feasibility and acceptability study	33	SZ 48.5% SZA 12.1% Other PD 39.4%	37.6	24	BPRS Positive Symptoms Total: 12.9	NA	Community outpatients
49	Pos, Meijer[80]	Netherlands	Observational study	50	SZ/SZphreniform 60% PNOS 18% SZA 6% Other 16%	23.70	20	Green Paranoid Thought Scales = 51.90	NA	Community outpatients
50	Radley, Barlow[81]	UK	Observational study	35	Psychosis 100%	41	80	NA	NA	NA
51	Raugh, James[20]	USA	Observational study	52	SZ 41.6% SZA 54.1% BDwPF 4.1%	38.56	65	NA	NA	Community outpatients
52	Raugh, Strauss[82]	USA	Feasibility and acceptability study	54	SZ 40.7% SZA 53.7% BDwPF 5.6%	39.17	65	PANSS Positive 13.58	NA	Community outpatients
53	Reininghaus, Kempton[83]	UK	Observational study	51	FEP 54% ARMS 46%	28.30	45	NA	NA	Community outpatients
54	Reininghaus, Gayer-Anderson[84]	UK	Observational study	50	FEP 54% ARMS 46%	28.40	44	NA	NA	Community outpatients
55	Reininghaus, Oorschot[85]	UK	Observational study	51	FEP 54% ARMS 46%	28.30	45	NA	NA	Community outpatients
56	Sa, Wearden[86]	UK	Observational study	25	FEP 33% SZ 38% SZA 5% PNOS 10% Other 14%	52.00	29	NA	NA	Community outpatients
57	Schick, Van Winkel[87]	Netherlands	Observational study	96	NAP 100%	33.45	33	PANSS Positive 11.83	NA	Community outpatients
58	Smelror, Bless[88]	Belgium Norway	Clinical trial	2	NAP 100%	17.70	NA	PANSS positive mean score = 14.00	2.80 (1.80)	Inpatients and outpatients
59	So, Chung[89]	China	Observational study	47	SZ spectrum 100%	43.83	63	PANSS Total = 51.98	NA	Outpatients

Table 1. Continued

	Study	Location	Type of Study	Sample Size	Clinical Condition	Mean Age	Gender (% Female)	Mean Illness Severity and Measure	Mean Illness Duration	Recruitment Context
60	So, Chau[90]	Hong Kong	Observational study	25	SZ 38% PNOS 38% MDwPF 15% DeID 8%	34.07	43	PANSS total = 64.07	NA	NA
61	So, Peters[91]	UK	Observational study	26	SZ 41% PNOS 23% MDwPF 14% SZA 9% SZphreniform 5% DeID 5% APD 5%	36.12	50	PANSS total = 64.23	NA	Psychiatric in-patients
62	So, Peters[92]	UK	Observational study	26	SZ 33% PNOS 33% MDwPF 13% SZA 7% DeID 7% APD 7%	36.12	50	PANSS total =64.23	NA	Psychiatric in-patients
63	Steenkamp, Parrish[93]	USA	Observational study	222	SZ 28.2% SZA 33% BDwPF 36.4% MDDwPF 2.4%	41.7	65	PANSS Positive Symptoms Total: 16.3	NA	NA
64	Strauss, Esfahlani[94]	USA	Observational study	30	SZ/SZA 100%	41.39	43	NA	NA	Outpatients
65	Swendsen, Ben-Zeev[95]	USA	Observational study	145	SZ 68% SZ 32%	46.50	39	PANSS total = 66.77	NA	Community outpatients
66	Vilardaga, Hayes[96]	USA	Observational study	25	SZA 56% SZ 28% BD 4% Other 12%	45.00	40	NA	NA	Community outpatients
67	Westermann, Grezellschak[97]	Germany	Observational study	15	SZ 100%	39.90	40	CAPE positive = 1.90 CAPE negative = 2.21	18.50	Community outpatients
68	Wright, Palmer-Cooper[98]	UK	Observational study	41	SZ spectrum 71% BD 21% PTSD 21% OCD 21% ASD 21%	31.85	46	NA	NA	Community outpatients

Note: AD, affective disorder; APD, acute psychotic disorder; ARMS, at-risk mental state; ASD, autism spectrum disorder; BDwPF, bipolar disorder with psychotic features; BD, bipolar disorder; BPD, borderline personality disorder; BPRS, brief psychiatric rating scale; CAPE, community assessment of psychic experiences; CHR, clinical high risk; CPD, cluster c personality disorder; DeID, delusional disorder; DD, depressive disorder; FEP, first episode psychosis; MDDwPF, major depressive disorder with psychotic features; MDwPF, mood disorder with psychotic features; NAP, non-affective psychosis; OCD, obsessive-compulsive disorder; PNOS, psychotic disorder not otherwise specified; PTSD, post-traumatic stress disorder; PANSS, Positive and Negative Symptom Scale; SAPS, scale for the assessment of positive symptoms; SANS, scale for the assessment of negative symptoms; SZA, schizo-affective disorder; SZ, schizophrenia; szphreniform, schizophreniform; SUD, substance use disorder UHR, ultrahigh risk; USPD, unspecified psychotic disorder

Table 2. EMA Study Methodology

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
1 Ainsworth, Palmier-Claus[35]	6	4	35	Stratified pseudorandomized prompts are scheduled at least 1 h apart within 12 h window from 9 AM to 9 PM. 15 min windows to complete survey.	$38 USD	SMS and mobile app	Multilevel modeling
2 Bartolomeo, Raugh[36]	6	8	16	Stratified pseudorandomized prompts are scheduled at least 18 min to 3 h apart within 12 h window from 9 AM to 9 PM. 25 min window to complete: 10 min prior to and 15 min after receiving a notification	$ 20 USD per hour for laboratory testing, $1 USD per EMA survey completed, $80 USD for returning the phone at the end of the study.	Smartphone app *mEMA app from ilumivu*	Multilevel modeling
3 Bell, Rossell[11]	6	10	39	Stratified pseudorandomized prompts are scheduled within 4 blocks of a personalized 12 h waking window. 15 min window to complete survey.	None	Smartphone app *Movisens*	NA
4 Bell, Velthorst[37]	7	10	34	Stratified pseudorandomized prompts scheduled at least 1 h apart within 12 h window from 8 AM to 10:30 PM with at least 15 min and at most 1.5 h between 2 consecutive beep.	40 pounds	iPod	Time-lagged multi-level modeling
5 Ben-Zeev, Ellington[38]	7	4	8	Randomized prompts are scheduled at equal intervals across 13 h window from 9 AM to 10 PM.	$35 USD	PDA *Purdue Momentary Assessment Tool (PMAT)*	Multilevel modeling
6 Ben-Zeev, Frounfelker[39]	7	6	24	Stratified pseudorandomized prompts are scheduled within 4 blocks of a personalized 12 h waking window. 15 min window to complete survey.	NA	PDA *Experience Sampling Program version 4.0*	Time-lagged multi-level modeling
7 Ben-Zeev, McHugo[40]	7	6	13	Randomized prompts are scheduled at equal intervals across 13 h window from 9 AM to 10 PM.	NA	PDA *Experience Sampling Program version 4.0*	Proximal and time-lagged multilevel modeling
8 Ben-Zeev, Morris[41]	7	4	15	Stratified pseudorandomized prompts are scheduled within 4 blocks of a personalized 12 h waking window. 15-min window to complete survey.	NA	PDA *Purdue Momentary Assessment Tool (PMAT)*	Time-lagged multi-level modeling
9 Berry, Emsley[42]	6	6	33	Pseudorandomized prompts are scheduled within personalized 11-h waking window. 15 min window to complete survey.	None	Smartphone	Multilevel modeling
10 Brand, Bendall[43]	6	10	4	Stratified pseudorandomized prompts are scheduled at least 1 h apart within 10 h window from 10 AM to 8 PM. 15 min windows to complete survey.	NA	Mobile app *Movisens*	Proximal and time-lagged multilevel modeling

Table 2. Continued

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
11	Buck, Munson[44]	30	4	12	Stratified pseudorandomized prompts scheduled at least 3 apart within 12-h window from 9 AM to 9 PM	$75USD	Smartphone app	Proximal and time-lagged multilevel modeling
12	Cristóbal-Narváez, Sheinbaum[45]	7	8	13	Randomized prompts are scheduled across 12 h window from 10 AM to m-10 PM.	NA	PDA	Multilevel modeling
13	Daemen, van Amelsvoort[46]	6	10	NA	Stratified pseudorandomized prompts are scheduled within 90-min window between 7:30 AM and 10:30 PM 10-min windows to complete survey.	NA	Smartphone app *PsyMate*	Proximal aggregated and time-lagged multilevel modeling
14	Daemen, van Amelsvoort[47]	6	10	10	Stratified pseudorandomized prompts are scheduled at least 90-min apart within 12 h window from 7:30 AM to 10:30 PM.	NA	Smartphone app *PsyMate*	Proximal and time-lagged multilevel modeling
15	Dokuz, Kani[48]	6	10	NA	Stratified pseudorandomized prompts are scheduled at least 90-min apart within 16 h window from 7:00 to 23:00 or 08:00 to 00:00. 15 min windows to complete survey.	NA	Smartphone	Multilevel modeling
16	Dupuy, Abdallah[49]	7	5	NA	Stratified pseudorandomized prompts are scheduled within 3 blocks of a 15 h waking window.	100 Euros for EMA and MRI component of study	Mobile app	Time-lagged multilevel modeling
17	Fett, Hanssen[50]	7	10	34	Pseudorandomized prompts are scheduled within 14.5-h window between 8 AM and 10.30 PM.	40 British Pounds	iPod/iPhone	Proximal and time-lagged multilevel modeling
18	Fielding-Smith, Greenwood[51]	9	10	8	Stratified pseudorandomized sampling within equal blocks during day. Max 15 min to respond.	NA	Mobile app *Movisens*	Proximal and time-lagged Multilevel modeling
19	Gaudiano, Ellenberg[52]	28	4	13	Randomized prompts are scheduled within 12 hour window 9 AM–9 PM. One fixed prompt at 9 PM.	$0.50 per survey, up to $60	Smartphone app *MyExperience Tool*	Time-lagged multilevel modeling
20	Geraets, Snippe[53]	6 to 10	10	16	Stratified pseudorandomized prompts are scheduled at least 1.5 h apart within 13 h window from 7:30 AM to 10:30 PM.	30 Euro	Mobile app *PsyMate*	Proximal and time-lagged Multilevel modeling and network analysis
21	Gohari, Moore[54]	30	3	NA	Stratified pseudorandomized prompts are scheduled at least 2 h apart within participant's sleep and wake schedule. 1 h windows to complete survey.	NA	Android smartphone	Multilevel modeling
22	Granholm, Loh[55]	7	4	14	Randomized prompts are scheduled at equal intervals across 13 h window from 9 AM to 10 PM.	$35 USD	PDA *Purdue Momentary Assessment Tool (PMAT)*	Multilevel modeling

Table 2. Continued

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
23 Hanssen, Balvert[56]	21	6	15	Stratified pseudorandomized prompts are scheduled at least 1.5 h apart within 12 h window from 10 AM to 10 PM	150 Euros	Mobile app *SMARTapp*	Multilevel modeling
24 Hartley, Haddock[57]	6	10	5	Stratified pseudorandomized prompts are scheduled intervals 15 h between 9 AM and 12 AM. 15 min window to complete survey.	NA	PDA *ESP software*	Proximal and time-lagged multilevel modeling
25 Hartley, Haddock[58]	6	10	7	Stratified pseudorandomized prompts are scheduled intervals across 15 h between 9 AM and 12 AM. 15 min window to complete survey.	NA	PDA *ESP software*	Proximal and time-lagged multilevel modeling
26 Harvey, Miller[59]	30	3	NA	Stratified pseudorandomized prompts are scheduled at least 2 h apart within 12 h window from 9 AM to 9 PM. 1 h windows to complete survey.	NA	SMS web link sent to Smartphone	Multilevel modeling
27 Jongeneel, Aalbers[9]	6	10	45	Stratified pseudorandomized prompts scheduled intervals across 15 h between 7:30 AM and 10:30 PM. 15 min window to complete survey.	NA	Mobile app *PsyMate*	Proximal and time-lagged, Time series network analysis
28 Kammerer, Mehl[60]	6	10	9	Stratified pseudorandomized prompts are scheduled intervals at least 30 min apart across 12 hs between 10 AM and 10 PM.	45 Euros	Mobile app *Movisens*	Proximal and time-lagged multilevel modeling
29 Kimhy, Lister[61]	1.5	10	10	Randomized prompts within 12 h window between 10 AM and 10 PM.	NA	PDA *iESP software*	Descriptive statistics, t-tests, correlations, moderation
30 Kimhy, Vakhrusheva[62]	2	10	16	Randomized prompts within 12 h window between 10 AM and 10 PM.	NA	PDA *iESP software*	Multilevel modeling
31 Kimhy, Wall[63]	3	10	NA	Randomized prompts within 12 h window between 10 AM and 10 PM.	NA	PDA *iESP software*	Multilevel modeling
32 Kimhy, Delespaul[64]	1	10	16	Stratified pseudorandomized prompts scheduled intervals across 12 h between 10 AM and 10 PM. 3 min window to complete survey.	NA	PDA *iESP software*	Multilevel modeling
33 Klippel[65]	6	10	23	Stratified pseudorandomized prompts. 10 min to complete survey	NA	PDA *PsyMate*	Multilevel modeling
34 Ludwig, Mehl[66]	6	10	19	Stratified pseudorandomized prompts scheduled intervals across 12 h between 10 AM and 10 PM. 30 min window to complete survey.	45 Euros	Mobile app *Movisens*	Time-lagged Multilevel modeling
35 Lüdtke, Kriston[67]	2	8	5	Fixed intervals of 4 h periods across 12 h window from 9 AM to 9 PM. 5 min to complete survey	NA	PC, laptop, smartphone, or tablet *EFS Survey*	Time-lagged Multilevel modeling
36 Lüdtke, Moritz[68]	7	10	13	NA	NA	Smartphone	Time-lagged Multilevel modeling

Table 2. Continued

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
37 Miller, Harvey[69]	30	3	10	Stratified pseudorandomized prompts scheduled intervals across 12 h between 9 AM and 9 PM. 1 h window to complete survey.	NA	Mobile app	Multilevel modeling
38 Moitra, Park[70]	28	4	13	Randomized prompts are scheduled within 12 h window 9 AM–9 PM. One fixed prompt at 9 PM.	$0.50 USD per survey	PDA *MyExperience*	Correlations
39 Monsonet, Rockwood[71]	7	8	NA	Stratified pseudorandomized prompts are scheduled within 11 h window from 11 AM to 10 PM. 15 min windows to complete survey.	NA	PDA and Smartphone app	Multilevel modeling
40 Morgan, Strassnig[72]	30	3	NA	Stratified pseudorandomized prompts are scheduled at least 1 h apart within 12 h window from 9 AM to 9 PM. 1 h windows to complete survey.	$1USD for each survey and $50USD endpoint assessment	SMS Web link sent to Smartphone	Multilevel modeling
41 Mulligan, Haddock[73]	7	5	16	Stratified random intervals within tailored waking hours. 10 min to complete survey.	NA	PDA *CamNtech PRO-Diary*	Time-lagged multilevel modeling
42 Nittel, Lincoln[74]	6	10	16	Randomized prompts within 14 h window between 9 AM and 11 PM.	30 Euros	iPod touch *iDialogPad*	Time-lagged multilevel modeling
43 Orth, Hur[75]	7	8	NA	Stratified pseudorandomized prompts are scheduled at least 1 h apart within 13 h window from 8 AM to 9 PM. 15 min windows to complete survey.	monetary bonus for completing 80% of EMAs	Smartphone app *OmniTrack for Research*	Proximal and time-lagged Multilevel modeling
44 Palmier-Claus, Ainsworth[18]	7	6	31	Pseudorandomized prompts are scheduled at least 1 h apart across 12 h window from 9 AM to 9 PM. 15 min window to complete survey	None	Smartphone app *ClinTouch*	Aggregated descriptive statistics and correlation
45 Parrish, Chalker[76]	10	3	7	Fixed schedule is chosen by participant (morning, afternoon, and evening). 1 h window to complete survey.	$1.66 per survey, max $50	Mobile app	Proximal and time-lagged multilevel modeling
46 Parrish, Chalker[77]	10	3	NA	Stratified pseudorandomized prompts are scheduled at least 2 h. 15 min windows to complete survey.	$1.66USD for each survey completed, for a maximum of $50USD	NeuroUX platform web link sent to Smartphone	Multilevel modeling
47 Perez, Tercero[78]	3	30	NA	Stratified pseudorandomized prompts are scheduled at least 2 h apart within 12 h window from 9 AM to 9 PM. 1 h windows to complete survey.	NA	SMS Web link sent to Smartphone	Multilevel modeling
48 Pieters, Deenik[79]	7	8	24	Stratified pseudorandomized prompts are scheduled at least 90-min apart within 12 h window from 10 AM to 10 PM. 15 min windows to complete survey.	NA	Smartphone app *PsyMate*	Descriptive statistics
49 Pos, Meijer[80]	6	10	52	Randomized prompts within 15 h window between 7:30 AM and 10:30 PM.	NA	PDA *PsyMate*	Multilevel modeling

Table 2. Continued

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
50 Radley, Barlow[81]	10	6	21	Stratified pseudorandomized prompts are scheduled at least 1 h apart within 14 h window from 9 AM to 11 PM. 5 min windows to complete survey.	25 pounds	Smartphone app *mobileQ*	Time-lagged Multilevel modeling
51 Raugh, James[20]	6	8	NA	Stratified pseudorandomized prompts are scheduled at least 90-min apart within 12 h window from 9 AM to 9 PM. 25 min windows to complete survey.	$1USD per survey completed, and an $80 USDbonus for returning the study phone.	Smartphone app *Ilumivu and the Alert app from Empatica*	Multilevel modeling
52 Raugh, Strauss[82]	6	8	NA	Stratified pseudorandomized prompts scheduled at least 90-min apart within 12 h window from 9 AM to 9 PM? minute windows to complete survey.	NA	Smartphone app *Ilumivu and the Alert app from Empatica*	Proximal and time-lagged Multilevel modeling
53 Reininghaus, Kempton[83]	6	10	24	Stratified pseudorandomized prompts within 90-min blocks. 10 min window to complete survey.	NA	PDA *PsyMate*	Multilevel modeling
54 Reininghaus, Gayer-Anderson[84]	6	10	18	Stratified pseudorandomized prompts within 90-min blocks. 10 min window to complete survey.	NA	PDA *PsyMate*	Multilevel modeling
55 Reininghaus, Oorschot[85]	6	10	24	Stratified pseudorandomized prompts within 90-min blocks. 10-min window to complete survey.	NA	PDA *PsyMate*	Multilevel modeling
56 Sa, Wearden[86]	6	10	26	Stratified pseudorandomized prompts scheduled intervals across 15 h between 9 AM and 12 AM. 15 min window to complete survey.	NA	PDA *ESP software*	Proximal and time-lagged Multilevel modeling
57 Schick, Van Winkel[87]	6	10	NA	10 times a day on 6 consecutive days with a semi-random sampling scheme within a fixed, predefined time frame	NA	Smartphone app *PsyMate*	Multilevel modeling
58 Smelror, Bless[88]	12 (average)	5	5	Stratified pseudorandomized prompts scheduled intervals across 12 h between 10 AM and 10 AM. 15 min window to complete survey.	NA	iPod touch *App developed in house*	Summary statistics, spearman's correlation
59 So, Chung[89]	6	10	9	Randomized prompts at least 30 min apart within 10–12 h waking window. 15 min window to complete survey.	NA	Smartphone/ ipod touch	Proximal and time-lagged multilevel modeling
60 So, Chau[90]	14	7	7	Stratified pseudorandomized prompts scheduled intervals across 12 h tailored to sleep–wake cycle. 20 min window to complete survey.	NA	PDA *Purdue Momentary Assessment Tool (PMAT)*	Time-lagged multilevel modeling

Table 2. Continued

Study	Length of EMA Period (Days)	Number Surveys Per Day	Total Number of Items Per Survey	Sampling Schedule	EMA Completion Reward	Technology Used	Analysis Approach
61 So, Peters[91]	14	7	23	Stratified pseudorandomized prompts scheduled intervals across 12 h tailored to sleep–wake cycle. 20 min window to complete survey.	NA	PDA *Purdue Momentary Assessment Tool (PMAT)*	Multilevel modeling
62 So, Peters[92]	14	7	20	Stratified pseudorandomized scheduled intervals across 12 h tailored to sleep–wake cycle. 20 min window to complete survey.	NA	PDA *Purdue Momentary Assessment Tool (PMAT)*	Multilevel modeling
63 Steenkamp, Parrish[93]	10	3	NA	Stratified pseudorandomized prompts are scheduled at least 2 h apart within 12 h window from 9 AM to 9 PM. 1 h windows to complete survey.	Each survey completed, participants received $1.66 USD with a maximum of $50 USD.	SMS Web link sent to phone	Multilevel modeling
64 Strauss, Esfahlani[94]	6	4	46	Stratified pseudorandomized prompts scheduled intervals across 12 h between 9 AM–9 PM. 15 min window to complete survey.	NA	PDA *Experience Sampling Program software*	Markov chain analysis + proximal and time-lagged multilevel modeling + network analysis
65 Swendsen, Ben-Zeev[95]	7	4	10	Stratified pseudorandomized prompts scheduled intervals across 12 h tailored to sleep–wake cycle. 15 min window to complete survey.	$35 USD	PDA *Purdue Momentary Assessment Tool (PMAT)*	Time-lagged Multilevel modeling
66 Vilardaga, Hayes[96]	6	9	14	Stratified pseudorandomized prompts scheduled intervals across 12 h tailored to sleep–wake cycle. 15 min window to complete survey.	$10 USD + $5 for meeting 80% survey completion	PDA *MyExperience*	Proximal and time-lagged Multilevel modeling
67 Westermann, Grezellschak[97]	7	10	8	Unclear	30 Euro	Smartphone app	Markov chain multilevel modeling
68 Wright, Palmer-Cooper[98]	14	7	27	NA	NA	*Movisens* Smartphone app *mindLAMP*	Proximal and time-lagged multilevel modeling

Note: USD, US Dollar; SMS, short messaging service; PDA, personal digital assistant.

*The term multilevel modeling was used as a broad term for analyses employing a multilevel structure, including Hierarchical linear model, Linear mixed model, Mixed multi-level regression, Multilevel linear mixed effects model, Multilevel linear regression, etc.

Table 3. EMA Completion Rates

Study	Percentage of Sample Meeting >33% Cutoff	Percentage of EMA Surveys Completed	Other Measure of Completion	Other Completion Outcome	Predictors of EMA Completion
1	Ainsworth, Palmier-Claus[35]	88% (smartphone) 71% (SMS)	69% (smartphone) 56% (SMS)	—	—	EMA completion significantly higher with the smartphone app compared to the SMS procedure. Completion rate lower in week 2 compared to week 1.
2	Bartolomeo, Raugh[36]	—	66% (of completers)	% sample ≥ 20% cutoff	94%	SZ sample had lower completion rates than controls. SZ sample had lower personal education compared to controls, no other differences on demographics.
3	Bell, Rossell[11]	100%	72%	—	—	No relationship between completion rates and confidence in using smartphone apps, demographic, or clinical variables.
4	Bell, Velthorst[37]	87.8%	68% (of completers)	—	—	No differences in completion rates between patients vs. controls or patients vs. relatives. However, differences in demographics (sex, education, living status, and ethnicity). No differences in age across samples.
5	Ben-Zeev, Ellington[38]	—	—	% completing ≥2 full days of monitoring	87%	—
6	Ben-Zeev, Frounfelker[39]	—	88%	—	—	—
7	Ben-Zeev, McHugo[40]	—	98%	—	—	—
8	Ben-Zeev, Morris[41]	—	—	% completing ≥2 full days of monitoring	87%	—
9	Berry, Emsley[42]	—	67%	—	—	No relationship between completion rate and age, clinical status, gender, own or loaned smartphone, employment status, or education.
10	Brand, Bendall[43]	83%	71%	—	—	Completion rate lower in week 4 compared to week 1.
11	Buck, Munson[44]	—	—	—	—	—
12	Cristóbal-Narváez, Sheinbaum[45]	—	—	—	—	—
13	Daemen, van Amelsvoort[46]	100%	63%	—	—	No differences in completion rates between patients vs controls or patients vs relatives. Differences between groups on age, gender, education, and marital status.
14	Daemen, van Amelsvoort[47]	—	—	—	—	No differences in completion rates between patients vs controls or patients vs relatives. Patients had higher levels of child abuse.
15	Dokuz, Kani[48]	88%	71% (of completers)	—	—	No relationships between ESM data and demographics, or duration of illness, or time without treatment.
16	Dupuy, Abdallah[49]	—	95%	—	—	—
17	Fett, Hanssen[50]	86%	77%	—	—	—
18	Fielding-Smith, Greenwood[51]	89%	60% (of completers)	—	—	—

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Table 3. Continued

	Study	Percentage of Sample Meeting >33% Cutoff	Percentage of EMA Surveys Completed	Other Measure of Completion	Other Completion Outcome	Predictors of EMA Completion
19	Gaudiano, Ellenberg[52]	—	45%	% completing ≥10 EMA survey	62%	Male gender and cannabis (but not alcohol or other drug) use is associated with lower completion rate. No relationship between completion rate and age, educational attainment, non-Latino White vs. minority ethnicity/race); positive, negative, and affective symptom severity, or cognitive functioning. Completion rate lower in week 4 compared to week 1.
20	Geraets, Snippe[53]	—	64%	—	—	—
21	Gohari, Moore[54]	—	75%	—	—	—
22	Granholm, Loh[55]	—	69% (of completers)	% completing >4 EMA surveys	87%	Poorer cognitive impairment in those who did not meet completion criteria. No relationship between completion rate and age, gender, positive, negative or total symptoms severity, or number of days in the study.
23	Hanssen, Balvert[56]	—	59%	% completing >30% EMA surveys	89%	No significant differences were found for completion between the feedback and no-feedback group.
24	Hartley, Haddock[57]	75%	59% (of completers)	% who "completed" the EMA phase	84%	No difference in education, employment status or gender, age, positive, negative or general symptoms, severity of delusions, or hallucinations between those that did and did not meet completion criteria.
25	Hartley, Haddock[58]	75%	59% (of completers)	% who "completed" the EMA phase	84%	No difference in education, employment status or gender, age, positive, negative or general symptoms, severity of delusions or hallucinations between those that did and did not meet completion criteria. SZ and BD differed in demographics and PANSS symptoms.
26	Harvey, Miller[59]	—	80%	—	—	—
27	Jongeneel, Aalbers[9]	—	72% (of completers)	—	—	—
28	Kammerer, Mehl[60]	—	72%	—	—	—
29	Kimhy, Lister[61]	—	75%	—	—	—
30	Kimhy, Vakhrusheva[62]	—	81% (of completers)	—	—	—
31	Kimhy, Wall[63]	—	89% (of completers)	—	—	—
32	Kimhy, Delespaul[64]	91%	81% (of completers)	—	—	—
33	Klippel[65]	86%	—	—	—	—
34	Ludwig, Mehl[66]	—	72%	—	—	—
35	Lüdtke, Kriston[67]	—	—	—	—	—

Table 3. Continued

Study	Percentage of Sample Meeting >33% Cutoff	Percentage of EMA Surveys Completed	Other Measure of Completion	Other Completion Outcome	Predictors of EMA Completion
36 Lüdtke, Moritz[68]	—	82% (of completers)	—	—	—
37 Miller, Harvey[69]	—	80%	—	—	—
38 Moitra, Park[70]	—	39%	—	—	Compliance rates did not differ between smartphone or PDA.
39 Monsonet, Rockwood[71]	—	—	—	—	—
40 Morgan, Strassnig[72]	—	73%	—	—	SZ had differences with BD on education, age, and mother's education.
41 Mulligan, Haddock[73]	100%	77%	—	—	—
42 Nittel, Lincoln[74]	87%	—	—	—	No difference in completion rates between recruitment methods (outpatients vs recruited via leaflet).
43 Orth, Hur[75]	—	67% (of completers)	% sample ≥ 25% cutoff	86%	Compliance rates did not differ on individual levels of paranoia.
44 Palmier-Claus, Ainsworth[18]	82%	72% (of completers)	—	—	More severe positive symptoms, but not negative symptoms, depression or age, predicted decreased likelihood of meeting 33% completion criterion. No relationship between these variables and completion rate.
45 Parrish, Chalker[76]	—	81% (of completers)	—	—	Completion not related to age, years of education, gender, symptom severity, cognition, or diagnosis; weak negative correlation with mania.
46 Parrish, Chalker[77]	—	80%	—	—	—
47 Perez, Tercero[78]	—	75%	—	—	—
48 Pieters, Deenik[79]	—	64%	—	—	No differences between SZ and BD.
49 Pos, Meijer[80]	97%	—	—	—	—
50 Radley, Barlow[81]	—	69% (of completers)	—	—	Time of day did not predict missing data. Participants missed more surveys towards the end of the study.
51 Raugh, James[20]	—	54%	% sample ≥ 20% cutoff	—	—
52 Raugh, Strauss[82]	—	62%	% sample ≥ 20% cutoff	92%	SZ sample had lower completion rates than controls.
53 Reininghaus, Kempton[83]	86%	60% (of completers)	—	—	—
54 Reininghaus, Gayer-Anderson[84]	—	—	—	—	—
55 Reininghaus, Oorschot[85]	86%	60% (of completers)	—	—	—
56 Sa, Wearden[86]	—	67% (of completers)	% completing ≥20 beeps	100%	—

Table 3. Continued

Study	Percentage of Sample Meeting >33% Cutoff	Percentage of EMA Surveys Completed	Other Measure of Completion	Other Completion Outcome	Predictors of EMA Completion
57	Schick, Van Winkel[87]	100%	68%	—	—	—
58	Smelror, Bless[88]	—	74% (of completers)	—	—	—
59	So, Chung[89]	—	67%	% completing >30% EMA surveys	77%	There was no significant difference in age, gender, years of education, number of psychiatric admissions, or any of the clinical and self-report measure for those that did and did not meet completion criteria.
60	So, Chau[90]	—	85% (of completers)	% completing >30% EMA surveys	58%	No difference in clinical severity measures for those that did and did not meet completion criteria.
61	So, Peters[91]	—	71% (of completers)	% completing >30% EMA surveys	62%	No relationship between completion rate and number of days in study.
62	So, Peters[92]	—	71% (of completers)	% completing >30% EMA surveys	62%	—
63	Steenkamp, Parrish[93]	—	—	—	—	—
64	Strauss, Esfahlani[94]	—	90% (of completers)	% completing >25% EMA surveys	93%	—
65	Swendsen, Ben-Zeev[95]	—	72% (of completers)	—	—	No relationship between completion rate and number of days in study.
66	Vilardaga, Hayes[96]	—	55% (of completers)	—	—	—
67	Westermann, Grezellschak[97]	—	78%	—	—	No relationship between completion rate and number of days in study.
68	Wright, Palmer-Cooper[98]	76%	42.2%	—	—	Compliance was related to working and lower levels of self-reflectiveness. No relationships with demographics or clinical variables.

Note: BD, Bipolar Disorder; EMA, ecological momentary assessment; SMS, short messaging service; SZ, Schizophrenia.
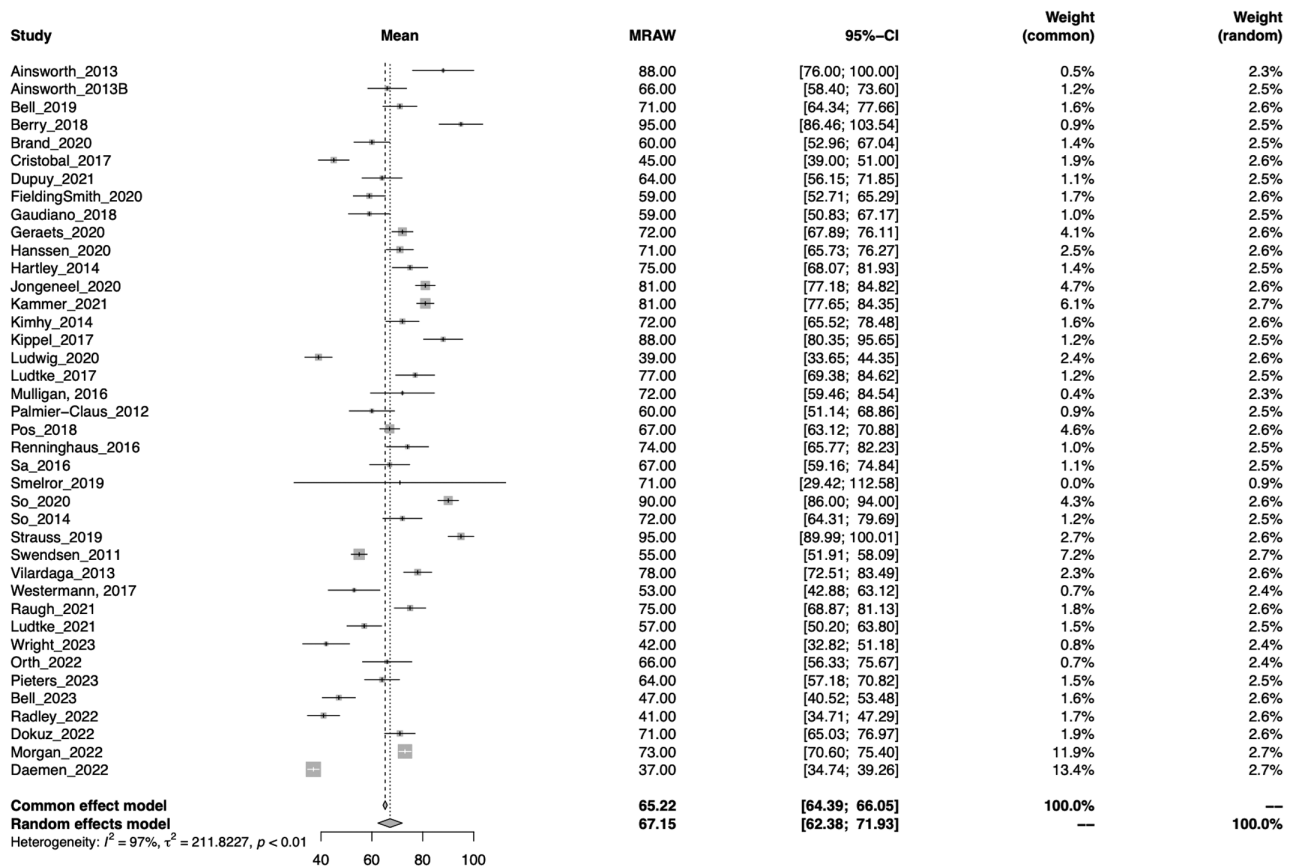
Study	Mean	MRAW	95%–CI	Weight (common)	Weight (random)
Ainsworth_2013		88.00	[76.00; 100.00]	0.5%	2.3%
Ainsworth_2013B		66.00	[58.40; 73.60]	1.2%	2.5%
Bell_2019		71.00	[64.34; 77.66]	1.6%	2.6%
Berry_2018		95.00	[86.46; 103.54]	0.9%	2.5%
Brand_2020		60.00	[52.96; 67.04]	1.4%	2.5%
Cristobal_2017		45.00	[39.00; 51.00]	1.9%	2.6%
Dupuy_2021		64.00	[56.15; 71.85]	1.1%	2.5%
FieldingSmith_2020		59.00	[52.71; 65.29]	1.7%	2.6%
Gaudiano_2018		59.00	[50.83; 67.17]	1.0%	2.5%
Geraets_2020		72.00	[67.89; 76.11]	4.1%	2.6%
Hanssen_2020		71.00	[65.73; 76.27]	2.5%	2.6%
Hartley_2014		75.00	[68.07; 81.93]	1.4%	2.5%
Jongeneel_2020		81.00	[77.18; 84.82]	4.7%	2.6%
Kammer_2021		81.00	[77.65; 84.35]	6.1%	2.7%
Kimhy_2014		72.00	[65.52; 78.48]	1.6%	2.6%
Kippel_2017		88.00	[80.35; 95.65]	1.2%	2.5%
Ludwig_2020		39.00	[33.65; 44.35]	2.4%	2.6%
Ludtke_2017		77.00	[69.38; 84.62]	1.2%	2.5%
Mulligan, 2016		72.00	[59.46; 84.54]	0.4%	2.3%
Palmier–Claus_2012		60.00	[51.14; 68.86]	0.9%	2.5%
Pos_2018		67.00	[63.12; 70.88]	4.6%	2.6%
Renninghaus_2016		74.00	[65.77; 82.23]	1.0%	2.5%
Sa_2016		67.00	[59.16; 74.84]	1.1%	2.5%
Smelror_2019		71.00	[29.42; 112.58]	0.0%	0.9%
So_2020		90.00	[86.00; 94.00]	4.3%	2.6%
So_2014		72.00	[64.31; 79.69]	1.2%	2.5%
Strauss_2019		95.00	[89.99; 100.01]	2.7%	2.6%
Swendsen_2011		55.00	[51.91; 58.09]	7.2%	2.7%
Vilardaga_2013		78.00	[72.51; 83.49]	2.3%	2.6%
Westermann, 2017		53.00	[42.88; 63.12]	0.7%	2.4%
Raugh_2021		75.00	[68.87; 81.13]	1.8%	2.6%
Ludtke_2021		57.00	[50.20; 63.80]	1.5%	2.5%
Wright_2023		42.00	[32.82; 51.18]	0.8%	2.4%
Orth_2022		66.00	[56.33; 75.67]	0.7%	2.4%
Pieters_2023		64.00	[57.18; 70.82]	1.5%	2.5%
Bell_2023		47.00	[40.52; 53.48]	1.6%	2.6%
Radley_2022		41.00	[34.71; 47.29]	1.7%	2.6%
Dokuz_2022		71.00	[65.03; 76.97]	1.9%	2.6%
Morgan_2022		73.00	[70.60; 75.40]	11.9%	2.7%
Daemen_2022		37.00	[34.74; 39.26]	13.4%	2.7%
Common effect model		**65.22**	**[64.39; 66.05]**	**100.0%**	**—**
Random effects model		**67.15**	**[62.38; 71.93]**	**—**	**100.0%**

Heterogeneity: $I^2 = 97\%$, $\tau^2 = 211.8227$, $p < 0.01$

40 60 80 100

Fig. 2. Forest plot of meta-mean of total completion rate.

the 33% cutoff (ie, "completers"). Additional completion criteria included across studies was the percentage of the sample that met the minimum cutoff of 33% (or one-third) of completed EMA surveys (33% of prompts in 14 studies, 30% in 3 studies, 20%–25% in 2 studies, and 3 used a criteria specific to the study). An average of 86.25% (range 62% to 100%) of participants across the 40 samples met the 33% (or 30%) cutoff criterion. To assess for possible publication bias, a sensitivity analysis was conducted comparing studies with small and large sample sizes (split by medium of 35 participants). No significant difference was detected, suggesting that the completion rate was not influenced by the sample size ($P > .05$).

Predictors of completion rates

Predictors of completion rates were reported in 26 studies. Of the 15 studies that examined the relationship between demographic or clinical variables and completion rates, 9 found no relationship with age, gender, and symptom severity measures. In the remaining 6 studies, lower completion rates were predicted by more severe manic symptoms (1 study), more severe positive symptoms (2 studies), less severe negative symptoms (1 study), not being in employment, and lower levels of

self-reflection (1 study), greater cognitive impairment (1 study), male gender, and cannabis (but not other drug or alcohol) use (1 study). Three studies compared completion rates between psychosis samples and controls, with 2 finding slightly lower rates in clinical samples and the other no difference was found. Eight studies examined the relationship between completion and number of days in the study, with 4 finding no relationship and 4 finding completion lower in the last week of assessments compared to the first week. Three studies examined the effects of EMA delivery methods. One found no significant difference in EMA completion rates when comparing participants receiving EMA-derived personalized feedback and those receiving no feedback. Another study reported significantly higher EMA completion using a smartphone app than an SMS-based EMA procedure, and another found no difference between a smartphone app and PDA. Where significant, effect sizes were small.

As shown in table 4, The results from the exploratory meta-regressions found no significant ($P > .05$) associations between completion rates and protocol length (questions), duration of ESM protocol in days, participant payment, inpatient status, whether device was a PDA or not, PANSS total, overall study quality, participant age, or percentage of female participants.

Table 4. Meta-Regression Coefficients

Variable	n	Coefficient	95% CI	P value
Total CREMIS Score	40	1.16	−1.14, 3.47	.35
PDA vs. smartphone or SMS	40	4.53	−5.78, 14.8	.37
Number of ESM surveys per day	40	−0.60	−2.64, 1.42	.54
Duration of ESM study protocol in days	38	−0.29	−1.15, 0.56	.48
Reimbursement vs. no reimbursement	18	−11.85	−31.95, 8.23	.22
Participant Age	39	0.19	−0.56, 0.95	.60
Outpatients vs. mixed in- and outpatient	36	−7.39	−61.27, 46.48	.78
Inpatients vs. mixed in- and outpatient	36	−1.60	−53.12, 49.92	.95
PANSS total score	21	0.15	−0.24, 0.56	.41
Percentage of females	38	0.05	−0.24, 0.34	.72

Note: PDA, personal digital assistance; PANSS, Positive and Negative Symptom Scale; CREMAS, (STROBE) Checklist for Reporting EMA Studies.

Constructs Examined and Properties of EMA Psychosis Items

A full list of the EMA items used to measure psychotic experiences is detailed in supplementary material S4. The most commonly measured constructs, aside from psychotic symptoms, were emotional states such as positive or negative affect (51 studies). Also measured were context and activities (15 studies), social processes (26 studies), psychological processes such as worry, rumination, dissociation, meta cognition, aberrant salience and thought control (9 studies), coping or behavioral responses (6 studies), appraisals (5 studies), emotion regulation (9 studies), and sleep (1 study).

Sixty studies reported the EMA items used to measure psychosis. EMA surveys varied in length from 52 items, with the average number of items being 19. A range of psychotic symptoms and dimensions were measured. This included hearing voices (42 studies), seeing visions (24 studies), specific delusional beliefs (41 studies), and unusual experiences such as dissociation (eleven studies). For hallucinatory experiences, either 1 or 2 items were most commonly used which referred to "hearing voices" and "seeing visions," whereas delusions were more likely to be captured at the level of the belief type with multiple items (eg, paranoia, mind reading, thought broadcasting, and ideas of reference). Twenty-six studies used the same response scale from 1 (not at all) to 7 (very/very much/very much so), with the remainder using varied rating scales.

Only 33 of the 68 studies reported any indices of reliability or validity for EMA scales and none had been fully validated. Internal consistency for psychosis scales was reported in 20 studies, and correlations between these scales and related constructs were examined for construct validity in 13 studies. Scales were most often constructed by adapting standard measures (eg, PANSS, Psychotic Symptom Rating Scales; PSYRATS) in conjunction with face validity procedures involving expert feedback from researchers, clinicians, and those with lived experience of psychosis.

Methodological Quality

See supplementary material S5 for a descriptive summary of reporting practices of all included studies using the STROBE Checklist for Reporting EMA Studies (CREMAS). Studies varied in reporting quality. Most studies mentioned EMA appropriately in title/keywords (55 studies; CREMAS item 1) and provided a good rationale for using EMA (41 studies; item 2). Although two-thirds of studies described EMA training adequately (item 3), the remaining studies provided little-to-no information on this. As expected, given the study inclusion criteria, EMA procedures were well described (items 4–8), although only one study provided information on the proportion of weekends/weekdays in the monitoring period (item 6) and whether prompt frequency differed on weekend days vs. weekdays (item 8). Around one-third of studies described design features to address potential sources of bias and/or participant burden (item 9). Although most studies reported attrition (item 10) and completion rates (item 13), the form in which these were reported was not always consistent and no studies reported these figures per monitoring day (or wave, where applicable). Studies usually reported (or provided enough information to calculate) the number of expected prompts (item 11) but rarely stated the number of delivered prompts. Similarly (item 12), 43 studies reported planned response latency (eg, 15-minute response window) but only one study reported actual latency (average time from prompt signal to answering the prompt). With regards to missing data (item 14), 25 studies examined whether EMA completion was related to demographic or time-varying variables, but the implications of this for the analysis were rarely discussed. Two-thirds of all reviewed studies detailed the limitations of the EMA method in the specific study context (item 15), provided a general interpretation of the results with reference to the benefits of EMA and/or discussed new ways that EMA has been used or could be used in the future (item 16).

Table 5. Recommendations for Reporting in Future EMA Studies in Psychosis

Recommendations	Rational
Recommendation 1: studies should consistently report completion rates in terms of: (1) The total number of prompts participants responded to out of the total number of actually delivered prompts (expressed as a fraction and a percentage), and (2) The average number of prompts responded to per participant (as a fraction and a percentage).	No single index of EMA completion was reported across all studies. Percentage of total EMA survey completion was often reported (or calculable from reported data). However, the number of actually delivered EMA prompts (as opposed to the intended number of prompts) was rarely reported, making it difficult to evaluate the accuracy of calculations based on supplied data.
Recommendation 2: studies should report the standard deviation of all reported completion indices. For example, the time to complete each EMA session may offer individual participant data on how they completed the questions. This timestamped data are already recorded with most EMA tools like smartphones.	Studies did not always report a measure of variability in completion between participants, precluding precise meta-examination of completion rates.
Recommendation 3: studies should provide information on the distribution of responses per day across the sample (e.g. graphically) and per wave, if applicable.	None of the reviewed studies reported completion rate per monitoring day (or wave). As others have argued,[50,53] density of sampling in EMA studies may be as important as overall percentage completion.
Recommendation 4: studies should report number of EMA prompts scheduled, number completed, and expressed as a percentage. If "completer" analyses are conducted, a clear rational must be provided.	Many studies only reported percentage EMA completion for study/EMA "completers" (often defined as those completing >33% EMA surveys), making comparison across studies difficult.
Recommendation 5: Where appropriate, researchers should examine possible predictors of non-completion to determine biases within the data and reasons for non-completion should be gathered and reported where possible. We contend that examining predictors of completion as a continuous variable will provide more valid insights than comparing the binary variable of "completers" and "non-completers." We also suggest reporting correlations between completion rates and key predictors to aid future meta-analytic work. Further, implications for missing data assumptions should be explicitly considered.	Detailed reasons for non-completion were not always reported. Although some studies examined predictors of EMA completion (which amounts to an examination of missing data), these were rarely explicitly considered in relation to missing data assumptions or potential biases within the data.
Recommendation 6: Future studies should include more detailed EMA items, particularly for assessing hallucinations (eg, include measures of voice content, beliefs, and distress), and evaluate their psychometric properties empirically. Studies should also consider and justify sampling frequency based on the phenomena of interest.	Psychotic symptom items were often brief, and evidence of psychometric validation was often lacking. Items assessing hallucinations were particularly underspecified and lacked complexity/granularity of the voice-hearing experience. Studies lacked consideration for the frequency of sampling based on the research questions and phenomena being measured.
Recommendation 7: Studies may wish to use the following standard format for reporting the EMA protocol (adjusting details as needed): "A 15-item EMA survey was delivered over a 7 d period, with 10 prompts per day occurring at stratified pseudorandomized intervals within 5 blocks of 2 h, within a 10 hour window from 9 AM to 7 PM."	Although generally well-reported in the reviewed studies, it is worth reiterating the CREMAS recommendations on reporting the EMA protocol itself. Namely, the following should be reported: number of EMA items per survey, frequency of prompts (eg, per day), sampling schedule (eg, fixed time, randomized within time windows), length of survey period (eg, number of days), prompting schedule (ie, event-based, user-initiated, time based), and number and duration of waves (eg, 2 monitoring periods over the course of 1 year), if applicable.

Discussion

This systematic review aimed to critically examine studies employing EMA methods for positive psychotic symptoms in psychosis samples by summarizing key methodological features and evaluating feasibility, with a particular focus on completion rates. The reviewed studies provide clear evidence that using digital devices to measure momentary positive psychotic experiences in daily life is feasible and acceptable for people with psychosis across a range of demographic and clinical characteristics.

Principal Findings in Context

Across 39 studies with unique samples, the meta-mean EMA completion rate was 67.15%, with 86.25 % of participants meeting the standard study cutoff criterion of 33% (or 30%) of EMA surveys completed, supporting the feasibility, and acceptability of the method in psychosis populations. Note that while 7 studies were excluded because they did not report a completion rate, it is unlikely these would have had a meaningful influence on the results given the number of studies included and relatively narrow confidence interval of the pooled completion rate estimate (62.3%–71.9%). The overall completion rate found in this review is notably lower compared to those reported in systematic reviews and meta-analyses of EMA use in chronic health conditions (74%–78% EMA completion[99,100]), and mental health research including clinical and nonclinical samples (78%–82% EMA completion[25,28,101]). This finding is consistent with a prior

meta-analyses which found lower completion rates in samples of people diagnosed with a psychotic disorder compared to other psychiatric conditions.[25] Together, this result suggests that a slightly lower rate of completion may be expected in psychosis populations compared to psychiatric conditions overall.

The methodological characteristics of the studies were variable. The most consistent EMA protocol (adopted in 10 studies) involved 10 surveys per day over 6 days delivered within a pseudorandomized schedule of prompts spread evenly across equal blocks during 12 waking hours (most often 9 AM to 9 PM), in which participants had 15 minutes to respond to each survey. Few studies examined the influence of methodology on completion rates, with one study finding advantage of smartphone app over an SMS-delivered EMA protocol[35] and another finding no difference between PDA and smartphone app delivery.[71] Four (of 8) studies found completion reduced over time and there was no effect of personalized feedback (vs. no feedback). Similarly, there was no evidence from the meta-regression findings that EMA completion rates were associated with protocol length and duration, inpatient status, or participant age, nor was there any association with other clinical or demographic variables. In contrast, prior meta-analyses in psychiatric populations have found very small links between male gender and lower compliance,[25,28] which was most pronounced with higher sampling rates (around 97 total surveys[28]), It is possible that the effect did not emerge in this review due to the lower average sampling rate (60 surveys), or that gender does not influence compliance in psychosis populations.

It is clear that EMA is a flexible method that can be used successfully across a wide range of groups and for a range of purposes. While the majority of the studies reviewed here used EMA to examine hypothesized relationships between specific variables of interest in a research context (eg, whether worry predicts hallucinatory experiences[57]), some studies have also investigated direct clinical applications of EMA methods in psychosis samples.[11] Similarly, there is increasing interest in using repeated self-reported assessments via smartphone apps to monitor early predictors of psychosis relapse[102] and fluctuations in other clinical outcomes.[56] Key advantages of EMA as a research method, such as increased ecological validity and reduced recall bias, also extend to clinical use. However, it is important to note that the current study excluded EMI studies where EMA was not a distinct component, therefore rates of EMA completion in these types of interventions are not reflected by the current findings.

Limitations in EMA Survey Design

Many of the reviewed studies cited the brevity of EMA items as a major limitation. EMA items used to assess psychotic symptoms were often simplistic and may therefore have lacked sensitivity to the multidimensional experience of hallucinations and delusions. Delusional experiences tended to be captured in more detail than hallucinations, despite hearing voices having highly varied phenomenological features (voice content, distress, beliefs about voices, etc[103]). While some studies assessed delusions using multiple questions which were sometimes individually tailored, voice-hearing experiences were assessed using more general questions. Fewer studies assessed negative or cognitive symptoms; however, this is not unexpected given these studies were only included if they measured positive symptoms as well. EMA scales used to measure psychosis constructs were also highly varied between studies, presenting issues for comparability of findings and conducting meta-analysis. While the findings suggest EMA is an acceptable data collection method for people diagnosed with schizophrenia, the scales presented here used many different EMA items, assessing a variety of positive symptom constructs which makes comparison of results challenging.

The approach to developing EMA scales typically involved adapting cross-sectional measures, with very few studies following formal validation procedures, and indices of reliability and validity were rarely reported. While the bipolar field has begun to research specific EMA scales for this disorder, such efforts are currently lacking for schizophrenia.[104] Notably, the focus of this review was not to evaluate psychometric properties of EMA scales of psychotic experiences, but rather to report approaches used in existing studies. The lack of studies reporting psychometric properties highlights a need for future studies to develop and validate EMA scales for psychotic experiences. Considerations for the brevity of these scales should balance validity with the time-intensive nature of EMA, as well as appropriate sampling schedules based on the construct of interest, where more frequent measurements may be required for brief or more rapidly fluctuating phenomena. Efforts in the psychosis field have commenced towards the development of validated EMA scales, including the *ESM Item Repository* led by Myin-Germeys and colleagues.[105]

EMA Completion Rate Reporting: Limitations and Considerations

Most studies reported the EMA rationale, methods, limitations, and conclusions adequately; however, many did not always meet CREMAS reporting recommendations. In particular, reporting of EMA completion rates was often inconsistent, with details regularly omitted. This accords with the findings of prior reviews which have also identified inconsistent reporting in EMA studies in other populations.[25,101] The adherence of research participants to the assessment protocol "must be sufficient to obtain a meaningful sample of experience during the sampling

period."[59] Hence, it is crucial that studies report EMA completion in enough detail for findings to be critically evaluated.

Thirty-nine studies with unique samples reported percent EMA completion (or an equivalent that allowed percent completion to be calculated), with 86.25% reporting the proportion of the sample meeting the 33% or one-third completion rate criteria. There is some dispute regarding the recommendation[23] that at least 33% of EMA surveys should be completed for a participant's data to be included in analysis. Arguably, this cutoff is arbitrary. Indeed, the source most commonly cited on the topic[106] provides no justification for this value.[107] Furthermore, the most widely used approach for statistically analyzing EMA data (multilevel modeling using maximum likelihood estimation) allows all available observations to be included,[107,108] obviating the need to exclude low-responders. In fact, by excluding participants who respond to less than a third of EMA prompts, existing selection biases may be exaggerated, since lower-functioning individuals are not only less likely to take part, but also more likely to drop out. We contend that the reliance on the 33% cutoff should be critically reviewed and that a more nuanced approach may be necessary. For example, some have argued[59,109] that the density of sampling in EMA studies (ie, percentage completion on a particular day) may be as important as overall percentage completion. This is particularly relevant where time-lagged analyses, examining associations between subsequent EMA surveys, are used.

Recommendations for Methods and Reporting of Future EMA Studies

There is a need for clear and consistent guidelines for EMA reporting in psychosis studies, and for researchers and journals to adopt these. Based on reporting limitations observed in the reviewed studies, and in line with recommendations outlined in the adapted STROBE Checklist for Reporting EMA Studies (CREMAS[34]), here we make 7 specific recommendations in table 5. These recommendations aim to facilitate comparison of results across studies and critical evaluation of findings, and to ensure that studies collect sufficient data for future meta-analyses to be possible. In each case, we present an observed limitation in the reviewed studies and an accompanying recommendation. While guidelines for conducting and reporting in EMA studies of psychiatric populations have been published more broadly,[25–28] the lack of adherence to these in subsequent studies has been notable.[26] We hope that by providing considered and explicit recommendations for psychosis populations, we may help future researchers adopt a more consistent standard in future publications, ultimately leading to more transparent findings that are more readily synthesizable in future reviews.

Review Limitations

The current review has several limitations. First, the focus of this review was solely on EMA as a research methodology for positive symptoms in psychosis studies, therefore the findings may not apply to other psychotic experiences such as negative symptoms and cognitive disorganization. Second, the decision to exclude passive sensing studies meant that these and related search terms (eg, digital phenotyping) were not included. As studies using passive sensing sometimes include EMA as a subcomponent, this meant that some relevant studies may have been missed. In recognizing the progression of the field towards multi-modal technologies that incorporate both passive sensing and active EMA data collection, the findings of this review apply to the distinct use of EMA only. Third, broader terms related to the use of mobile technology for assessment and treatment (eg, "mobile health") were not included in order to focus the search on EMA as a methodology. However, this may have resulted in studies of similar app-based monitoring studies being missed. Fourth, while included studies provided a good representation of typical research participants with psychosis, some populations were underrepresented including inpatient, ultrahigh risk, and first episode psychosis samples. Sixth, while the meta-regression reflected trends across studies, this cannot apply to individual-level relations. Furthermore, while attempts were made to exclude studies where data were reported elsewhere, this was not always clear nor determinable from the study details, which may potentially distort estimates. Similarly, clarity of reporting for completion rate criteria were not always transparent, with some studies reporting completion rates from analyzed samples which included data from participants who met the 33% cutoff criteria. It is possible that future studies which include the *full* sample may expect a slightly lower rate of completion. Finally, the aforementioned lack of clear and consistent methodological reporting within this body of research also impairs the quality of this review.

Conclusions

In conclusion, this review has determined that EMA is a feasible and acceptable methodology for use with psychosis populations with high levels of completion rates that appear unrelated to clinical or demographic predictors. Variations in study reporting highlighted a need for clear and consistent guidelines for EMA studies in psychosis, for which recommendations have been provided in this review. Further research is needed to develop validated EMA scales for psychotic experiences.

Supplementary Material

Supplementary material is available at https://academic.oup.com/schizophreniabulletin/.

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Ethical Standards

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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